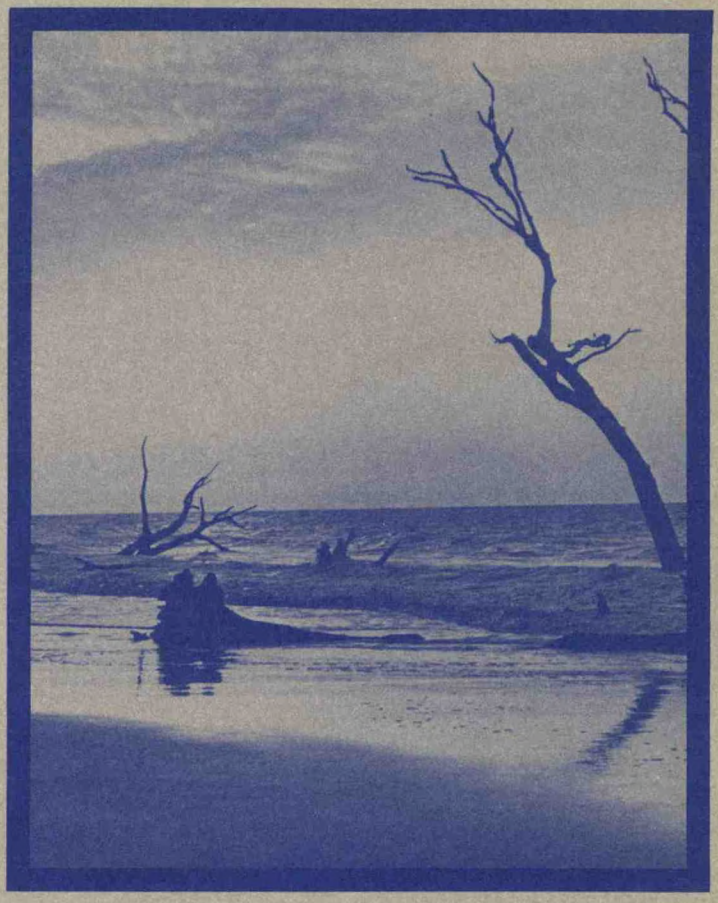
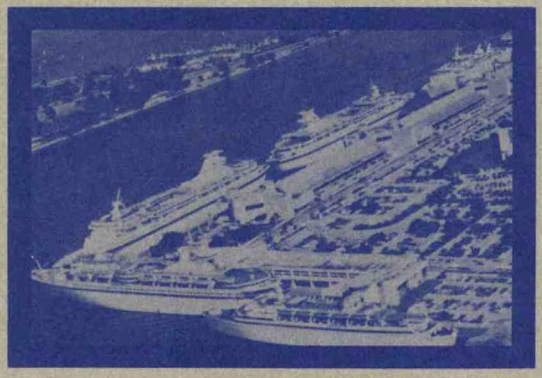
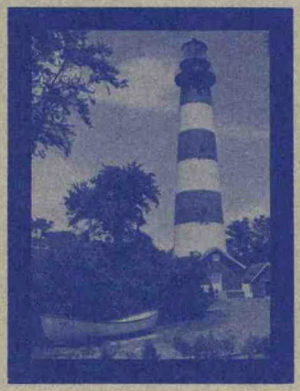
Marine Environmental Assessment

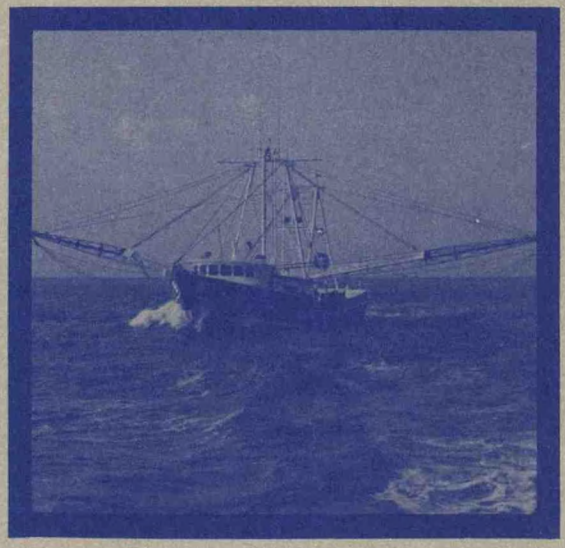
SOUTHEASTERN U.S.

1986 ANNUAL SUMMARY









U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Assessment and Information Services Center

CLIMATE IMPACT ASSESSMENT
UNITED STATES

The AISC/Marine Environmental Assessment Division (MEAD), Marine Assessment Branch (MAB), produces periodic assessments of environmental impacts on economic sectors of various marine-related activities. Since 1981, MAB has issued assessments of Chesapeake Bay in the economic sectors of fisheries, recreation, and transportation. For the Chesapeake Bay region, which served as a model for assessment development, there are now quarterly and annual issues. Also available are annual assessments for the Gulf of Mexico, Puget Sound, and San Francisco Bay. This is the prototype annual summary for the Southeastern U.S.

Please send comments or subscription queries to the Chief, Marine Assessment Branch, Marine Environmental Assessment Division, NOAA/NESDIS/AISC, E/AI32, 1825 Connecticut Avenue, NW, Washington, DC, 20235, or call (202) 673-5400.

Front Cover Photographs

Shrimp boat - Johnson Shipbuilding
Shoreline scene - J. Jordan
Port of Miami - Miami Port Authority
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1. INTRODUCTION

This Southeastern U.S. assessment is a prototype summary covering the calendar year 1986 which includes information on weather, oceanography, fisheries, recreation, transportation, and pollution. The Assessment and Information Services Center has produced assessments for other areas along U.S. coasts including Chesapeake Bay, the Gulf of Mexico, Puget Sound, and San Francisco Bay.

The assessment focuses on the effects of environmental events (meteorology, oceanography) on the marine resources of the region. Impacts of short- and long-term processes and events are identified and quantified, where possible, in the fisheries, recreation, and transportation resource sectors. The assessment provides a multi-disciplinary view of the marine sectors of the Southeast. The study compiles data from numerous federal and state agencies, universities, and line offices of NOAA, evaluates the data according to known relationships, and examines the environmental and economic consequences of the events observed. Relationships between study variables are presented where possible. Where it is difficult to establish clear relationships, data from scientific and economic areas are presented to further display the multiple uses of the Southeast Coast.

1.1 Organization of the Report

The report comprises nine sections. In the introductory section we delineate the concept of marine environmental assessment embodied in this report, specify the coverage of the present study, and describe the marine-oriented economy of the Southeast Region.

Section 2 provides an overview of the highlights of the environmental events identified in 1986 in the study area and the impacts of the events on sectors of the area economy.

Sections 3 and 4 describe the weather and oceanographic conditions which prevailed during 1986. Study variables are presented with the observed 1986 values and long-term averages, where possible, to show how the 1986 weather and oceanography compared to a "normal" year in the study area.

Fisheries, recreation, and transportation are addressed as sectors of the marine-oriented economy in Sections 5 through 7. The fisheries section focuses on the fish and shellfish which were landed in the four Southeast states in 1986 and on the variety of habitats and distributions of species of the Southeast. In recreation, we provide an overview of marine-related recreation along the Southeast Coast by identifying the categories of recreation and describing their importance to the

regional economy. The transportation section presents information on shipping and related shore activity for the major ports of the Southeast during 1986. Pollution, which is a topic of major concern nationally, including the Southeast, is addressed in Section 8, and includes information on pollutant sources, spills, and effluents.

1.2 Description of the Study Area and Scope of the Report

The study area includes the coastal Southeastern U.S. and adjacent coastal ocean of North Carolina, South Carolina, Georgia, and east coast of Florida (Figure 1.1). The study area extends offshore and inshore as required to accommodate individual environmental and economic analyses as they pertain to the coastal zone. Meteorological station data and other environmental data such as streamflow are incorporated as required over the area drainage basins.

The study period covers the calendar year 1986. Where discussion of environmental patterns or events requires reference to 1985 or 1987, coverage is extended at those specific instances.

The assessment covers the marine and estuarine environments of the coastal zone, including the 20 estuarine systems of the region (Table 1.1). The Southeast has 14 percent of the total area of U.S. estuaries, and 18 percent of the estuarine drainage area. The combined Albemarle-Pamlico systems in North Carolina are the nation's second largest estuarine area after Chesapeake Bay. The Indian River in south Florida is the most diverse estuary in the U.S. with approximately 400 species of fish.

NOAA's National Ocean Service National Estuarine Inventory characterizes the Southeast estuarine areas by two general types of shoreline formations. The first type is a low-lying, marshy shoreline with a dendritic pattern of tributaries flowing to the sea. This shoreline type is most prevalent on the South Carolina and Georgia coasts. The second type is represented by lagoons landward of extensive barrier island developments found in North Carolina and central Florida. A unique exception to these types is the St. Johns River, a large river with limited access to the sea, but tidally influenced far upstream. Some areas of the coastal Southeast have undergone alterations which have considerably affected water flow patterns, notably the Cooper River rediversion project near Charleston, SC, and canals in south Florida which connect Lake Okeechobee to the coast.

The continental shelf adjacent to the Southeast States is a relatively shallow-water area which provides an enormous habitat for many different species of fish and shellfish. The coastal marine area of the Southeast is influenced by the warm water of the Gulf Stream and the temperate climate to the north.

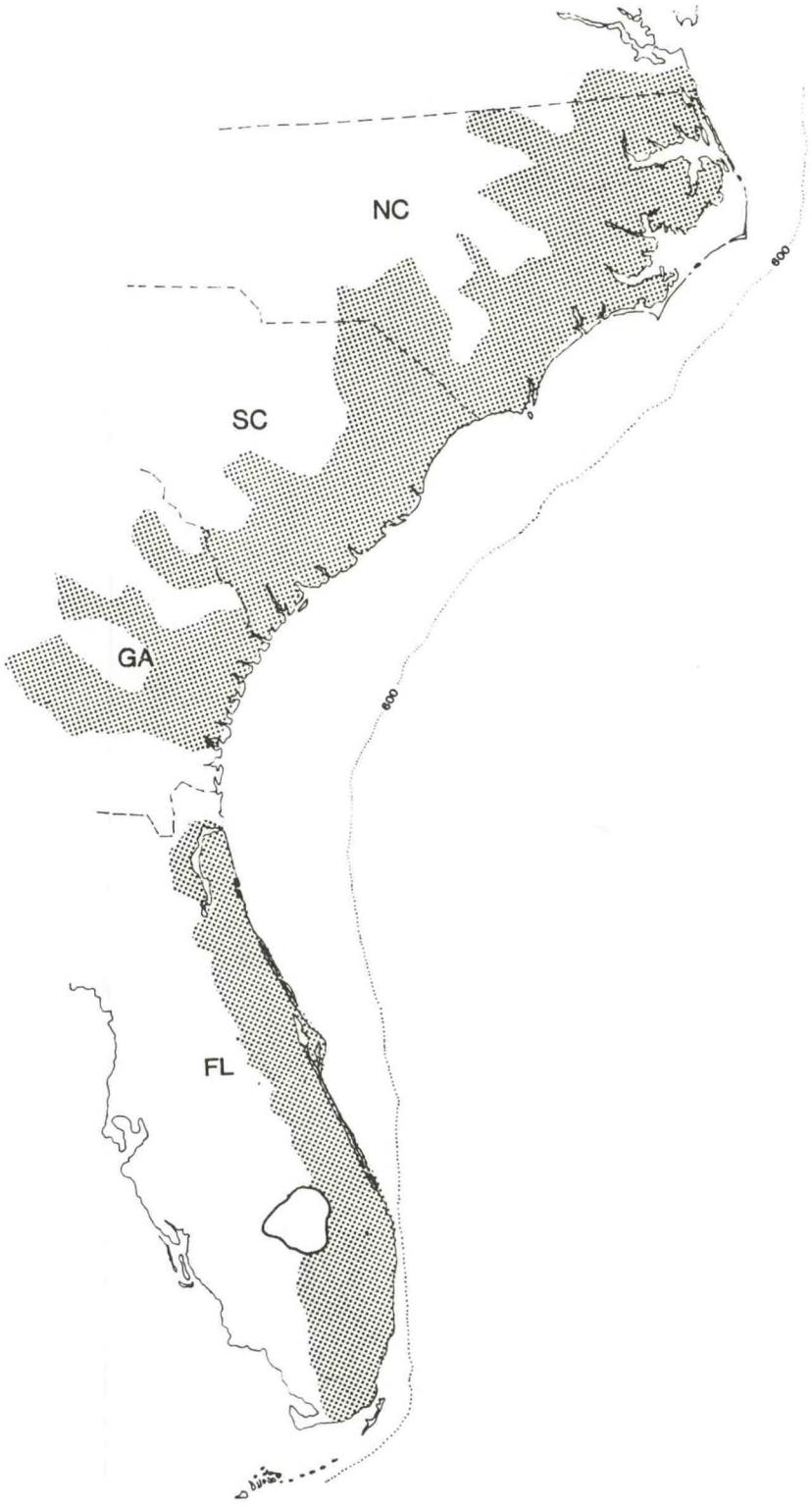


Figure 1.1 Coastal features of the Southeast, showing shaded estuarine drainage (the land and water component of the watershed that most directly affects the estuary) and edge of continental shelf (600 ft. contour).

Table 1.1 Estuaries of the Southeast.[1] Data from National Ocean Service, NOAA.

Estuary	Surface area (Sq. mi.)	Estuarine drainage area (Sq. mi.)
Albemarle Sound (NC, VA)	922	5,804
Pamlico Sound (NC)	2,027	5,790
Pamlico and Pungo Rivers (NC)	166	2,107
Neuse River (NC)	173	2,200
Bogue Sound (NC)	102	680
New River (NC)	32	470
Cape Fear River (NC)	38	4,340
Winyah Bay (SC, NC)	30	9,511
North and South Santee Rivers (SC)	9	718
Charleston Harbor (SC)	37	1,202
St. Helena Sound (SC)	85	1,537
Broad River (SC)	100	1,000
Savannah Sound (SC, GA)	33	916
Ossabaw Sound (GA)	33	1,490
St. Catherines/Sapelo Sound (GA)	75	965
Altamaha River (GA)	15	1,510
St. Andrew/St. Simons Sound (GA)	72	3,260
St. Johns River (FL)	258	6,500
Indian River (FL)	280	1,246
Biscayne Bay (FL)	269	1,850
Total for all U.S. estuaries	32,000	276,400
Southeast as percent of U.S. total	14%	18%

[1] The number of estuaries portrayed represent approximately 90 percent of the total estuarine area along the Southeast Coast. The surface area of some estuaries may be larger or smaller than areas cited in the table due to tidal differences.

Over much of the year, inshore coastal waters are cooler and turbid with the clearer and warmer water of the Gulf Stream offshore. The ocean bottom is mostly sand, constantly shifting with waves and currents. In southern Florida, corals grow abundantly in the tropical influence of the Gulf Stream. To the north, reef-building corals diminish as the water becomes cooler. Above the Vero Beach - Ft. Pierce area, the marine zone becomes less tropical, though hard-bottom outcrops are found to North Carolina with lush species assemblages on the otherwise sandy bottom.

1.3 The Marine Economic Sectors of the Southeast

The Southeast Region of the United States is on a growth spurt economically and the marine portion of the economy is playing a major share in that growth. However, the growth is not coming from areas we traditionally associate with the marine environment. For example, commercial fisheries landings declined to 248,634 thousand pounds in 1986 from the historic high landings of 543,006 thousand pounds in 1981 and the value of the landings in 1986, about $154.7 million dollars, did not match the historic high value of landings in 1983 of about $172.6 million dollars. Despite this decline in landings, the number of processors and wholesalers located in the Southeast has been on the rise: in 1970 there were 432 such establishments and in 1985 there were 657. In the area of marine transportation, the Southeast has increased its share of tonnage carried from and to its ports only slightly since 1970: from 7.1 percent of the national total in 1970 to 7.6 percent in 1985. Selected ports in the Southeastern Region are themselves experiencing improved business. Savannah and Charleston ports each have grown about 20 percent since 1976.

One of the strongest factors in growth in the Southeast has been development in the coastal zone which is related to the major attractiveness of the area for recreational activities.

Coastal development

While Florida is identified as a state whose economy has been strongly influenced by recreational-residential development, similar development is occurring in the other states of the Southeast Region. Development in the Southeastern States is being influenced by a series of climatic, economic, and social forces that may be characterized as the region "being in the right place at the right time." Among these factors are

1) the increasing amount of leisure time available to Americans;
2) an aging population with retirement security;
3) excess disposable personal income on the part of a significant share of the population allowing investment in second homes and vacation properties;
4) increased attention by state governments to the tourist trade;
5) an attractive climate for recreation along most of the Southeastern Coast and the desire of society to be near a tropical marine environment;
6) barrier islands, beaches, and varied coastal landscapes and ecosystems affording a myriad of recreational experiences;
7) construction of major interstate highways which have linked the Northeast and Midwest to the Southeast;
8) development of major airline routes in the Southeast; and
9) the success of Florida.

Population growth

Population growth may be an indicator of the significance of coastal recreation to growth in the Southeast. In North Carolina population growth in Carteret and Brunswick Counties between April 1, 1980 and July 1, 1985 was up 19.1 and 26.9 percent, respectively, far exceeding the state average population growth of 6.4 percent for the period. Both of these counties are popular beach-fishing-recreation areas. In South Carolina the figures for coastal-county growth in the same period show a similar growth. The coastal counties of Beaufort, Berkely, Dorchester, and Horry experienced 28.3, 26.1, 23.5, and 24.9 percent growth rates, respectively, while the average state growth rate was 7.2. Beaufort County is the location of Hilton Head Island, a vast leisure-retirement-recreational complex, and Horry is the location of the popular Myrtle Beach recreation area. In Georgia, the coastal county of Camden experienced a 35.3 percent population rise compared with a state average of 9.4. Florida continued to have strong growth along the coasts and in the interior. The 16.6 percent growth for the state during the period was the third largest in the nation. In terms of actual population growth rather than percentages, Florida also ranked third in the nation experiencing an increase of approximately 1.6 million people. Estimates of population growth compiled by the University of Florida Bureau of Economic and Business Research indicate about 11 percent of the state's population growth between 1980 and 1985 came from natural increase; the remainder was the result of net migration.

Employment

An important indicator of the nature of economic growth in any state is the job distribution by economic sector. These data yield two types of information. First, they are an indication of the impact of leisure-recreational growth on the economy since job growth from such development will be found in specific employment sectors. Secondly, the job mix helps describe the level of recreational usage that may arise from type of employment. It is frequently assumed in recreation studies that stable, fixed-workweek, relatively well-paying employment gives individuals an opportunity for more leisure time and the income to engage in recreational activity.

Figures 1.2a-d shows the 1983 distribution of employment in the four states of the Southeast and the projected growth for 1990. Unfortunately, present industrial classification systems do not sufficiently identify recreational businesses. Nor is it generally possible to obtain data on employment in marine sectors for states, except for a few very limited occupations. However, analysis of Figure 1.2 a-d does yield some insights into economic development related to recreation-residential expansion.

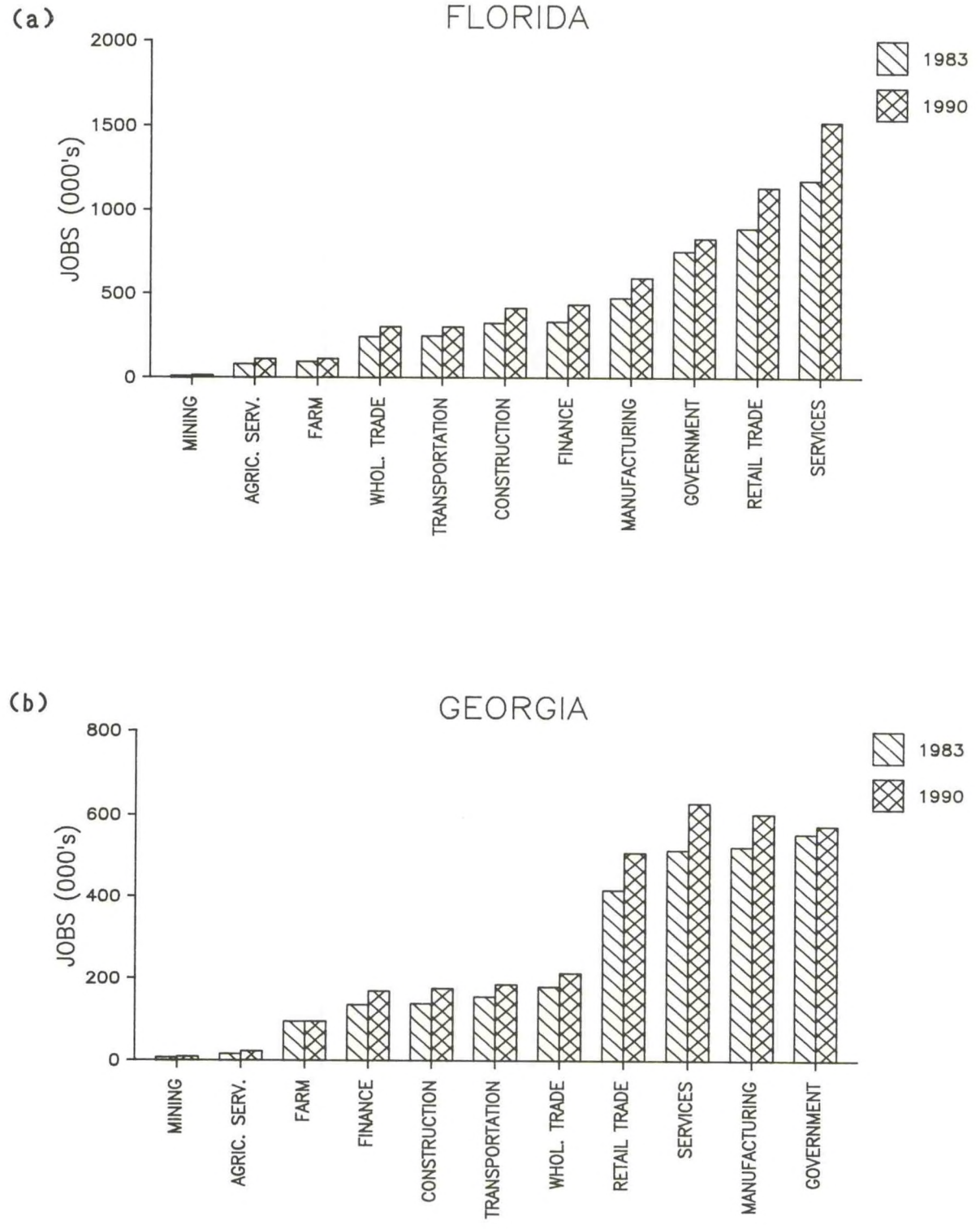
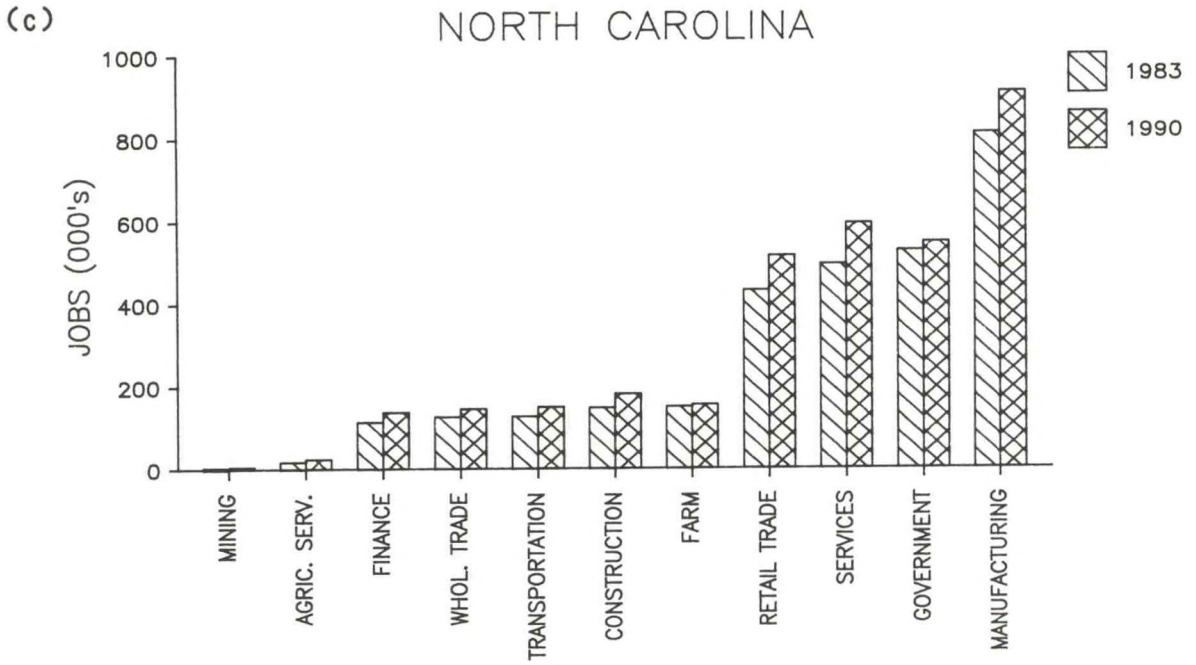


Figure 1.2 (a-b) Distribution of jobs in 1983 ranked by numbers and projections for 1990 for (a) Florida and (b) Georgia. Data from U.S. Department of Commerce.



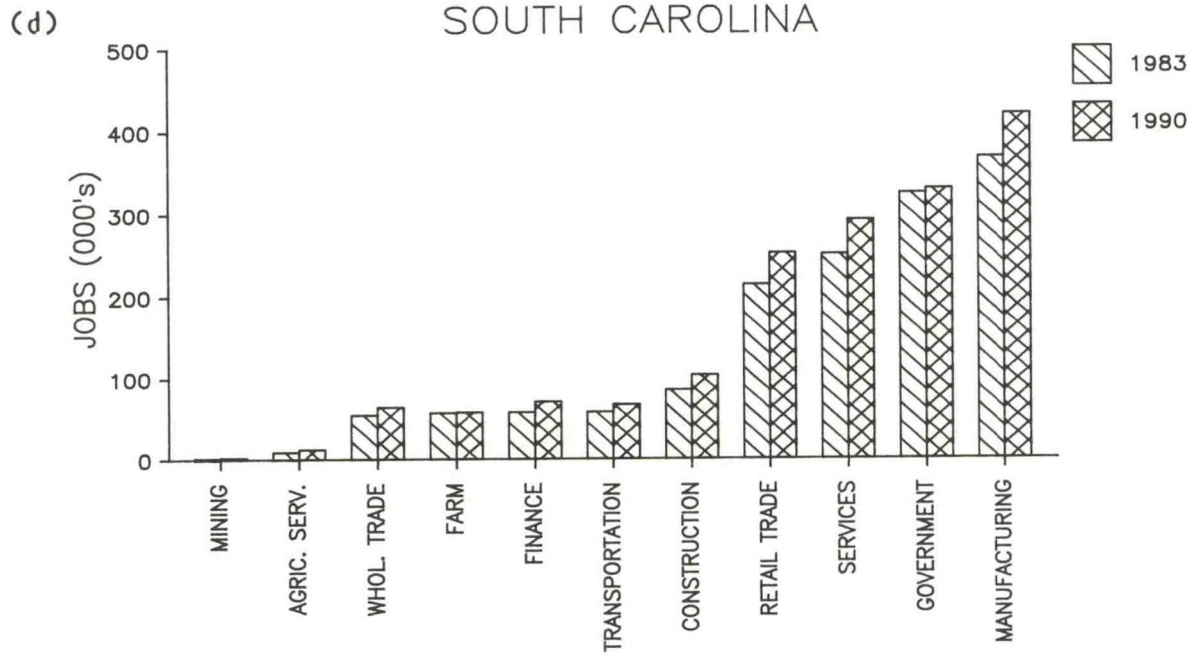


Figure 1.2 (c-d) Distribution of jobs in 1983 ranked by numbers and projections for 1990 for (c) North Carolina and (d) South Carolina. Data from U.S. Department of Commerce.

In all of the Southeast States the job distribution graphs show that the top four sectors of employment are manufacturing, government, retail trade, and services, but in each state the rank of these four sectors is different. Retail trade and services are the two areas of employment which would show the greatest impact from recreational expansion. In Florida these two sectors accounted for about 45 percent of the employment in 1983. In North Carolina and South Carolina manufacturing is the leading sector of employment followed by government. In Georgia government is the leading employer. The significance of government as an employer (at all jurisdictional levels) is the degree of job and income stability it affords, which,it is believed, increases recreational demand. A large component of the government sector is Federal employment with both civilian and military installations located in the Southeast. All of the four leading employment sectors in the Southeast indicate a workforce with a strong demand for leisure-recreational facilities. The four leading sectors in 1983, with some changes in rank, are projected to dominate the employment in 1990.

Impacts of coastal development

Recreation and leisure activities strongly influence the economies of the states of the Southeast and must be considered major determinants in regional development. Direct impacts of these activities include expenditures for recreational fishing and boating, for wildlife observation and hunting, for cruises, and other tourism. Indirect impacts will be found in increased residential construction, transportation of goods, and demand for services to support this coastal development. Industrial, business, and agricultural development frequently follow this type of demand. For example, as food demands of the coastal zone increase, local truck farming usually develops to support these needs. Clearly, coastal zone development has significant effects on the entire structure of the regional economy.

While there are many positive benefits from development, there may be negative impacts as well. Most of these involve the fragile coastal environment which has attracted the tourism and recreating. Uncontrolled development may destroy the natural beauty and resources that draw people to coastal areas. A host of environmental problems may be created by exploitation of beach and dune areas, land clearing, building, industrial use, and agriculture. Other problems may manifest themselves as new residents experience the natural shore ecosystem. Mosquitos and other insects along beaches frequently prompt calls for ways to control them, including pesticide applications. As development spreads along the rivers and estuaries in the coastal zone, multiple use conflicts grow larger and the potential for pollution increases. For example, such a series of events have taken place in the Albemarle and Pamlico estuaries of North Carolina but the entire Southeast Coastal region is facing similar problems.

Population growth in coastal areas increases environmental problems. There are approximately 1,400 industrial, public, and private waste water treatment plants impacting the coastal zone of the Southeast, of which 210 are major plants with flows of a million gallons a day or more. In 1985, of the 2,417,500 acres of productive estuarine shellfish beds in the Southeast, 488,800 were closed to fishing and 26,000 were conditionally approved due to coliform bacteria levels in the water. By this measure of water quality, over 21 percent of the shellfish beds in the region are showing the negative impacts of pollution.

Weather and oceanographic events in 1986 tended to support further coastal development. The impacts of the major weather event of 1986, the Southeastern drought, were minor in coastal areas with the exception of South Carolina. Coastal storms in December (one on December 1 and a second and more severe one which began on December 31) caused substantial beach erosion in South Carolina and property damage of about $16 million. Tropical cyclone activity in 1986 produced only one hurricane, Charley, which was of minimal strength. None of these events were significant enough to alter the underlying trend in the Southeast coastal zone toward development.

2. HIGHLIGHTS - ENVIRONMENTAL EVENTS AND IMPACTS

Weather and climate

- The Southeast experienced the worst drought since precipitation records began in 1876. The drought was the most intense over the drainage area of the Southeast Coast during the spring months of April and May. Although heavy rains came in August, the dryness resumed in September. Coastal areas did not experience drought to the same degree as inland areas.

- Frigid arctic air pushed into the upper Mississippi Valley in late January and moved into the Gulf of Mexico and through most of Florida. Temperatures below freezing were recorded along the Atlantic Coast of Florida. Because of daytime warming, crops suffered little damage.

- Hurricane Charley made landfall in the Southeast Region in mid-August. It had minimal strength and was the only tropical cyclone to be classified a hurricane during the season. The storm crossed the Outer Banks of North Carolina on August 17. While Charley carried beneficial rains to some areas, wind damage and flooding resulted in property and crop loss damage of about $15 million and the storm was responsible for five deaths.

- Beginning on the night of December 31, a coastal storm combined with a peculiar tide-enhancing alignment of sun, moon, and earth caused severe damage to South Carolina beaches and property. Property damage alone was estimated at $13 million.

Oceanography and hydrology

- Lessened streamflow and runoff due to drought conditions resulted in positive salinity anomalies at National Ocean Service stations from Myrtle Beach, SC, to Mayport, FL. The highest anomalies were that of 11.5 parts per thousand at Mayport in October and 9.6 parts per thousand at Charleston, SC, in August.

Fisheries and biological resources

- Total landings of finfish and shellfish in the Southeastern States totaled 248.6 million pounds and were worth $154.7 million. This was about 62 million pounds lower than in 1985. A large part of the drop in landings was due to decreased catch of menhaden. National Marine Fisheries Service scientists had predicted that the menhaden fishery could not sustain the record landings of 1983 and 1984.

- A major disease problem has been occurring in estuarine finfish species of the Southeast Region over the last several years. The disease is manifested primarily in skin lesions which are heavily colonized by fungal mycelia. Extremely high incidences of this disease are being found in the mouth of the St. Johns River in Florida, and in the Pamlico River in North Carolina.

Table 2.1 Environmental impact summary, Southeast Region, 1986.

EVENT	ECOSYSTEM						COASTAL ZONE USAGE			ECONOMY	
	WATER QUALITY	FISH	SHELLFISH	MARINE WILDLIFE	HABITAT/WETLANDS	SHORELINE EROSION	TRANSPORTATION	RECREATION	TOURISM/TRAVEL	BUSINESS INCOME	JOBS
DROUGHT OF SPRING AND SUMMER	−	⊖	−	⊖	−			−	−	−	−
RECORD LOW STREAM FLOWS IN SOME RIVERS	−	⊖		⊖	−			−	−	−	−
HIGH SALINITIES IN PAMLICO SOUND IN APRIL AND MAY 1985 AND 1986			−								
OIL SPILL IN SAVANNAH RIVER	−	−	−	−	−		⊖	−	−		
ACID RAIN EPISODES AT PORT OF JACKSONVILLE	−	⊖	⊖	⊖	⊖		−			−	−
ULCERATIVE MYCOSIS DISEASE		−								⊖	⊖
ALGAL BLOOMS IN LAKE OKEECHOBEE	−	⊖		⊖	⊖						
HURRICANE CHARLEY						−		−			
DECEMBER 31 STORM				⊖		−					

KEY

+	FAVORABLE
−	UNFAVORABLE
⊕	POTENTIALLY FAVORABLE
⊖	POTENTIALLY UNFAVORABLE
	NO IDENTIFIABLE EFFECT, DATA UNAVAILABLE, OR NOT APPLICABLE

- Extensive blooms of blue-green algae occurred in Lake Okeechobee, FL, covering more than 100 square miles of the lake. Highest concentrations were reported from August 11-15 along marshes in the northwest part of the lake. Although algal blooms are a seasonal occurrence in this and other subtropical lakes in Florida during the summer, these high concentrations over such a large area have caused concern over potential impacts of deterioration in water quality in Lake Okeechobee.

Recreation

- Leading indicators of recreational activity for the Southeast were up for 1986 pointing to a continued trend toward recreational expansion in the region. Attendance at selected national park locations rose 20 percent over 1985. State park visits rose in Florida, Georgia, and North Carolina, but in South Carolina they declined due to the negative impacts of the drought. Boating registration in the region rose 9 percent in 1986, or about three times the national average.

- The recreational cruise business continued its growth in Florida in 1986. Cruise passengers carried from Port of Miami, the number one cruise port in the world, grew 6 percent from 1985 while both Port Everglades and Port Canaveral enjoyed sharp increases in their cruise growth, each carrying over a half million passengers in 1986.

Transportation

- Imports to South Atlantic ports in 1986 rose over those in 1985 while exports declined. This reflects a larger national pattern of trade evident since the 1980's began.

- Savannah has become the fastest-growing port in the Southeast with 6.8 million tons of cargo crossing its docks in 1986--an 11.5 percent increase in total tonnage over 1985.

Pollution

- A major oil spill occurred in the Savannah River in early December. Over 500,000 gallons of diesel oil leaked from the tanker Amazon Venture. Marsh grass, wildlife, fish, and other marine resources suffered negative impacts from the spill which carried into the Savannah National Wildlife Refuge.

- At the Port of Jacksonville, FL, on August 8, the paint on 2,000 automobiles was pocked and scarred after an acid rain shower. This was the worst of 11 acid rain showers recorded in 1986 and dissolved the paint on some cars down to the metal.

3. WEATHER

3.1 Introduction

The weather over the Southeastern U.S. is influenced by the position of a large subtropical high-pressure cell, the Bermuda High, in the warmer seasons and the position of the polar front in the colder seasons. In the winter months of December, January, and February the Bermuda High is quite distinct as the subtropical high-pressure center is much reduced in size and centered about five degrees of latitude farther south. In this season the upper part of the southern U.S. has frequent incursions of cold air caused by the southward movement of the polar front. Frequent frontal passages, in the 3 1/2- or 7-day cycle, occur. Also, due to the land-water temperature contrast, low-pressure areas frequently form on cold fronts off the North Carolina coast. These bring colder temperatures, precipitation, winds, and waves to the coastal areas. Florida as far south as Miami frequently is affected by this colder air. Overall, the winter season along the coast is relatively shorter and milder than the winter inland.

With the advent of spring, the Bermuda high-pressure circulation moves northwestward bringing warm, moist air to the Southeast. In summer the high becomes centered over the Florida Atlantic Coast and draws warmer, more moist Gulf of Mexico air into the region. After May precipitation becomes more showery and less steady than it was in winter. In central to southern Florida the pattern is different. Winter is dry, and a rainy season extends from May through October. Along the entire coast, summers are long, quite hot, and humid except in the immediate coastal areas where the sea breeze keeps the temperatures about $3^{o}F$ cooler than 50 miles inland. An important feature of summer and early fall is the North Atlantic hurricane. These storms form in the tropical waters of the Atlantic or Caribbean and track west and northwest toward the northeast coastal areas. Hurricanes affect large areas with heavy rain, high winds, and wind-driven waves. Flooding, wind damage, and beach erosion occur. The other severe storm that occurs in the Southeast is the tornado. These may occur from spring through fall, are relatively small in size, but can do enormous damage. The damages from tornadoes and severe thunderstorms made up a sizable part of the damage figures for the Southeast U.S. in 1986 (Table 3.1). In fall, the high-pressure cell shifts to a position over the continent. This is frequently the most pleasant time of year with mild temperatures and little precipitation. This subtropical center of high pressure then retreats to a mid-Atlantic position near the Tropic of Cancer in the winter.

There are basically two climatic regimes in the Southeast. The northern section, which includes southern Virginia, the Carolinas, and Georgia is a modified temperate region. From the Georgia-Florida border southward the climate is subtropical, with

Table 3.1 Summary of major weather events and impacts, Southeast U.S., 1986. Includes storms which resulted in coastal damage, losses over $0.5 million, and fatalities. Extracted from Storm Data, National Climatic Data Center, NOAA.

Date	Storm Event (Location)	Impact Description	Loss Estimates (in millions of dollars) NA = not available
January 11	Winter storm (NC, SC, GA, FL)	Beach erosion from waves exceeding 6 ft	NA
January 23-25	Winter storm (NC)	Beach erosion from waves of nearly 9 ft	NA
February 25	Cold front (NC)	Generated 7 ft waves along NC Outer Banks	NA
March 10	Thunderstorm (FL)	A 50-ton gantry crane was moved off its track in Monroe County; a man was injured when lightning struck his umbrella in Dade County; winds overturned 8 railroad box cars	
March 14	Tornadoes, thunderstorm, lightning (FL)	Damage to powerlines, residential and industrial buildings, barns, cars, equipment, and trees	$ 2.5
April 7-8	Hail, tornado (GA)	Damage to apartments, a manufacturing plant, mobile homes, and farm buildings	$ 0.5
May 1-31	Drought (NC)	Wildfires burned 70,000 acres in southeast coastal North Carolina	
May 1-31	Drought (SC-statewide)	Crop damage	$ 5.0
May 8	Lightning (Volusia Co., FL)	A man was killed while poling a boat	
May 21	Thunderstorm, winds, hail (NC)	Damage to property and crops	$ 1.0
May 29-30	Hail, thunderstorm, winds (Southeastern NC)	Hail damage to crops; one man injured by lightning; property damage	$ 4.5
June 1-30	Drought (NC, SC)	Wells and ponds were drying up, and streams were very low in NC; in SC crops were suffering extensively, wells were failing, streams and reservoirs were much lower than normal resulting in reduced hydroelectric power generation	NA (NC) $ 5.0 (SC)
June 1-3	Hail, thunderstorm winds, lightning (NC, SC, GA, FL coastal counties)	Hail damage to crops in NC and NC, wind damage to trees, power lines, barns, cars in SC, GA, and FL; resturant burned after lightning strike in NC	$ 1.0
June 2	Heat (SC)	Man died from heat stress in Charleston	
June 7	Tropical Storm Andrew (NC)	Drowning in heavy surf on NC beach	
June 8	Thunderstorm, winds, lightning (NC,SC)	Wind damage to trees, roofs, and cars in NC; lightning ignited building in Beaufort, SC	$ 0.5
June 12	Lightning (Broward Co., FL)	Man killed while walking on beach	
June 16	Thunderstorm, winds (Orange Co., FL)	Wind damage to property	$ 0.5
June 17	Lightning (Orange Co., FL)	Boy killed while walking across soccer field	$ 0.5

Table 3.1 (continued). Summary of major weather events and impacts, Southeast U.S., 1986.

Date	Storm Event (Location)	Impact Description	Loss Estimates (in millions of dollars) NA = not available
June 21	Waterspout/tornado (Monroe Co., FL)	Tornado that began as a waterspout damaged trailers and downed trees and power lines on Plantation Key	$ 0.5
June 22	12-ft. Ocean wave (Oregon Inlet, NC)	The ocean wave destroyed a 40-ft. fishing boat and injured 1 of 2 people aboard	$ 0.5
June 22	High tides and ocean waves (Hilton Head Is., SC)	Springtide accompanied by onshore winds caused beach erosion, mostly at Hilton Head Island	
June 24	Lightning (Palm Beach Co., FL)	Man killed by lightning while working in nursery	
July 1-31	Drought and heat (NC-statewide)	Wells, ponds, and streams dried up; water levels in some rivers and large lakes several feet below normal; heat blamed in part for seven deaths	$ 400
July 1-31	Drought and heat (SC-statewide)	The most severe drought in South Carolina's history heavily damaged agriculture and resulted in record low stream levels in western SC; average monthly temperatures were the highest since the beginning of records	$ 500 (Cumulative effects)
July 2	Strong tornado (Onslow Co., NC)	A strong tornado touched down in a trailer park at Jacksonville, NC killing 3 people and injuring 10 others, destroying 10 mobile homes and damaging 20 others	$ 0.5
July 5	Heavy thunderstorm, rain and lightning (Beaufort Co., Hilton Head Island, SC)	Urban flooding at South Forest Beach; Lightning struck a large home on Hilton Head Island	$ 0.5
July 10	Thunderstorm, winds (Charleston and Horry Co's., SC)	Trees downed in the Charleston area; roof blown off house in North Myrtle Beach	$ 0.5
July 10	Heat (Charleston, SC) (Maximum temperatures reached or exceeded 100° F for 11 days total in July at Charleston)	Woman died from heat stress	
July 12	Lightning (Beaufort Co., NC)	Boy killed by lightning strike while getting out of a boat after water-skiing	
July 13	Heat (Horry Co., SC)	Man died from heat stress in Myrtle Beach	
July 15	Thunderstorm, winds, lightning (4 counties in NC)	Trees and powerlines down, homes and vehicles damaged, 3 persons injured from wind effects; 2 hangars and several aircraft damaged at Wilmington airport; numerous lightning-caused structure fires	$ 0.5
July 18	Heat (Berkeley Co., SC)	Woman died of heat stress	
July 19	Thunderstorm, winds, hail, waterspout (areas surrounding Albermarle Sound)	Damage to roofs, farm property and to crops from wind and 3/4" to 1 3/4" hail	$ 0.5

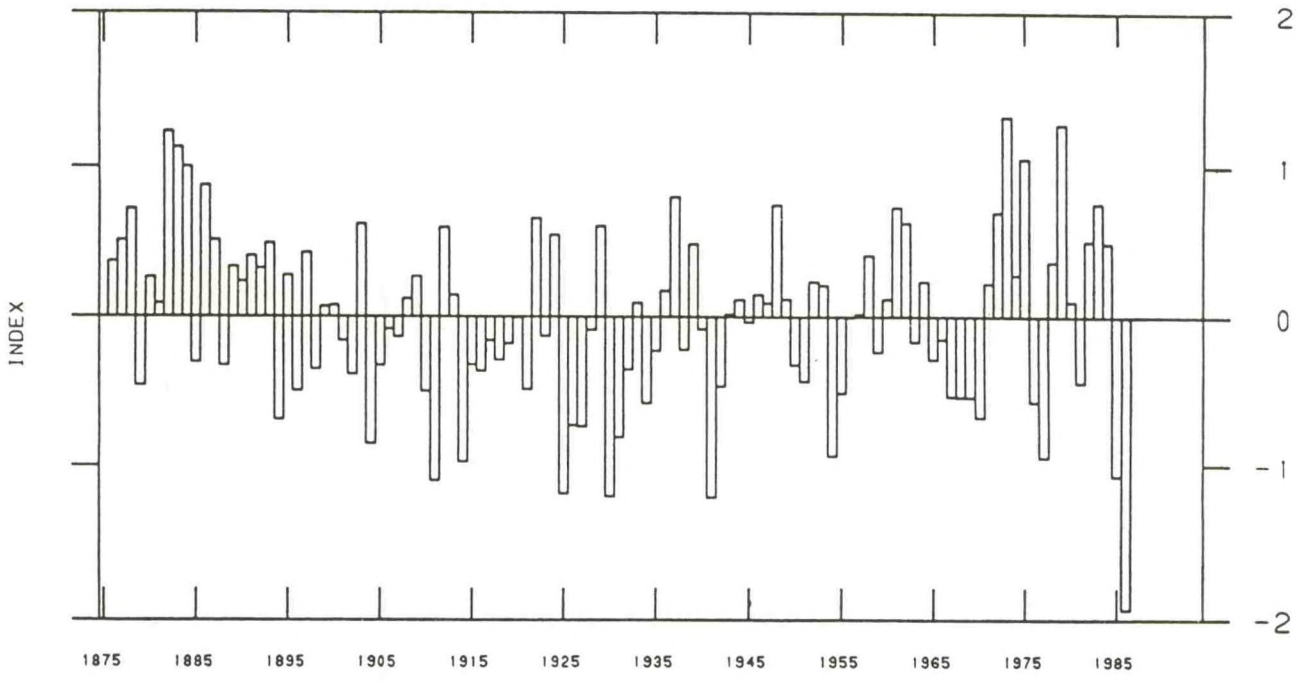
Table 3.1 (continued). Summary of major weather events and impacts, Southeast U.S., 1986.

Date	Storm Event (Location)	Impact Description	Loss Estimates (in millions of dollars) NA = not available
July 20	Heat (Charleston, SC)	Man died of heat stress	
July 21	Thunderstorm winds, hail, lightning (Coastal Co.'s SC)	Wind upset boat drowning a person at Myrtle Beach; wind upset a construction trailer injuring the man inside in Charleston; winds broke utility poles and blew over a 100 ft. tower west of Myrtle Beach; lightning strike at a power substation near Myrtle Beach caused power outages for nearly 20,000 people	$ 0.5
July 23	Heat (Beaufort Co., SC)	Approximately 400 fish killed by heat and low water levels around Hilton Head Island	
July 30	Lightning (Volusia Co., FL)	Boy killed by lightning while water skiing	
July 31	Lightning (Chatham Co., GA)	Women killed by lightning which struck and burned her mobile home	
August 17	Hurricane Charley: Heavy rain, strong winds, and storm tide (Coastal Zone, NC)	Woman was killed at Nags Head when her car was swept off the road and into a canal; property damages from wind and crop damage from flooding	$ 3.0 (NC) $15.0 (overall)
August 17-18	Heavy rain and flash flooding (along Santee-Cooper watershed, SC)	21 people in Santee-Cooper watershed drowned as a result of flash flooding in western SC	
August 28	Lightning (Palm Beach Co., FL)	Man killed by lightning while standing under a tree	
September (1-30)	Drought, heat (NC)	Hot, dry weather returned after a very wet August; cumulative drought effects continue where subsoil moisture not replenished	
September (1-30)	Drought (SC)	Much below-normal rainfall plus record high temperatures intensified drought conditions which had not recovered during the wet month of August	
October 8	Heavy rains, flash flooding, lightning (Myrtle Beach, SC)	Flash flooding (7.82 inches of rain) in a 6-12 hr. period produced the worst flooding since Hurricane Gloria; flooding along Highway 17	$ 0.5
November 14	Cold weather (NC, SC, GA)	Sharp drop in temperatures from 18°F above normal to 18°F below normal in some areas	
November 27	Warm weather (FL)	Record warm temperature in southern Florida	
December 1	Coastal storm (SC, GA, FL)	Beach erosion from strong wave action	
December 23-24	Coastal storm (GA)	Beach erosion	
December 31	Tornado (Palm Beach Co., FL)	Tornado south of Ft. Pierce, FL	
December 31 - January 1, 1987	Strong coastal storm with heavy rain strong, onshore winds, springtide (NC, SC, GA, FL)	Extensive beach erosion from wind-waves and storm augmented tides; erosion of 30 to 40 ft. of beach along parts of SC; extensive damage to homes, swimming pools, roads, powerlines, and other facilities	$13.0 (SC) NA (NC, GA,) FL)

Jacksonville, FL about the northern limit of the easterly tradewinds.

In 1986 the main weather event in the Southeast was the drought in spring and summer, primarily in the Carolinas and Georgia. The 1986 drought is believed to be the worst in the region in 111 years. A precipitation index developed by the NOAA Climate Analysis Center shows the January-June period in 1986 was the driest since 1875, the beginning of the period of record. (Figure 3.1). Other major weather events in the Southeast in 1986 were numerous damaging thunderstorms throughout the area,

Figure 3.1 Precipitation index for 22 selected weather stations in the Southeast Region, January - June, 1875-1986 (bars that extend above the zero line indicate wetter-than-average years; bars extending below zero indicate relatively dry years). Data from Climate Analysis Center, National Weather Service.



Hurricane Charley in August, and a strong coastal storm at the end of December in North Carolina and South Carolina.

Figure 3.2 shows the selected weather stations for which

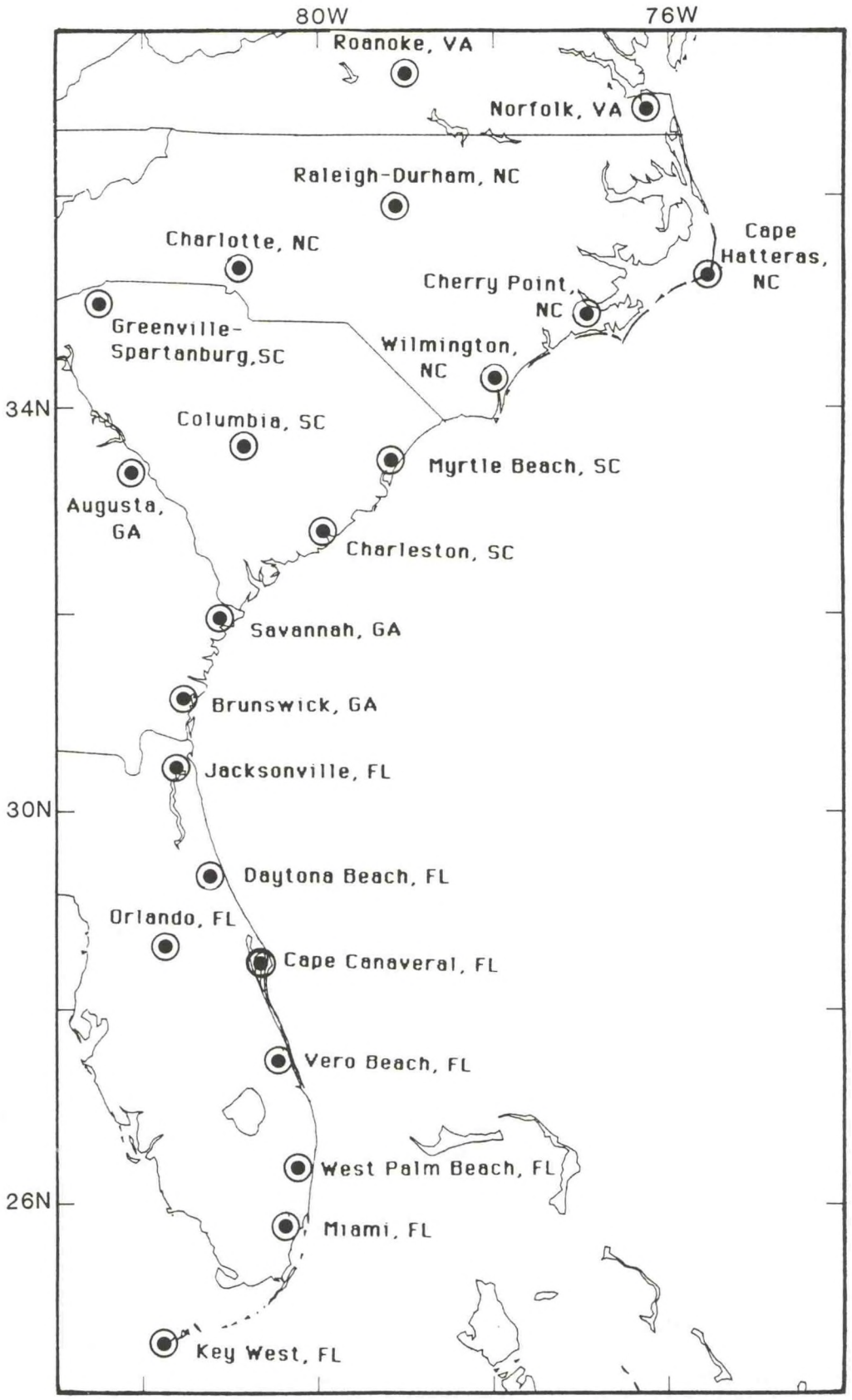


Figure 3.2 Selected meteorological stations, Southeast Region.

temperature and precipitation data have been tabulated. Figure 3.3 shows monthly precipitation at four selected stations along the Southeast Coast.

3.2 Summary of Major Weather Events

The drought began in December and January and intensified through the first five months of the year, attaining its maximum strength in May. Though heavy rains came during August, especially in the interior of South Carolina, the dryness resumed in September. Even during the final months of the year some areas continued to get less-than-normal rainfall. Hot weather accompanied the lack of rain much of the summer, exhausting what little moisture was available through evaporation. Table 3.2 gives (a) normal monthly precipitation and (b) departures from normal for 1986.

The drought conditions are reflected in Table 3.2 (b) which indicates many of the precipitation departures from normal were negative. Exceptions to these negative values are the greater than 200 percent values along coastal Florida in January and the 459 percent positive departure value for Miami in March.

Wilmington, NC, had positive or near-zero values for May through August, contrary to almost all of the rest of the North Carolina-through-Georgia region. Wilmington's coastal location coupled with a number of strong thunderstorms during the drought period explain this situation.

In August, the greater than 100 percent values over the Carolinas and the Georgia coasts were due to Hurricane Charley. The greater than 100 percent values in Florida (528 percent for Key West, FL)in December were due to cold fronts near the end of the year.

Tropical storm Andrew threatened the coast in June, but its track ran nearly parallel to the coast from 250 miles east of Miami to 70 miles east of Cape Hatteras. One drowning in heavy undertow was attributed to this storm. Hurricane Charley affected the area in August. The storm crossed the Outer Banks of North Carolina on August 17 with minimal hurricane strength. Copious rainfall, at the time beneficial, was produced. However, over the entire area of its impact Charley caused about $15 million in damages and five deaths with $3 million of damages and one death occurring in North Carolina.

Several tornadoes and thunderstorms caused greater than $1 million in damages to property on May 14 in Florida, on May 21 in North Carolina, and on June 1-3 in the Carolinas, Georgia, and coastal Florida.

At the end of the year (December 31, 1986 - January 1, 1987) a strong storm affected the entire coastal area, but particularly

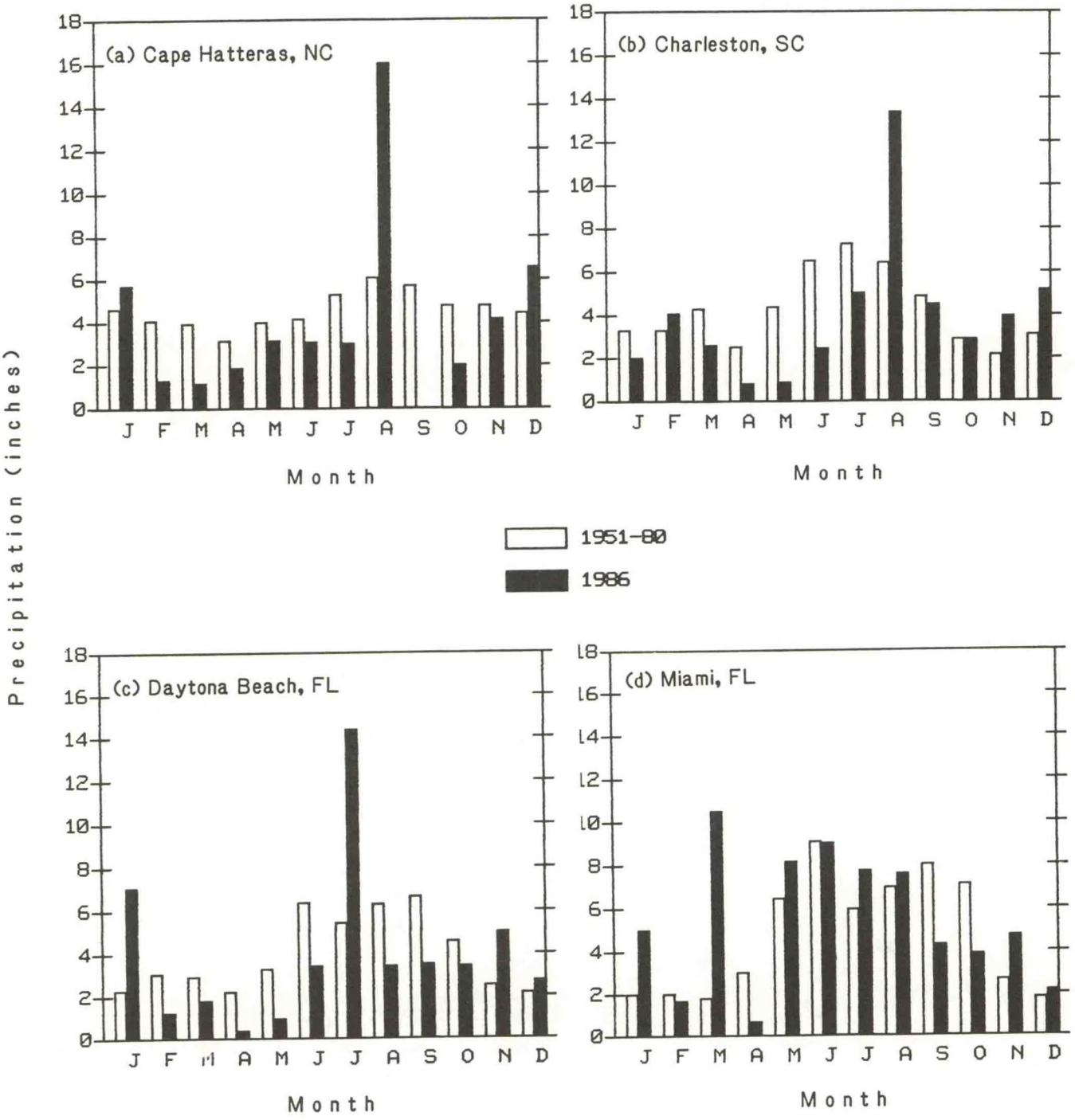


Figure 3.3 Monthly precipitation at four stations along the Southeast Coast. Normal (1951-1980) is shown by plain bars and 1986 by solid bars. The null amount shown for September 1986 at Cape Hatteras was actually 0.08". Data from National Climatic Data Center.

Table 3.2 (a-b) (a) Normal monthly precipitation and (b) 1986 departures from normal for selected stations in the Southeast. Data from National Climatic Data Center.

(a) Normal monthly precipitation, inches

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Norfolk, VA	3.72	3.28	3.86	2.87	3.75	3.45	5.15	5.33	4.35	3.41	2.88	3.17	45.22
Roanoke, VA	2.83	3.19	3.69	3.09	3.51	3.34	3.45	3.91	3.14	3.48	2.59	2.93	39.15
Raleigh-Durham, NC	3.55	3.43	3.69	2.91	3.67	3.66	4.38	4.44	3.29	2.73	2.87	3.14	41.76
Cape Hatteras, NC	4.72	4.11	3.97	3.21	4.09	4.22	5.36	6.11	5.78	4.83	4.84	4.48	55.72
Cherry Point, NC	4.07	3.98	3.66	2.94	4.33	4.85	6.66	6.26	5.51	3.58	3.24	3.83	52.89
Charlotte, NC	3.80	3.81	4.83	3.27	3.64	3.57	3.92	3.75	3.59	2.72	2.86	3.40	43.16
Wilmington, NC	3.64	3.44	4.04	2.98	4.22	5.65	7.44	6.64	5.71	2.97	3.19	3.43	53.35
Myrtle Beach, SC	3.76	3.53	4.27	2.96	4.59	5.62	6.15	5.69	5.76	3.08	2.41	3.27	51.09
Columbia, SC	4.38	3.99	5.16	3.59	3.85	4.45	5.35	5.56	4.23	2.55	2.51	3.50	49.12
Greenville-Spartanbg, SC	4.21	4.39	5.87	4.35	4.22	4.77	4.08	3.66	4.35	3.49	3.21	3.93	50.53
Charleston, SC	3.33	3.37	4.38	2.58	4.41	6.54	7.33	6.50	4.94	2.92	2.18	3.11	51.59
Savannah, GA	3.09	3.17	3.83	3.16	4.62	5.69	7.37	6.65	5.19	2.27	1.89	2.77	49.70
Augusta, GA	3.99	4.04	4.92	3.31	3.73	3.88	4.40	3.98	3.53	2.02	2.07	3.20	43.07
Brunswick, GA	3.08	3.48	3.68	2.80	3.92	5.74	6.16	6.42	7.60	3.29	2.26	2.70	51.13
Jacksonville, FL	3.07	3.48	3.72	3.32	4.91	5.37	6.54	7.15	7.26	3.41	1.94	2.59	52.76
Daytona Beach, FL	2.37	3.11	2.99	2.25	3.38	6.41	5.52	6.34	6.68	4.62	2.59	2.20	48.46
Orlando, FL	2.10	2.83	3.20	2.19	3.96	7.39	7.78	6.32	5.62	2.82	1.78	1.83	47.82
Cape Canaveral, FL	2.20	3.09	3.30	2.16	4.06	6.93	8.40	7.77	8.36	5.45	2.73	2.24	56.69
Vero Beach, FL	2.43	2.86	3.05	2.59	4.39	6.52	5.76	5.39	7.96	5.94	2.55	1.97	51.41
West Palm Beach, FL	2.71	2.62	2.69	3.21	6.02	7.92	6.06	5.78	9.29	7.77	3.39	2.26	59.72
Miami, FL	2.08	2.05	1.89	3.07	6.53	9.15	5.98	7.02	8.07	7.14	2.71	1.86	57.55
Key West, FL	1.74	1.92	1.31	1.49	3.22	5.04	3.68	4.80	6.50	4.76	3.23	1.73	39.42

(b) Departures from normal of 1986 monthly precipitation totals in percent

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Norfolk, VA	-32	-17	-81	15	-62	-56	-50	-10	-94	-52	-57	18	-41
Roanoke, VA	-67	-11	-63	-46	18	-81	-18	10	-3	-21	45	83	-14
Raleigh-Durham, NC	-32	-52	-17	-65	-19	-50	-3	174	-71	-52	16	-8	-9
Cape Hatteras, NC	22	-66	-69	-40	-22	-25	-42	164	-99	-57	-13	48	-12
Cherry Point, NC	-29	-67	-6	-73	-79	18	-30	183	-96	-70	24	2	-12
Charlotte, NC	-74	-74	-38	-64	-56	-88	-42	45	-77	29	40	-6	-36
Wilmington, NC	-42	-27	2	-84	68	-1	52	72	-88	13	39	83	11
Myrtle Beach, SC	-35	-32	-24	-69	-41	-50	-60	101	-79	45	125	25	-15
Columbia, SC	-76	-63	-38	-90	-71	-80	-77	72	-87	138	190	-27	-28
Greenville-Spartanbg, SC	-74	-67	-55	-74	50	-81	-60	60	-41	75	68	5	-22
Charleston, SC	-38	24	-39	-68	-79	-62	-31	106	-7	1	85	68	-6
Savannah, GA	-34	67	-26	-88	-55	-48	-26	85	-91	-12	133	83	-9
Augusta, GA	-65	-38	-34	-69	-25	-63	42	194	-79	94	161	30	4
Brunswick, GA	-41	51	-83	-93	-89	-79	-90	10	-83	58	74	61	-38
Jacksonville, FL	36	36	46	-72	-57	-53	-50	34	-73	-47	47	80	-16
Daytona Beach, FL	202	-59	-38	-80	-71	-45	161	-45	-46	-25	96	25	-1
Orlando, FL	256	-35	-17	-78	-77	29	-25	-3	-21	92	-10	97	4
Cape Canaveral, FL	231	-33	-54	-78	-57	-67	-41	-46	-76	-74	-95	96	-43
Vero Beach, FL	32	-38	-23	-99	-60	-46	38	-36	-54	58	-24	105	-16
West Palm Beach, FL	134	-40	104	-90	-74	24	68	-16	-56	4	101	347	16
Miami, FL	142	-16	459	-77	26	-1	31	9	-46	-45	75	19	15
Key West, FL	-26	9	2	-38	-72	6	22	18	-25	-50	-72	528	4

impacted South Carolina causing over $13 million in property losses. Heavy rains and strong onshore winds coupled with the very high tide (springtide) were responsible for the damage.

3.3 Weather Elements

Wind, fog, sky cover

Wind speeds, fog days, and sky cover (characterizing each day as clear, partly cloudy, or cloudy) were studied for four locations--Cape Hatteras, NC; Charleston, SC; Daytona Beach, FL; and Miami, FL. In 1986 slightly lighter winds were found for the northern three stations than long-term average wind speeds, and an even mix of higher and lower speeds for Miami.

The number of heavy fog days were less than the long-term averages. However, Charleston had 10 heavy fog days in November, more than twice the normal number.

In general, the number of clear days at the four stations along the Southeast Coast was greater in 1986 than the long-term averages. This was particularly true in April when all of the locations had above-average number of clear days. Both Miami, FL, and Daytona Beach, FL, had a doubling of the number of clear days in the month compared to the averages. Charleston, SC had a 73 percent increase and Cape Hatteras, NC had a 50 percent increase in clear days. April was also the month which was the most deficient in rainfall throughout the region.

Precipitation

The 1986 annual precipitation departures shown in Table 3.2 (b) indicate 11 of the 15 coastal stations had values for the year that ranged from 60 percent of normal to just below normal and the other four had above-normal totals. Five of the seven inland stations showed below-normal precipitation amounts for the year. The first seven months had a preponderance of below-normal precipitation, as did September and some periods in October. In April, May, and June more than half the stations received less than 50 percent of normal precipitation. Figure 3.3 reflects the low values in April, May, and June for four coastal stations.

Although Florida received abundant rainfall in January, stations from Georgia northward had precipitation that ranged from 32 to 76 percent below normal, with the exception of Cape Hatteras which had 120 percent of normal. Rains were greater in the second half of the month in the Carolinas, but in Florida much of the rainfall came early in the month from lows developing in the Gulf of Mexico and moving across the State.

Dry conditions continued through February in the Carolinas and extended into Florida with the exception of the coastal area from Jacksonville, FL north to Charleston, SC. Savannah, GA had

67 percent above-normal precipitation. Rainfall was more evenly distributed during the month than in January. However, in Savannah most of it fell in the first ten days.

March was dry, like the preceding month, except for the southern Florida, Jacksonville, FL, and Wilmington, NC. Miami received heavy rains (greater than 2 inches) on the 10th, 25th, and 30th.

April was extremely dry with 19 stations shown in Table 3.2 having precipitation less than one-half monthly normal and only one station with greater-than-normal rainfall. Some interior stations received less than 10 percent of their normal rainfall. Rains came mostly from thunderstorms. It was the driest April on record in Columbia, SC, and other stations in the central and western part of the State. Stations along coastal Florida recorded some of the lowest rainfall levels in the Southeast.

May was not as dry as April, especially along the northern part of the coast. Wilmington, NC, in fact, had a considerable surplus, having benefitted from the presence of an upper low-pressure center and a stationary front off the coast near the middle of the month. Coastal Florida was nearly as dry as in April, although Miami was slightly above normal.

June's precipitation generally followed the pattern of May, but with more precipitation in Florida. Daytona Beach had considerably more precipitation, and Orlando and West Palm Beach had small surpluses. Coastal South Carolina and Georgia remained dry. Coastal North Carolina continued to get isolated rains. Cherry Point was slightly above normal and Wilmington was near normal. These areas benefitted from the close approach of tropical storm Andrew, which moved roughly parallel to the coast and came within 70 miles of Cape Hatteras on June 8 before moving off to the northeast. Other rainfall came as showers associated with frontal systems.

July was somewhat more varied in its precipitation pattern over the coast than either May or June. While many areas were short of rainfall, others had excesses. Most of Florida had above-normal rainfall occurring at the beginning of the month and again after mid-month. This was especially evident at Daytona Beach, FL, which had over 2 1/2 times its normal amount. Wilmington, NC, and Augusta, GA, had excesses. However, all other stations in North Carolina, South Carolina, and Georgia listed in Table 3.2 (b) had negative departures. Cold-front-induced thunderstorms during the second half of July brought fairly frequent rainfall to the southern coast of North Carolina. Parts of interior North Carolina were near normal for the month. Despite these variations, the drought in July was very evident throughout the region, particularly through central South Carolina. Very high temperatures accompanied the dryness in July making it an oppressive month.

August brought welcome relief to coastal and inland areas north of Florida. Temperatures were also cooler than normal for the first time since January in many areas. Two vigorous cold fronts brought precipitation to much of the drought-stricken area early in the month. These were followed by Hurricane Charley which developed from a low-pressure system that migrated across Georgia from the Gulf of Mexico and subsequently moved north along the coast. Hurricane Charley crossed over Pamlico and Albemarle Sounds August 17th before continuing northeastward across the Atlantic Ocean. Many stations along the coast had more than twice their normal monthly rainfall as a result of the hurricane storm system. Flooding occurred in Charleston and in central South Carolina. Despite this rainfall, many effects of the drought (low soil moisture and water-table levels) would continue for some time.

September marked a return to dry conditions throughout the region. No station showed surplus precipitation, and warmer-than-normal temperatures prevailed, although not as warm as those in June or July. At Wilmington, NC, and Savannah, GA, rainfall for the month was nearly as low as in April.

October amounts were above normal from southern North Carolina through Georgia. Coastal stations tended to receive less than inland stations. This was due to the frontal passages that tended to dissipate as they reached the coastal area. Rainfall reached most of the Southeast from the 7th to the 9th following a vigorous cold front and from the 25th to the 26th from a low-pressure system which moved from the Gulf of Mexico to the Appalachian Mountains.

Precipitation in November was generally above normal over the region. South Carolina and Georgia had abundant amounts in November. Columbia, SC had nearly three times its normal November rainfall, much of it coming after the middle of the month, as frontal systems intensified. Some Florida stations had positive departures in December and others had negative departures.

Rainfall in December was somewhat more evenly distributed throughout the region than in November with above-normal amounts from central South Carolina southward. In Florida, West Palm Beach, and Key West received more than four times and more than six times normal rainfall, respectively. Storms or fronts on the 2nd, 12th, 18th, 23rd, and 31st of December contributed most to the rainfall.

Air temperature

Overall, all the Southeastern States had a warmer-than-normal year, although for Florida the increase was not as great as that for other States. Air temperatures during 1986 averaged from less than 1°F above normal at several stations in coastal Florida to nearly 3°F above normal in Charleston, SC, and

Savannah, GA. Table 3.3 gives the (a) normal monthly mean temperatures and the (b) departures from normal temperatures. In the Carolinas and Georgia all months except January and August were above normal. In January stations throughout the region had below-normal temperatures. The Florida coast had below-normal temperatures in January, March, April, and May. For the entire coastal area of the Southeast, of the cooler months, February and November had the greatest above-average departures. December was well above normal along the Florida coast. For the warmer months, June and July had well above-normal temperatures from northern Florida northward. In July temperatures were close to 6°F above normal at several locations north of Florida, but only about 1°F greater along the Florida coast.

Analysis of the number of days with maximum temperatures above 90°F for four stations (Cape Hatteras, NC; Charleston, SC; Daytona Beach, FL; and Miami, FL) shows that at Charleston there were 83 days in 1986 compared to the long-term average of 49 and at Miami there were 92 compared to the average of 67. At Daytona Beach the increase was from 54 average days to 68 in 1986 and at Cape Hatteras, a cooler location, the increase was from 4 average days to 10 in 1986. This analysis reinforces the observation of hot conditions, particularly in the central Southeastern States.

The number of days with minimum temperatures less than or equal to 32°F was less than normal at these four stations. This was most apparent in February and during the last three months of the year. However, a cold outbreak near the end of January caused daily average temperature on the 28th to drop 22 to 25°F below normal from Wilmington, NC, to Miami, FL. This had some impact on agriculture, but subsequent cold outbreaks in the spring proved even more damaging.

Table 3.3 (a-b) (a) Normal monthly air temperatures and (b) 1986 departures from normal for selected stations in the Southeast. Data from National Climatic Data Center.

(a) Normal monthly mean temperatures, degrees F

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Norfolk, VA	39.9	41.1	48.5	58.2	66.4	74.3	78.4	77.7	72.2	61.3	51.9	43.5	59.5
Roanoke, VA	35.5	37.9	46.1	56.3	64.7	71.6	75.7	74.7	68.2	56.8	46.9	38.3	56.1
Raleigh-Durham, NC	39.6	41.6	49.3	59.5	67.2	73.9	77.7	77.0	71.0	59.7	50.0	42.0	59.0
Cape Hatteras, NC	45.1	45.6	51.1	59.2	66.9	74.0	78.2	78.2	74.2	64.9	56.0	48.7	61.8
Cherry Point, NC	44.8	46.2	52.8	61.7	69.5	75.9	79.4	79.2	74.7	64.8	55.4	47.5	62.7
Charlotte, NC	40.5	42.9	50.4	60.3	68.2	75.0	78.5	77.9	72.0	60.7	50.7	42.6	60.0
Wilmington, NC	45.6	47.4	54.1	63.1	70.7	76.6	80.3	79.7	74.8	64.5	55.4	48.2	63.4
Myrtle Beach, SC	45.3	47.3	54.9	63.6	71.2	77.0	80.4	79.8	74.9	64.4	55.0	47.4	63.4
Columbia, SC	44.7	47.1	54.5	63.8	71.5	77.7	81.0	80.2	74.8	63.4	53.9	46.7	63.3
Greenville-Spartanbg, SC	41.1	43.6	51.0	60.5	68.3	74.8	78.2	77.5	71.7	60.7	50.9	43.4	60.1
Charleston, SC	47.9	49.8	56.7	64.3	72.2	77.6	80.5	80.0	75.7	65.8	56.7	50.0	64.8
Savannah, GA	49.2	51.6	58.4	66.0	73.3	78.6	81.2	80.8	76.6	66.9	57.5	51.0	65.9
Augusta, GA	45.0	47.5	54.8	63.2	71.0	77.4	80.6	79.9	74.6	63.5	53.9	46.9	63.2
Brunswick, GA	51.2	53.0	59.4	67.1	74.2	79.4	81.8	81.3	78.1	69.0	60.0	53.4	67.3
Jacksonville, FL	53.2	55.1	61.3	67.7	74.1	79.0	81.3	81.0	78.2	69.5	60.8	54.8	68.0
Daytona Beach, FL	57.9	58.8	64.1	69.6	75.1	79.2	81.1	80.9	79.5	73.2	65.2	59.5	70.3
Orlando, FL	60.5	61.5	66.8	72.0	77.3	80.9	82.4	82.5	81.1	74.9	67.5	62.0	72.5
Cape Canaveral, FL	60.2	61.0	66.2	71.4	76.2	79.9	81.5	81.5	80.0	74.1	67.0	61.6	71.7
Vero Beach, FL	61.9	62.6	67.2	71.7	76.2	79.4	81.1	81.4	80.2	75.2	68.9	63.4	72.4
West Palm Beach, FL	65.2	65.8	70.1	73.8	77.6	80.4	82.0	82.5	81.4	77.3	71.6	67.0	74.6
Miami, FL	67.1	67.8	71.7	75.3	78.5	81.0	82.4	82.8	81.8	77.9	72.8	68.5	75.6
Key West, FL	68.7	70.1	74.1	77.7	80.6	82.9	84.5	84.3	82.6	80.1	75.5	71.0	77.7

(b) Departures from normal of 1986 monthly mean temperatures in degrees F

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Norfolk, VA	-0.6	0.8	1.4	-0.9	1.1	1.8	3.7	-1.1	0.2	3.8	3.0	1.1	1.2
Roanoke, VA	-0.3	0.2	1.1	2.5	-1.2	2.6	3.1	-2.3	0.7	2.0	0.6	0.2	0.8
Raleigh-Durham, NC	-1.3	2.8	2.5	1.5	0.1	4.4	4.0	-1.4	1.1	3.3	3.1	0.6	1.7
Cape Hatteras, NC	-0.4	3.7	0.7	1.0	1.2	1.9	2.7	-1.2	0.9	3.6	6.8	2.9	2.0
Cherry Point, NC	-1.6	3.8	2.1	1.3	1.6	1.9	4.5	-0.6	2.7	4.2	5.6	1.5	2.2
Charlotte, NC	-2.2	3.7	2.3	3.7	1.2	5.4	6.2	-1.3	1.9	3.2	2.5	0.6	2.3
Wilmington, NC	-1.4	4.2	1.5	1.2	1.2	2.8	3.7	-0.9	1.7	2.8	4.3	1.7	1.9
Myrtle Beach, SC	-0.5	4.7	0.3	1.2	0.6	3.2	5.4	1.2	1.6	3.8	5.8	2.6	2.5
Columbia, SC	-4.1	4.2	0.5	-0.3	0.5	4.2	5.2	-0.5	1.5	1.5	5.5	-0.1	1.5
Greenville-Spartanbg, SC	-1.9	3.9	1.3	1.0	0.4	3.6	4.7	-1.6	1.0	1.0	2.0	-0.8	1.2
Charleston, SC	-2.1	5.7	1.3	1.8	2.1	3.8	5.6	-0.1	2.9	3.0	6.4	2.8	2.8
Savannah, GA	-1.6	5.3	0.7	0.8	1.7	3.9	4.5	0.8	3.1	3.1	7.5	2.9	2.7
Augusta, GA	-2.7	4.8	0.8	-0.1	1.3	4.1	5.4	-0.4	2.9	2.7	6.9	1.3	2.3
Brunswick, GA	-1.6	4.9	0.3	0.0	0.6	2.8	3.7	0.7	2.5	3.5	7.8	2.4	2.3
Jacksonville, FL	-1.7	4.2	-0.6	-1.7	-0.8	2.3	2.5	0.5	1.5	2.5	7.9	2.5	1.6
Daytona Beach, FL	-1.2	3.6	-1.0	-3.3	-1.3	0.7	0.3	0.5	0.1	2.1	7.3	5.2	1.1
Orlando, FL	-1.3	2.5	-1.5	-2.9	-0.7	0.6	-0.2	0.8	0.6	2.5	8.1	5.3	1.1
Cape Canaveral, FL	-1.2	3.2	-2.2	-4.5	-3.0	-1.3	-0.5	-0.5	-0.7	2.2	6.8	5.0	0.3
Vero Beach, FL	-1.1	3.8	-1.5	-3.7	-1.4	0.5	0.2	0.1	0.2	2.0	7.4	5.5	1.0
West Palm Beach, FL	-1.0	3.4	-2.0	-2.2	0.0	0.4	0.1	0.4	1.1	2.1	6.8	5.0	1.2
Miami, FL	-1.9	1.6	-3.1	-3.6	-1.0	0.3	0.7	0.8	1.5	2.4	6.5	5.1	0.8
Key West, FL	-1.1	1.7	-2.7	-3.4	-0.5	0.6	1.0	-0.8	0.9	1.4	5.1	3.8	0.5

4. OCEANOGRAPHY AND HYDROLOGY

4.1 Streamflow

The area of the South Atlantic coastal region from Cape Hatteras, NC, to Cape Canaveral, FL, is marked by both open and semi-enclosed embayments. This physical configuration limits the manner in which streamflow into the various estuaries in the Southeast can be examined as the flows of many rivers are gaged far upstream from the point at which they discharge their flows into the estuaries.

The examination of freshwater flow in coastal areas is important for several reasons. The flow of water affects the water quality of the receiving waters as the amount and concentration of pollutants and sediments depend on the rate and volume of streamflow. Streamflow also affects the temperature and salinity of the receiving waters of the rivers. Pollution, sedimentation, salinity, and water temperature, in turn, affect the plant, wildlife and fish distributions. All these factors should be considered when evaluating the health of estuaries.

Streamflow from the rivers of the Southeastern United States accounts for 35 percent of the total freshwater inflow into the Atlantic Ocean from rivers on the East Coast. Flows from most of the rivers along the Southeastern Coast follow the traditional hydrologic cycle having maximum flows between February and April and minimum flows between September and November. The temporal patterns of the flows of the rivers in Florida, however, differ from the flows for the northern rivers, as the Florida rivers have maximum flows in the summer and fall and minimum flows in the spring. The long-term mean monthly flows for the major rivers of the Southeast and the flows for 1986 grouped by state are depicted in Figure 4.1. The major rivers for which gage data were used are shown in Figure 4.2.

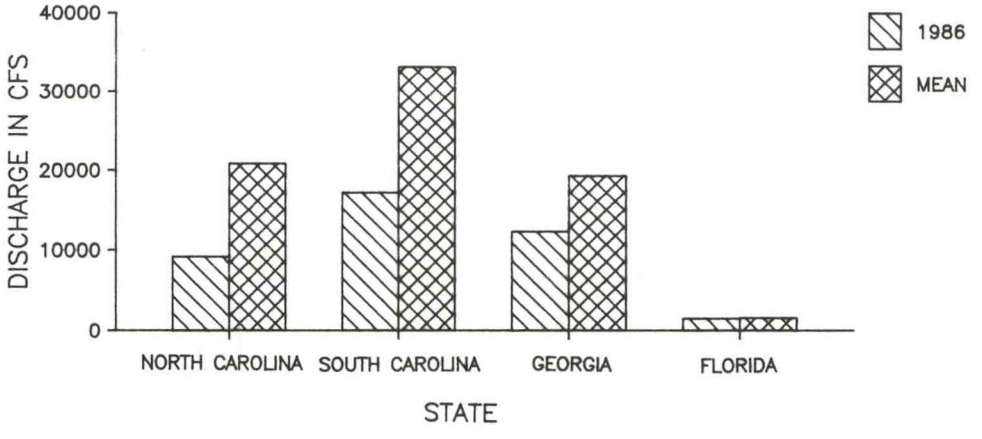


Figure 4.1 Southeast streamflow by state, 1986 and long-term mean. Data from U.S. Geological Survey.

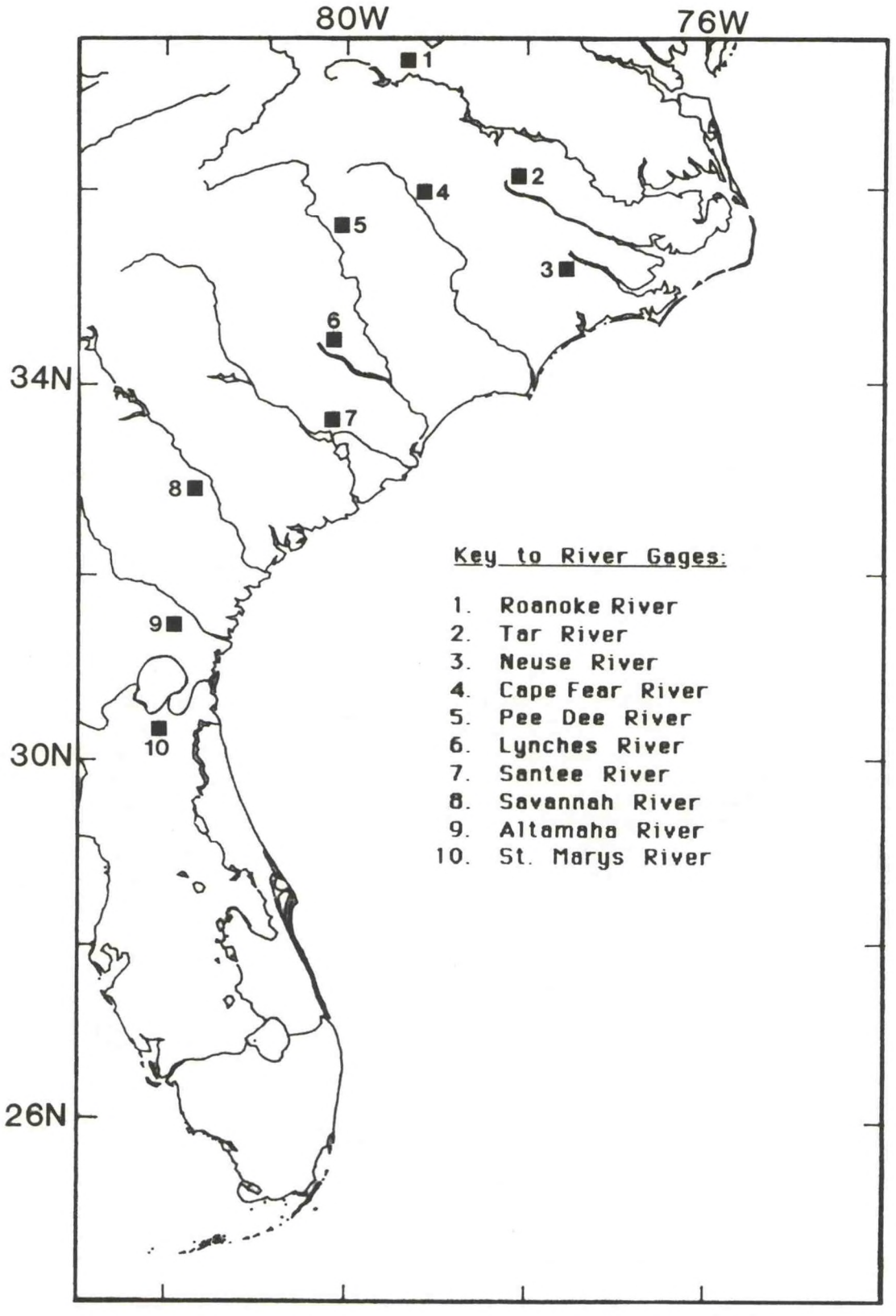


Figure 4.2 Streamflow gages on major Southeast rivers. Minor rivers and streams not included. Map generated from data from the Central Intelligence Agency.

The drought in 1986 depressed streamflows of almost all the rivers in the Southeast. With the exception of the St. Mary's River in Florida, all the rivers investigated had mean annual flows below normal with most rivers experiencing the period of maximum flows during the normal period about February and March, but having minimum flows from May through July.

The effects of the drought on streamflow appeared to decrease south from North Carolina to Florida. Flow in North Carolina was 45 percent of normal in 1986; flow in South Carolina was 52 percent of normal; flow in Georgia was 65 percent of normal; and flow in Florida, although also below normal, was 95 percent of normal.

Figure 4.3 (a-j) shows the 1986 data plotted against the mean for the rivers examined.

Roanoke River

The Roanoke River is monitored at Roanoke Rapids, NC. Monthly flows were below normal for all of 1986. Flow in December was nearest to normal at 93 percent. Total flow for the year was 55 percent of normal.

Tar River

The Tar River, monitored at Tarboro, NC, had monthly flow patterns for the first seven months of 1986 that were similar to the long-term average. Well-above normal precipitation in the drainage basin was probably the reason the flow in August was 185 percent of normal, and well-below normal rainfall in September and October dropped flow rates below normal for these months. Flow for the year was 45 percent of normal.

Neuse River

The Neuse River is monitored at Kinston, NC. Streamflow in 1986 followed the normal pattern, but at rates that were well-below normal. Flow was below normal for all months except August, when above-normal precipitation raised streamflow to 102 percent of normal. Flow for the year was 37 percent of normal.

Cape Fear River

The Cape Fear gaging station at Lock 1 near Kelly, NC, measured streamflow that was below normal for each month in 1986. Although the Cape Fear experienced its normal maximum in March, flow was depressed to 50 percent of normal. A secondary maximum on August can probably be attributed to precipitation levels that were well-above normal for the month. Streamflow for 1986 was 35 percent of normal.

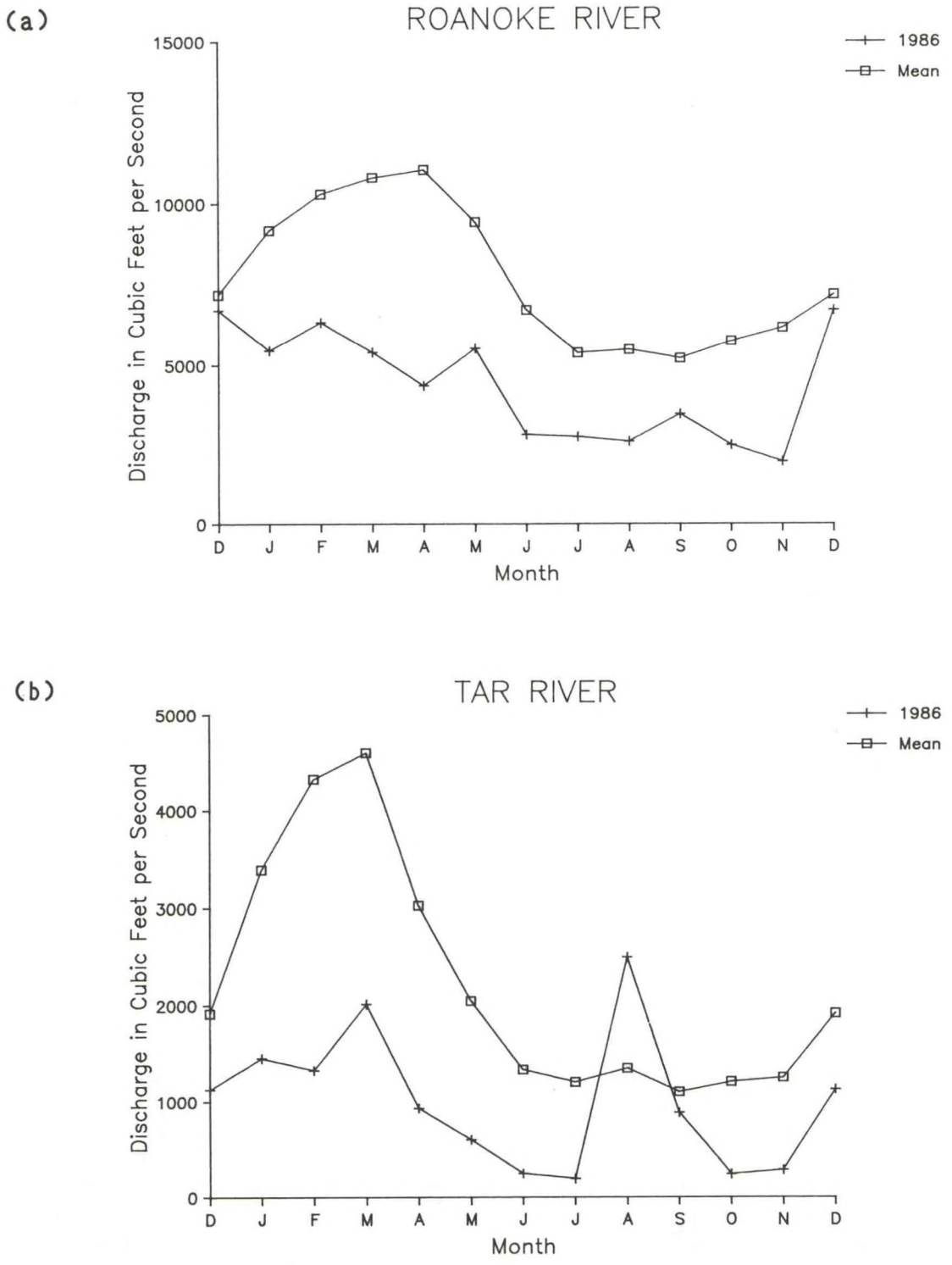
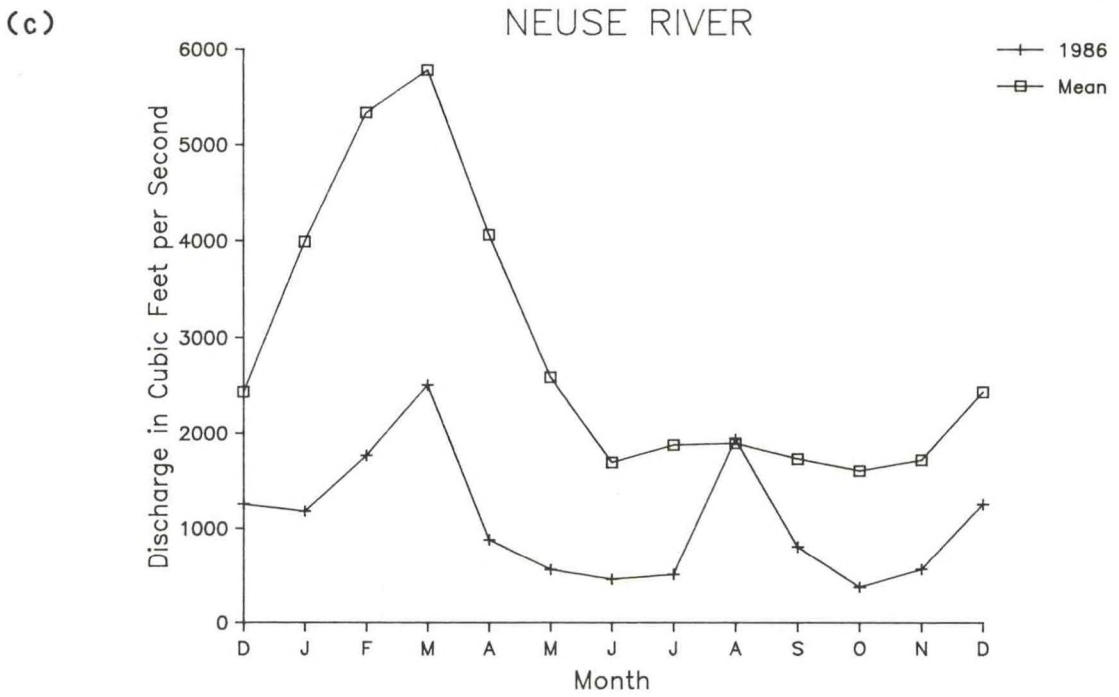


Figure 4.3 (a-b) Monthly streamflow from (a) Roanoke River and (b) Tar River during 1986 and the long-term average. Data from the U.S. Geological Survey.



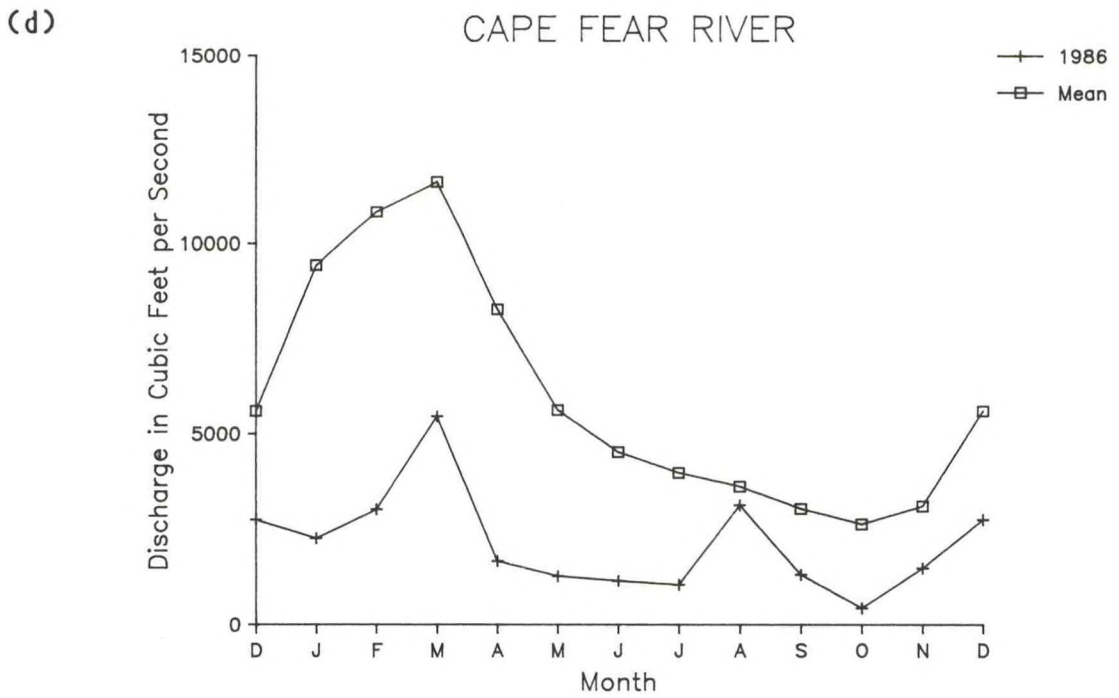
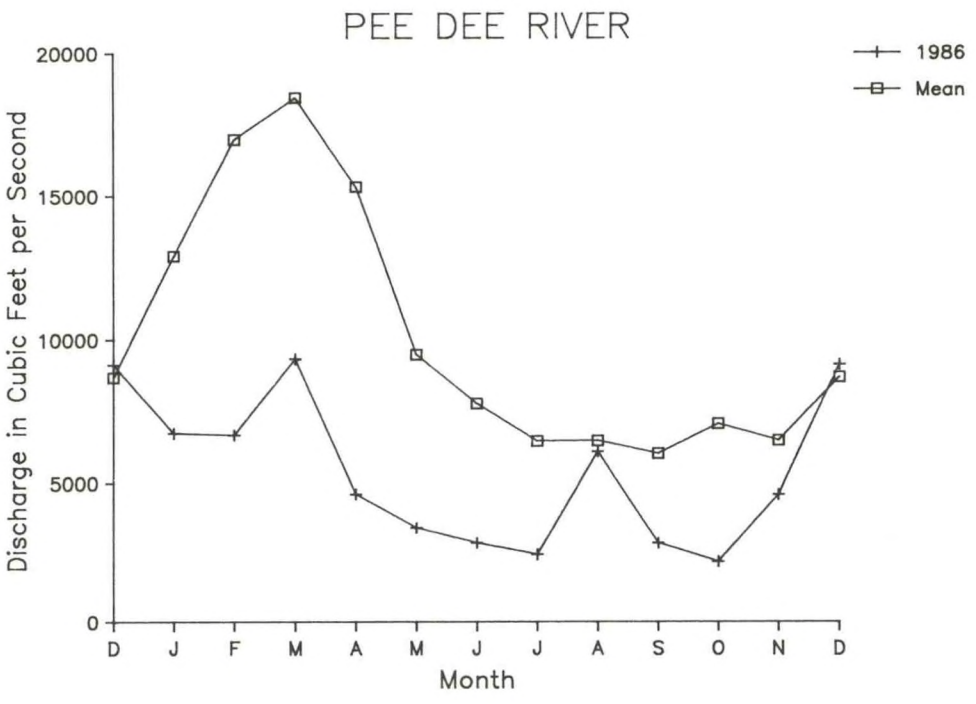


Figure 4.3 (c-d) Monthly streamflow from (c) Neuse River and (d) Cape Fear River during 1986 and the long-term average. Data from the U.S. Geological Survey.

(e)



(f)

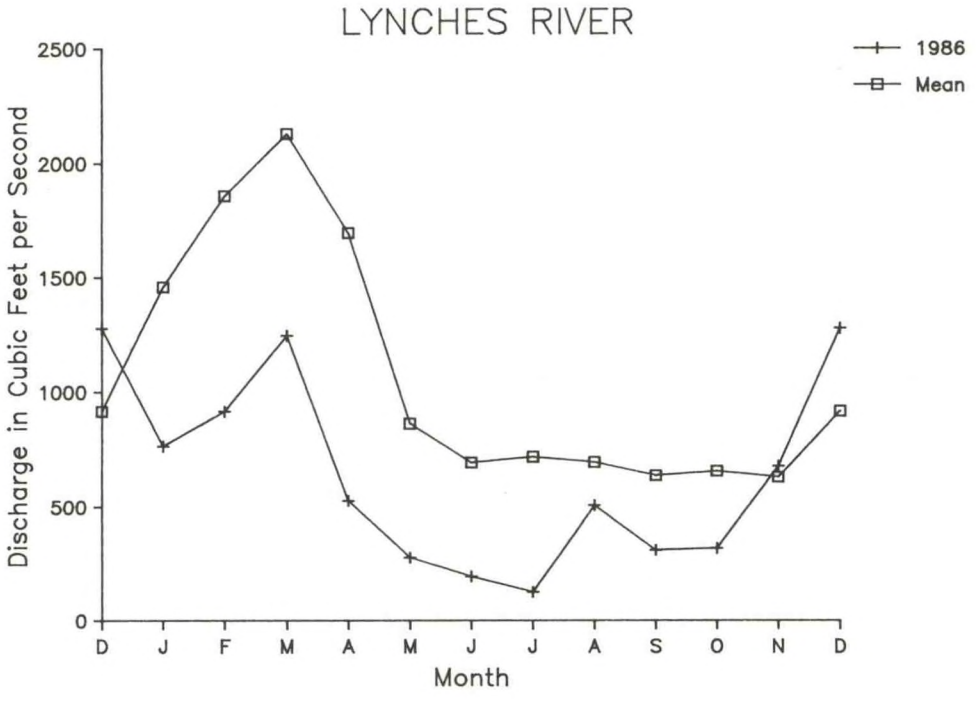
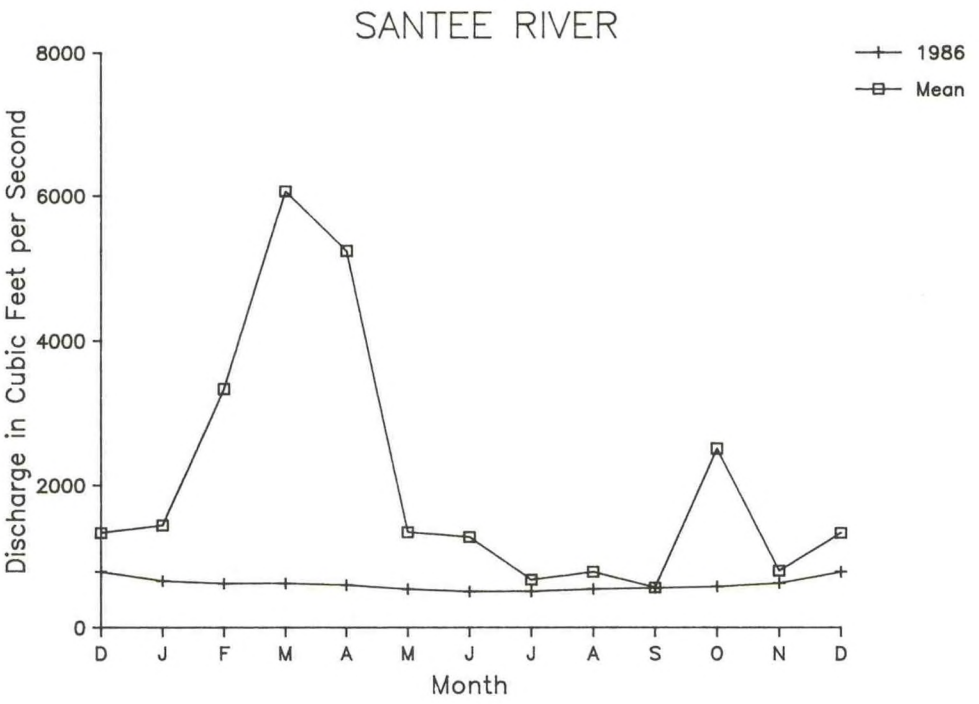


Figure 4.3 (e-f) Monthly streamflow from (e) Pee Dee River and (f) Lynches River during 1986 and the long-term average. Data from the U.S. Geological Survey.

(g)



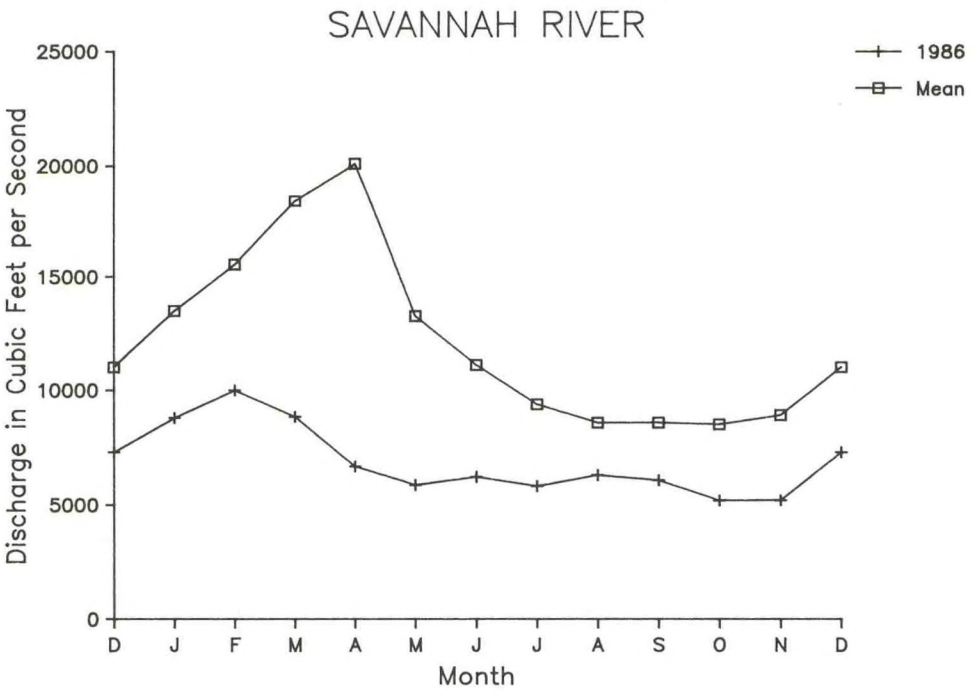
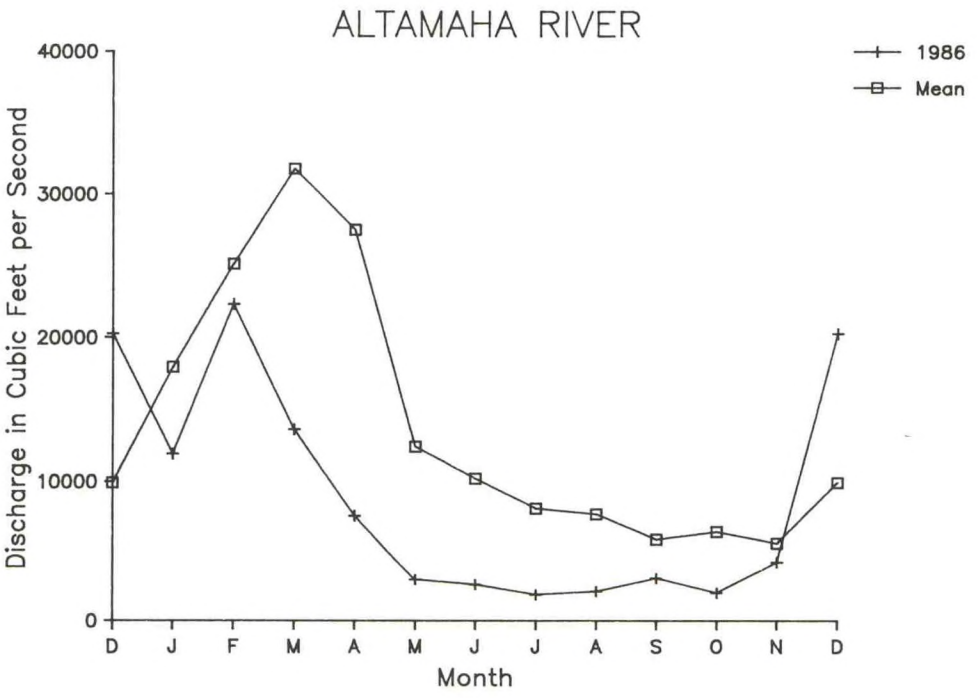


Figure 4.3 (g-h) Monthly streamflow from (g) Santee River and (h) Savannah River during 1986 and the long-term average. Data from the U.S. Geological Survey.

(i)



(j)

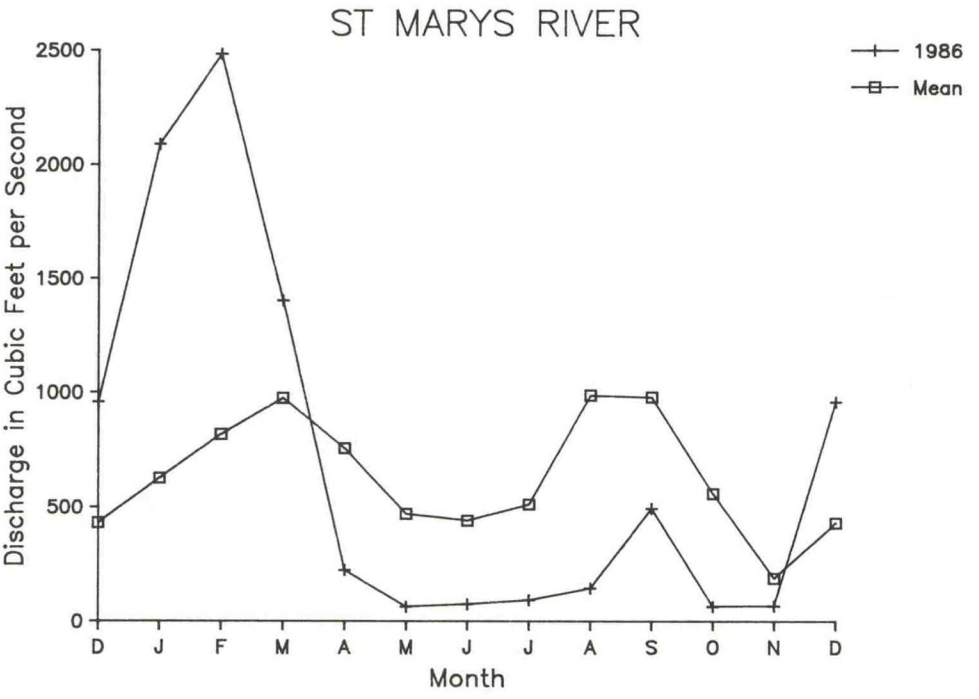


Figure 4.3 (i-j) Monthly streamflow from (i) Altamaha River and (j) St. Marys River during 1986 and the long-term average. Data from the U.S. Geological Survey.

Pee Dee River

The gaging station at Galivant's Ferry, SC, is the monitoring site for the Pee Dee River. The Pee Dee River had flows below normal all of 1986, except December. August streamflow was almost normal and was probably augmented by above-average precipitation in the drainage basin. Flow for the year was 50 percent of normal.

Lynches River

The Lynches River, monitored at Effingham, SC, had streamflow below normal for the first ten months of 1986. Streamflow was just above normal in November and was 140 percent of normal in December. The Lynches River had streamflow that was 55 percent of normal for the year.

Santee River

The Santee River, monitored near Pinesville, SC had below-normal flows throughout 1986. September was the only month for which streamflow was not greatly depressed, as flow was 99 percent of normal. Flow for the year was 30 percent of normal.

Since the monitoring gage on the Santee River is upstream from the junction of the influx of the Cooper River Rediversion Project, a project that diverts 80 percent of the flow of the Cooper River into the Santee, the data collected by the gage possibly do not reflect the actual streamflow conditions coastward that could dramatically influence the marine resources.

Savannah River

The Savannah River, monitored near Clyo, GA, had flows below normal for the entire year, with flows for all months less than 75 percent of normal. Flow for 1986 was 55 percent of normal.

Altamaha River

Streamflow for the Altamaha River, monitored at Doctortown, GA, was below normal for all months in 1986, except December, when streamflow was 205 percent of normal. The maximum that normally occurs in March, occurred in February in 1986. Flow for the year was 55 percent of normal.

St. Marys River

The St. Marys River, the only river in the Southeast that was examined that had streamflow above normal in 1986, is monitored near Macclenny, FL. Well-above normal precipitation in Florida in January and December probably elevated flows to above-normal levels. The above-normal flows from January to March and in December brought the annual rate to 105 percent of normal.

4.2 Surface Water Salinity and Temperature

Surface water salinity and temperature were evaluated for selected National Ocean Service (NOS) stations (Figure 4.4). Table 4.1 (a) gives the average monthly salinities (ppt) for these stations and (b) gives the 1986 departures (anomalies). Table 4.2 (a) shows the average monthly surface water temperatures (Deg C) for these stations and (b) shows the 1986 departures (anomalies).

The Myrtle Beach station was replaced by Springmaid Pier and the Miami station by Haulover Pier. The mean data utilized for these new stations were from their old locations as recommended by NOS.

Salinity

Following the description of the long-term seasonal salinity patterns at the selected NOS stations, the monthly mean surface salinity distributions during 1986 will be discussed.

The mean seasonal cycle of salinity for the two southernmost NOS stations, Haulover Pier/Miami and Key West, is one of nearly constant salinity of greater than 36.1 ppt for the entire year. September and October are the only months when the salinity has a negative departure from this value.

The Fernandina Beach and Mayport stations have similar cycles of mean surface water salinity. There is a spring minimum in February or March. A summer yearly maximum occurs in June or July while a secondary minimum occurs in the early fall (October). A fall secondary maximum occurs in December.

Charleston and Fort Pulaski both show similar mean salinity cycles of decreasing salinity during fall and winter to a spring minimum in March or April. Salinities gradually increase to a yearly maximum in October. A fall freshet leading into a wintertime maximum is not observed at these stations. The rivers flowing past these NOS stations are heavily regulated by numerous dams, which could explain the observed seasonal cycle of surface salinity.

The Springmaid Pier/Myrtle Beach NOS location is not near a large freshwater source as are Charleston and Fort Pulaski. This probably accounts for the reduced seasonal salinity variability as compared to these other two NOS locations. The yearly mean salinity is 34.0 ppt, and the maximum mean departure is 1.1 ppt. A spring freshet is observed in March and April and a reduced fall freshet in October.

Large positive salinity anomalies were observed for the five NOS stations from Myrtle Beach to Mayport. The magnitude of the positive anomalies resulted from the large reduction in regional rainfall over the Southeastern United States with the largest

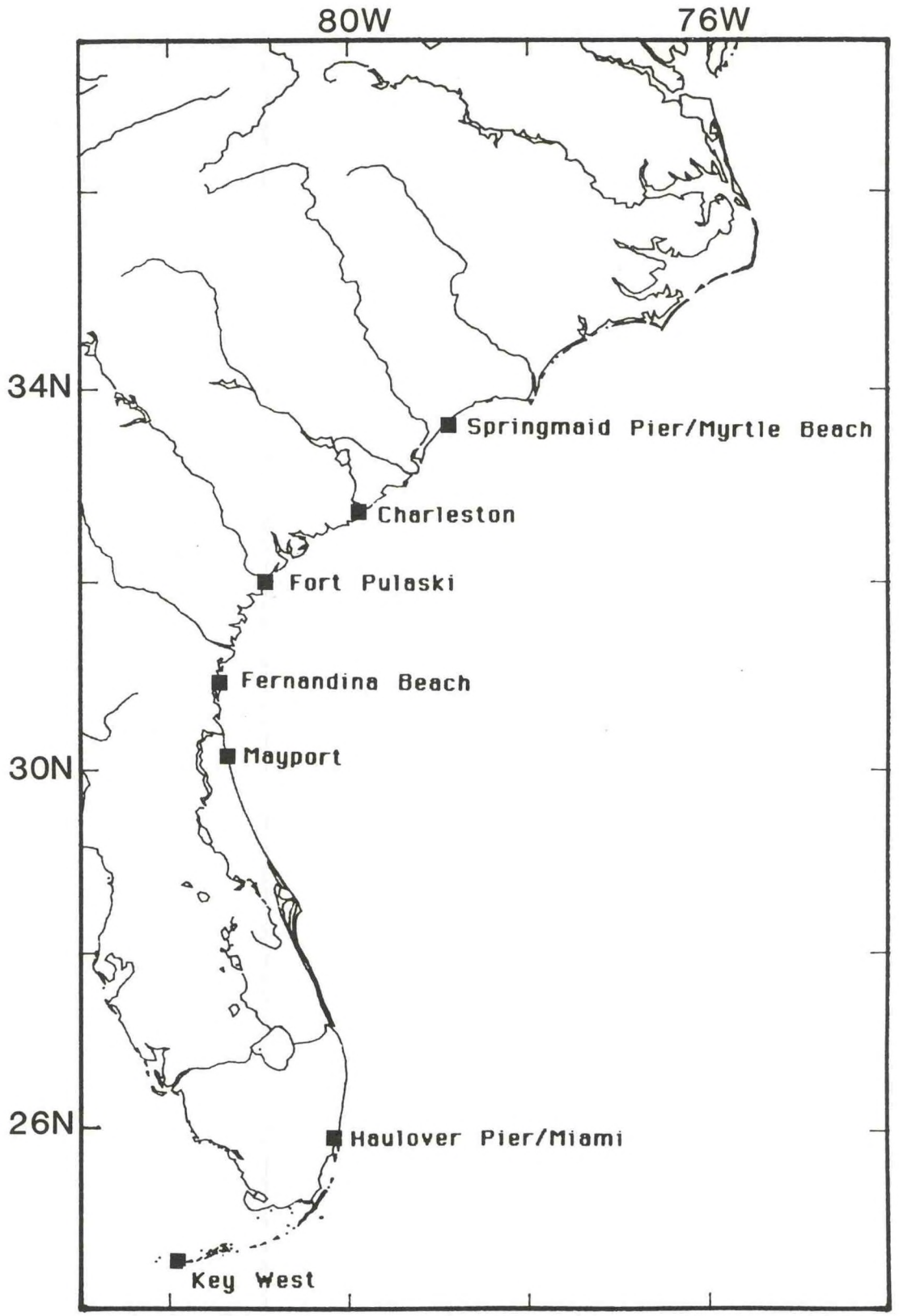


Figure 4.4 Selected National Ocean Service stations which measure sea water temperature and density along the Southeast Coast.

Table 4.1 (a-b) (a) Average monthly salinities (ppt) for selected National Ocean Service stations, Southeast Coast, and (b) 1986 departures (anomalies).

(a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Springmaid Pier\ Myrtle Beach	34.0	33.7	33.1	32.9	33.6	34.1	34.4	34.5	34.8	34.5	34.4	34.2
Charleston	16.6	14.4	12.9	13.2	14.9	15.7	17.1	17.8	18.8	20.3	19.3	17.9
Fort Pulaski	15.7	14.5	12.0	12.0	14.2	16.7	18.0	18.9	18.8	19.6	19.3	17.8
Fernandina Beach	29.3	28.8	28.0	29.0	31.2	32.0	31.9	31.2	29.1	28.0	29.5	30.2
Mayport	23.3	23.0	22.7	25.7	28.5	28.8	25.7	24.6	23.5	21.2	21.3	23.3
Haulover Pier\ Miami	35.8	36.1	36.2	36.4	36.4	36.2	36.2	36.1	35.3	34.9	35.3	35.7
Key West	36.1	36.2	36.4	36.7	37.0	36.6	36.7	36.7	36.2	35.8	36.3	36.2

(b)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Springmaid Pier\ Myrtle Beach	-0.1	0.0	0.9	2.0	1.7	1.2	1.4	1.8	0.7	1.4	1.0	0.5
Charleston	3.3	-	5.1	7.4	8.0	9.0	9.2	9.6	4.2	1.8	3.8	5.0
Fort Pulaski	3.3	3.7	4.7	8.0	6.9	6.9	8.9	6.2	4.3	4.5	4.7	1.5
Fernandina Beach	-2.4	-2.7	-1.5	1.2	2.0	2.9	3.6	4.2	4.7	6.3	4.1	0.4
Mayport	1.1	0.3	-0.0	2.2	4.6	4.9	5.6	6.7	7.3	11.5	9.4	4.7
Haulover Pier\ Miami	-	-	-1.4	-0.9	-0.1	0.3	-	0.7	0.2	-0.2	-0.2	-0.2
Key West	-	-	0.6	0.1	-	0.8	1.0	0.8	0.1	0.6	0.6	0.5

Table 4.2 (a-b) (a) Average monthly surface water temperatures (Deg C) for selected National Ocean Service stations, Southeast Coast, and (b) 1986 departures (anomalies).

(a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Springmaid Pier\ Myrtle Beach	8.8	9.4	12.4	17.2	22.1	26.1	27.9	27.7	26.0	21.5	15.8	10.8
Charleston	10.5	11.0	13.9	18.6	23.2	26.9	28.6	28.6	26.7	22.1	16.7	11.9
Fort Pulaski	10.7	11.6	14.6	19.2	23.6	27.2	28.8	28.8	26.8	22.5	17.2	12.4
Fernandina Beach	13.3	14.0	16.6	20.7	24.6	27.4	28.5	28.5	27.5	23.6	18.9	14.6
Mayport	13.8	14.3	16.7	20.4	24.1	27.0	28.1	27.9	27.5	23.9	19.4	15.4
Haulover Pier\ Miami	21.7	22.1	23.2	25.1	27.1	28.8	30.2	30.3	29.3	27.0	24.4	22.6
Key West	21.7	22.2	23.7	25.8	27.9	29.6	30.4	30.6	29.7	27.6	24.4	22.3

(b)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Springmaid Pier\ Myrtle Beach	0.5	0.3	-0.1	0.1	0.8	0.7	1.7	-0.3	-0.3	0.5	1.6	2.0
Charleston	-2.5	-	1.0	0.6	0.1	-0.5	1.2	1.4	0.5	2.6	3.1	2.6
Fort Pulaski	-0.3	1.0	0.7	0.2	0.3	0.9	1.5	0.6	-2.5	1.8	2.6	2.1
Fernandina Beach	-1.1	0.5	0.2	-0.5	-0.7	0.8	0.6	-0.4	0.2	1.1	2.5	1.4
Mayport	-0.0	1.6	0.6	0.2	-0.1	1.6	1.0	-1.2	1.0	2.1	3.2	1.8
Haulover Pier\ Miami	-	-	0.0	-1.4	-1.4	-0.4	-	-0.5	0.5	1.2	2.2	2.1
Key West	0.5	-	-0.2	-1.4	-	0.4	0.2	-0.3	0.3	1.5	3.3	2.5

departures at Charleston Harbor probably caused by decreased water flow into the Cooper River and Charleston Harbor as a result of the Cooper River rediversion project. Heavy rains in August resulted in reductions in surface salinity anomalies in either August or September. A further increase in salinity anomaly was again recorded through October or November when a reduction in surface values was observed. This reduction generally brought the anomaly values to their lowest value since early winter and followed the pattern of generally increasing rainfall in excess of normal for the Southeastern United States. It appears that the return of excess rainfall (August and October through December) does not result in quick reductions in salinity. A delayed response of several months before salinities are reduced is evident.

The salinities at the two southern NOS stations were nearly normal throughout the year, with salinity anomalies generally less than $\pm$ 1 ppt. There does not appear to be a direct relationship between rainfall anomaly and salinity anomaly for the southernmost stations, i.e., Haulover Pier/Miami and Key West. This could be the result of the dominating influence of oceanic (Loop/Florida Current) processes across the narrow shelf on the local runoff at these coastal stations.

Temperature

The study region for this report extends over 11^{o} of latitude from the tropical Florida Keys - Miami area to the temperate Cape Hatteras area of North Carolina. Winter thermal differences of approximately 10^{o}C or greater exist between the northern and southern stations, while approximately 5^{o}C or greater summertime gradients are observed.

The seasonal pattern seen in Figure 4.5 begins with the winter minimum temperatures occurring in January. With increasing solar insolation, warming begins in February and quickly accelerates in April and May. The temperatures increase more slowly during June and July, reaching the yearly maxima in July or August. Cooling begins in September and accelerates during October and November. In December, the cooling slows, and the temperatures approaches the yearly minima. The winter minimum temperatures at the northern stations are lower than those measured at the southern sites due to three main factors, (1) solar insolation is significantly higher for the southern sites, (2) cold continental air masses passed more frequently through the northern portion of the study region, and (3) the southern sites are located just inshore of the warm Florida Current, which acts as a heat source. Periodic upwelling events, sometimes with water temperature declines of 5.5^{o}C to 11^{o}C in less than 24 hours, affect the entire coast.

Sea water temperature anomalies for 1986 of greater than $\pm$ 1^{o}C shown in Table 4.2 (b) appear to follow the air temperature anomalies seen in Table 3.4, i.e. increases (decreases) of air

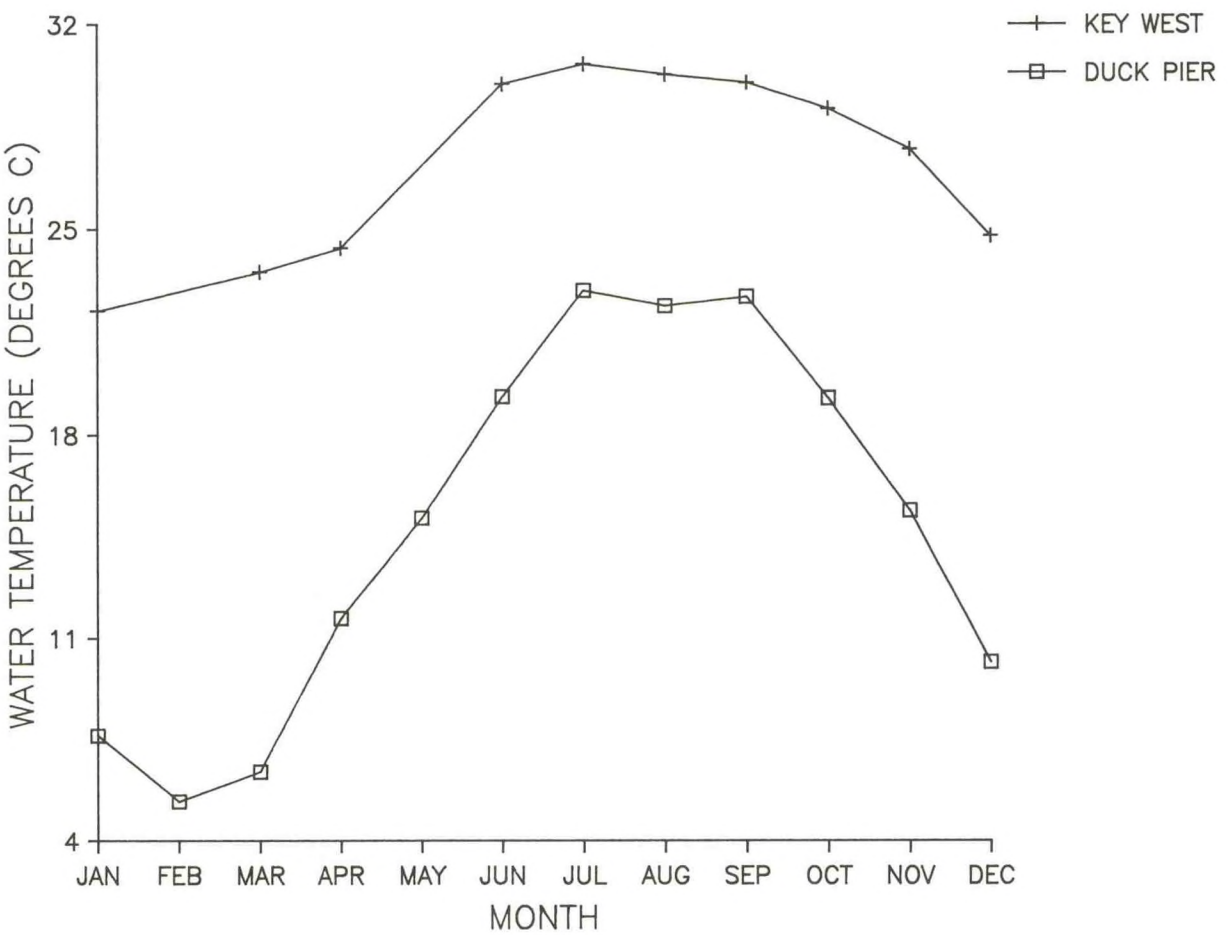


Figure 4.5 Surface water temperature profiles for Key West, FL, and Duck Pier, NC, for 1986.

temperature (2°F <air temperature anomalies> -2°F) result in increases (decreases) of sea surface temperature. There are two instances when this did not occur, Charleston in June and Fort Pulaski in September . The Fort Pulaski data may be accounted for by the extreme precipitation in August in the Savannah River drainage basin resulting in increased runoff and mixing due to turbulence at the data collection site.

4.3 Sea Surface Temperature Analysis

The Atlantic Ocean and Gulf of Mexico 1986 Monthly Mean Sea Surface Temperature (SST) fields of the Oceanographic Monthly Summary were digitized and made into pseudo-color images. The SST fields of the Oceanographic Monthly Summary have a 1°C contour interval and are produced from merging the 1° square monthly mean satellite data and in-situ collected temperature data. The pseudo-color images were mapped into a Mercator projection with a pixel resolution of 10 kilometers, thus fine scale features seen in high resolution satellite data (~1 kilometer/pixel) are not seen in this data due to the 1° square averaging.

The northeast Atlantic and Gulf of Mexico monthly mean SST data and monthly mean wind-induced mass transport vectors are displayed in Figure 4.6 (a-l). The pseudo-color contouring interval is 2°C to allow for the wide range in temperatures. The scale for Figure 4.6 (a-l) is 1/4 inch equals 4 cubic meters/sec per meter. Only the Southeast Region monthly mean SST field will be discussed at this time. Discussion of the wind-induced mass transport appears in section 4.4 of this report.

Summary

The isotherms of the Southeast Region generally parallel the coastline orientation most notably from Cape Hatteras to Florida. In southern Florida the narrowness of the shelf and proximity of the Gulf Stream produces near-uniform temperatures across the straits between Florida and the Bahama Banks.

Solar warming during the summer months of July and August produces near-uniform temperature over the entire region and temperature contours perpendicular to the coastline, e.g., classical zonal or latitudinal variation in SST field that is generally observed in the open ocean. Delineation of the Gulf Stream from the SST field becomes difficult during late spring and summer due to low thermal contrast between the coastal and Gulf Stream water temperatures.

The range of SST values within each month for the Southeast Region is generally less than that observed to the north, Mid-Atlantic Bight, while greater than that seen in the Gulf of Mexico.

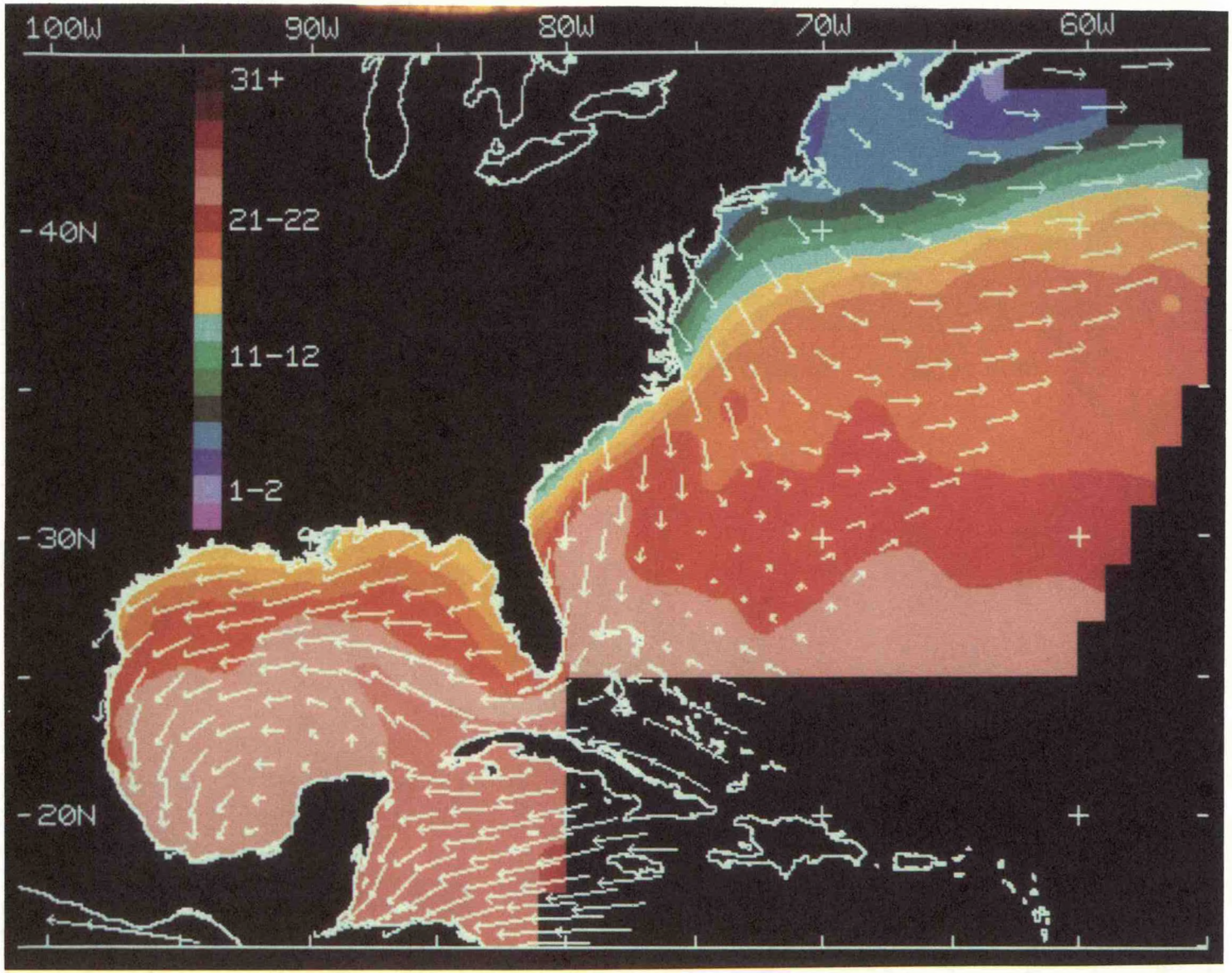


Figure 4.6 (a) January 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

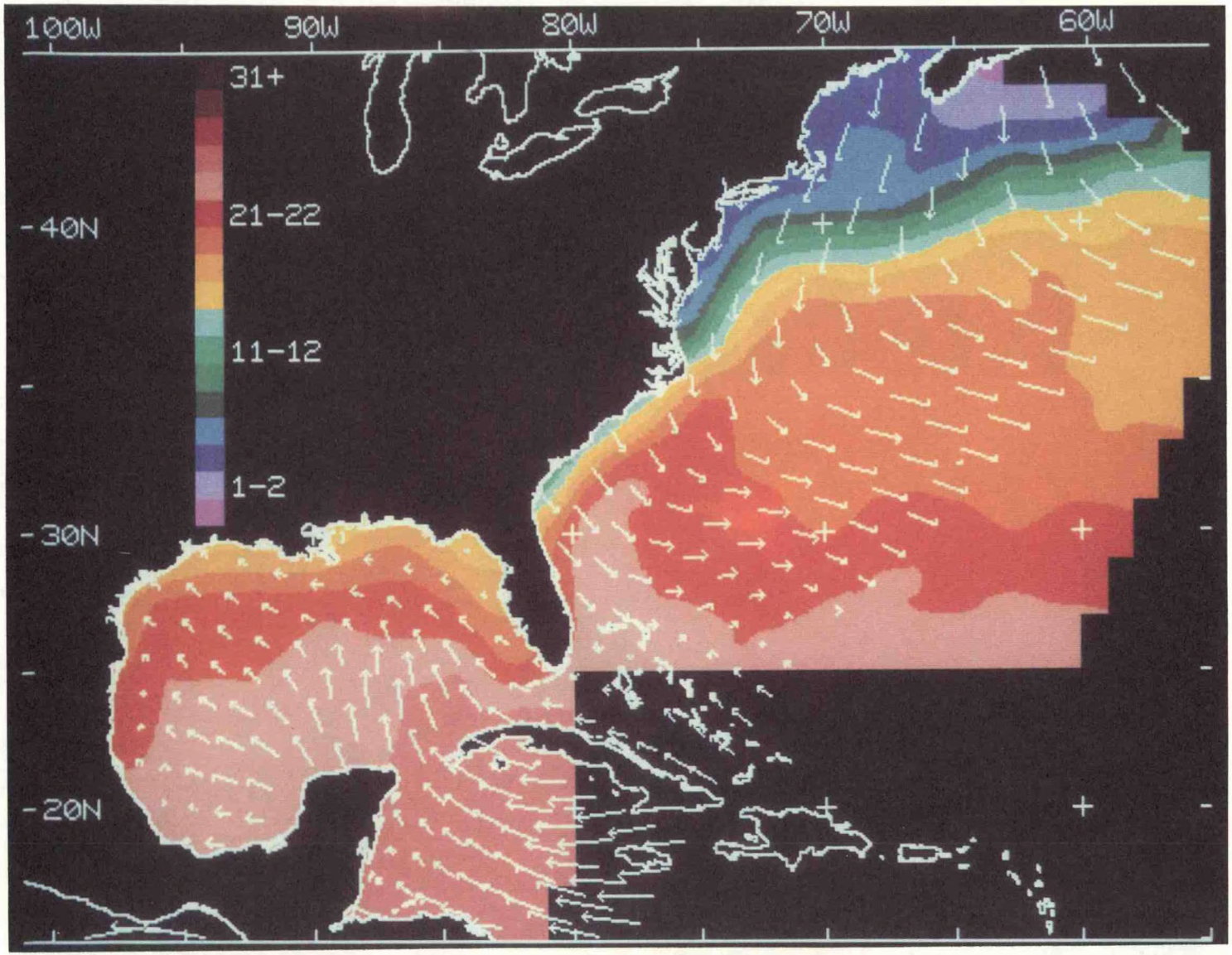


Figure 4.6 (b) February 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

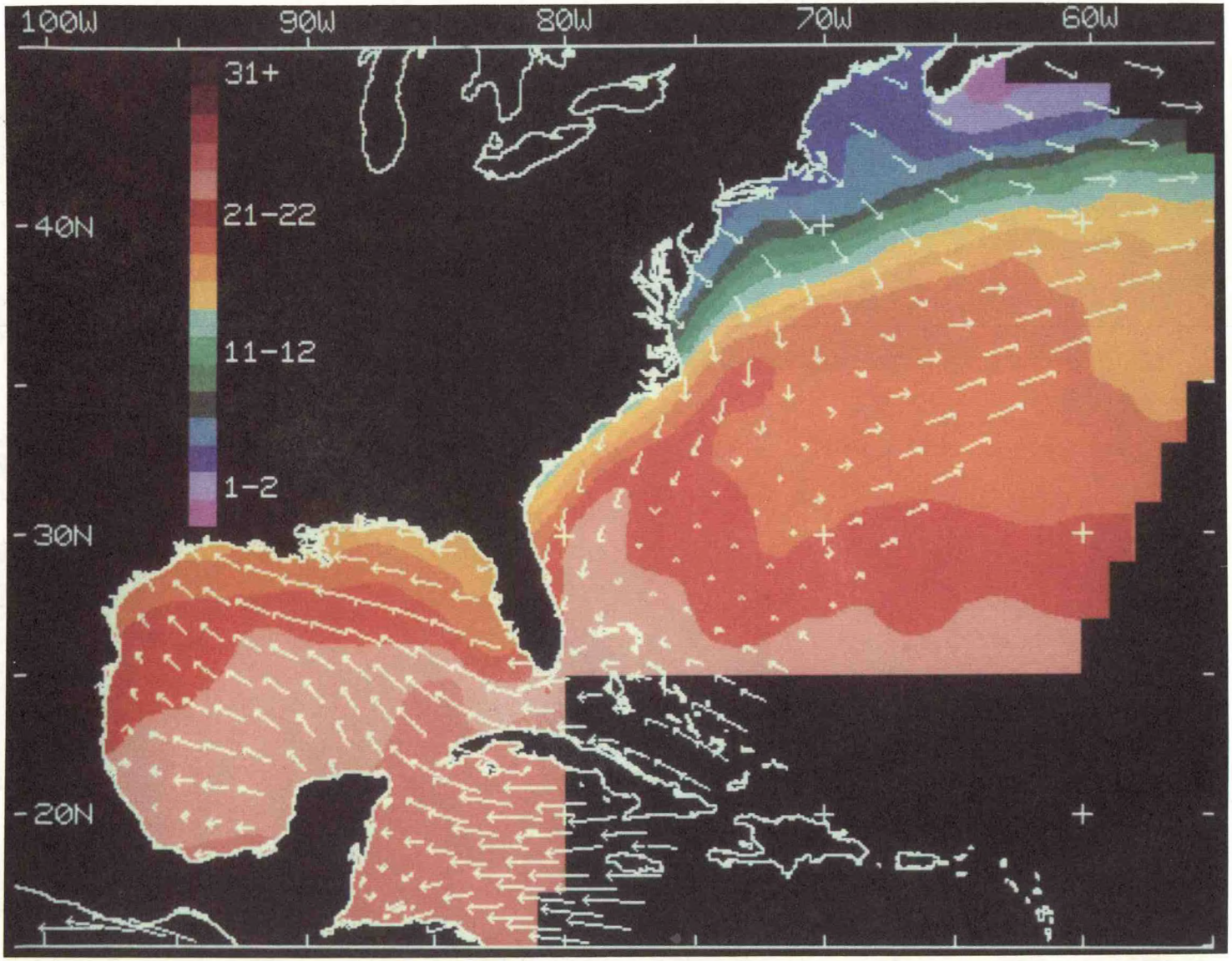


Figure 4.6 (c) March 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

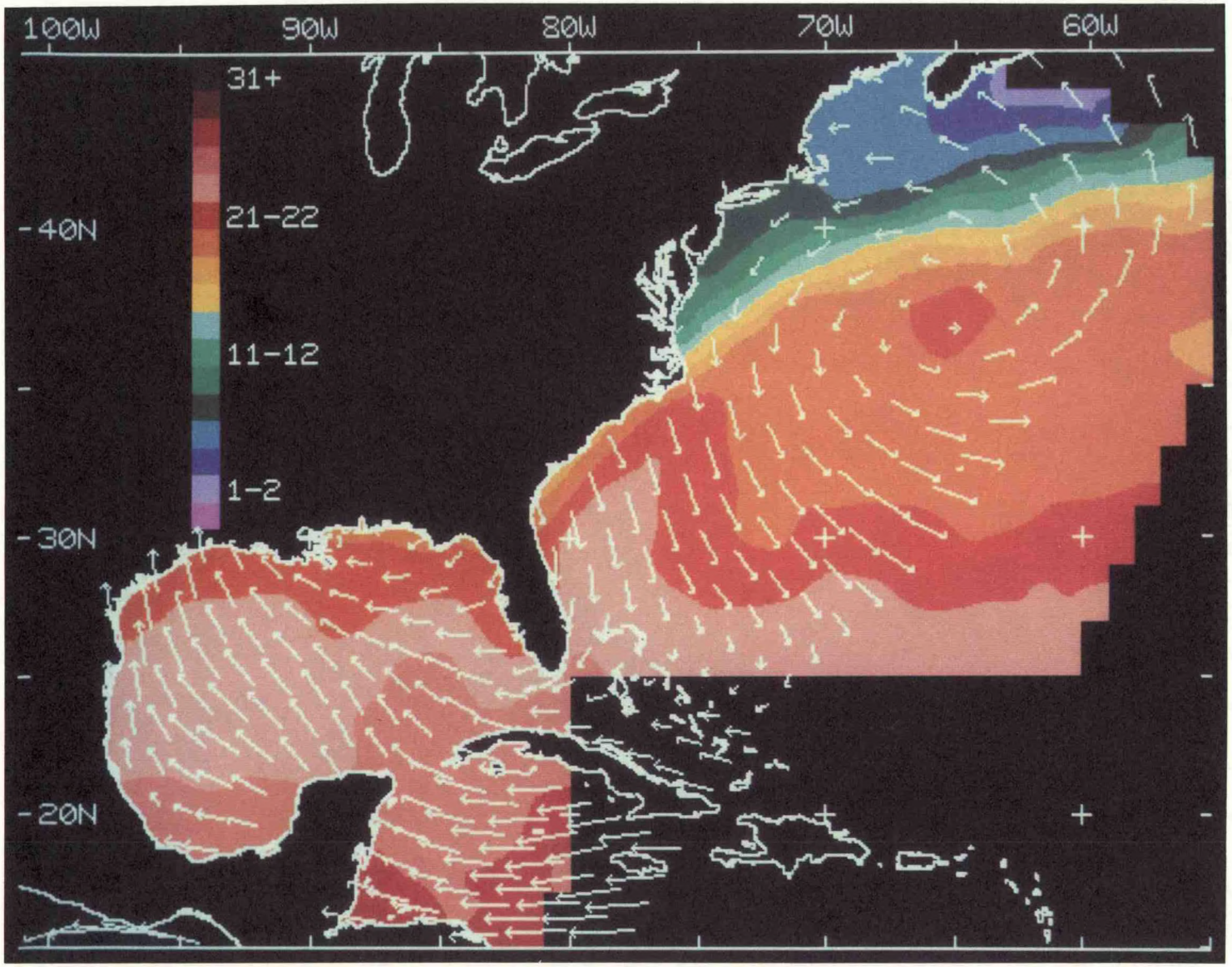


Figure 4.6 (d) April 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

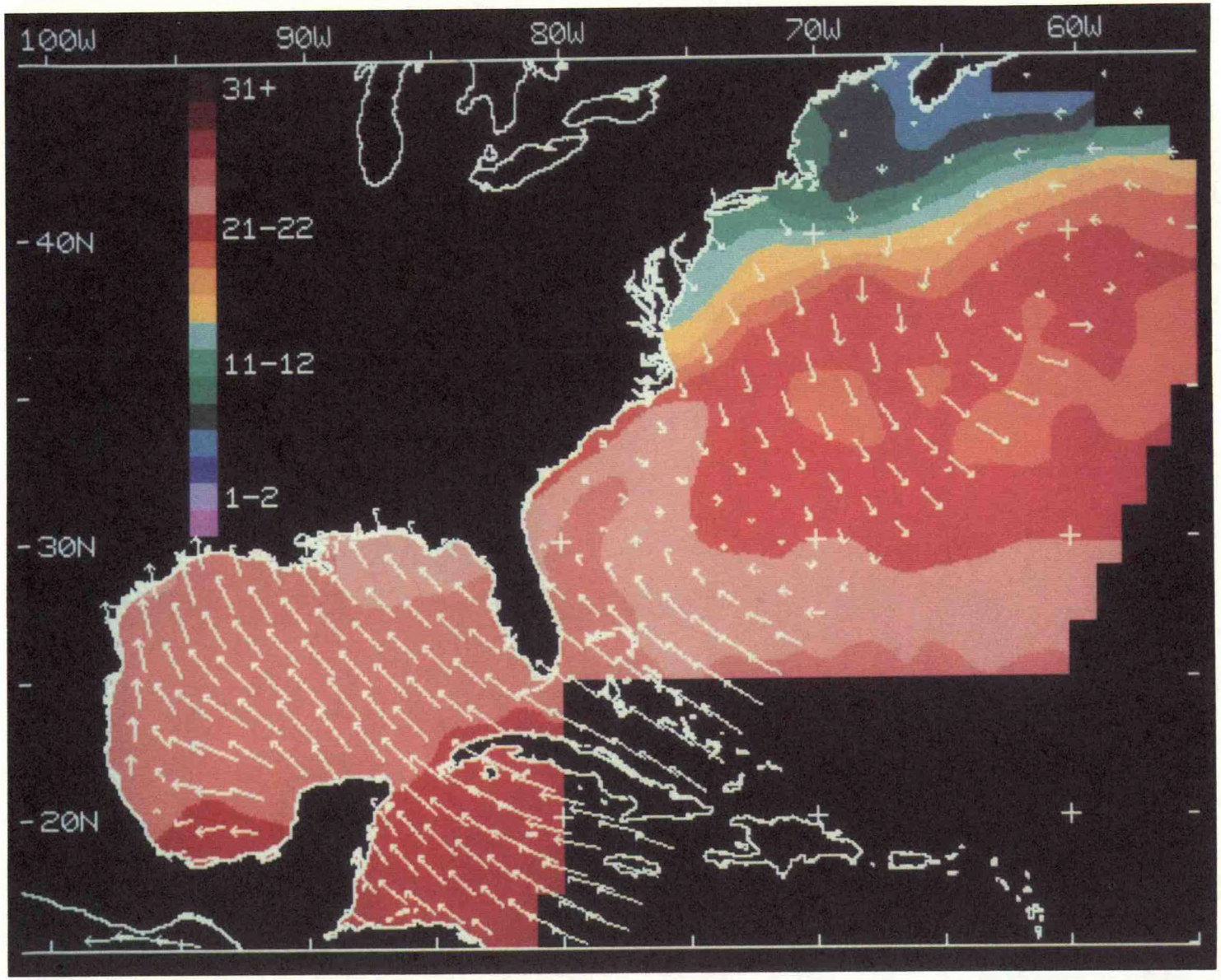


Figure 4.6 (e) May 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

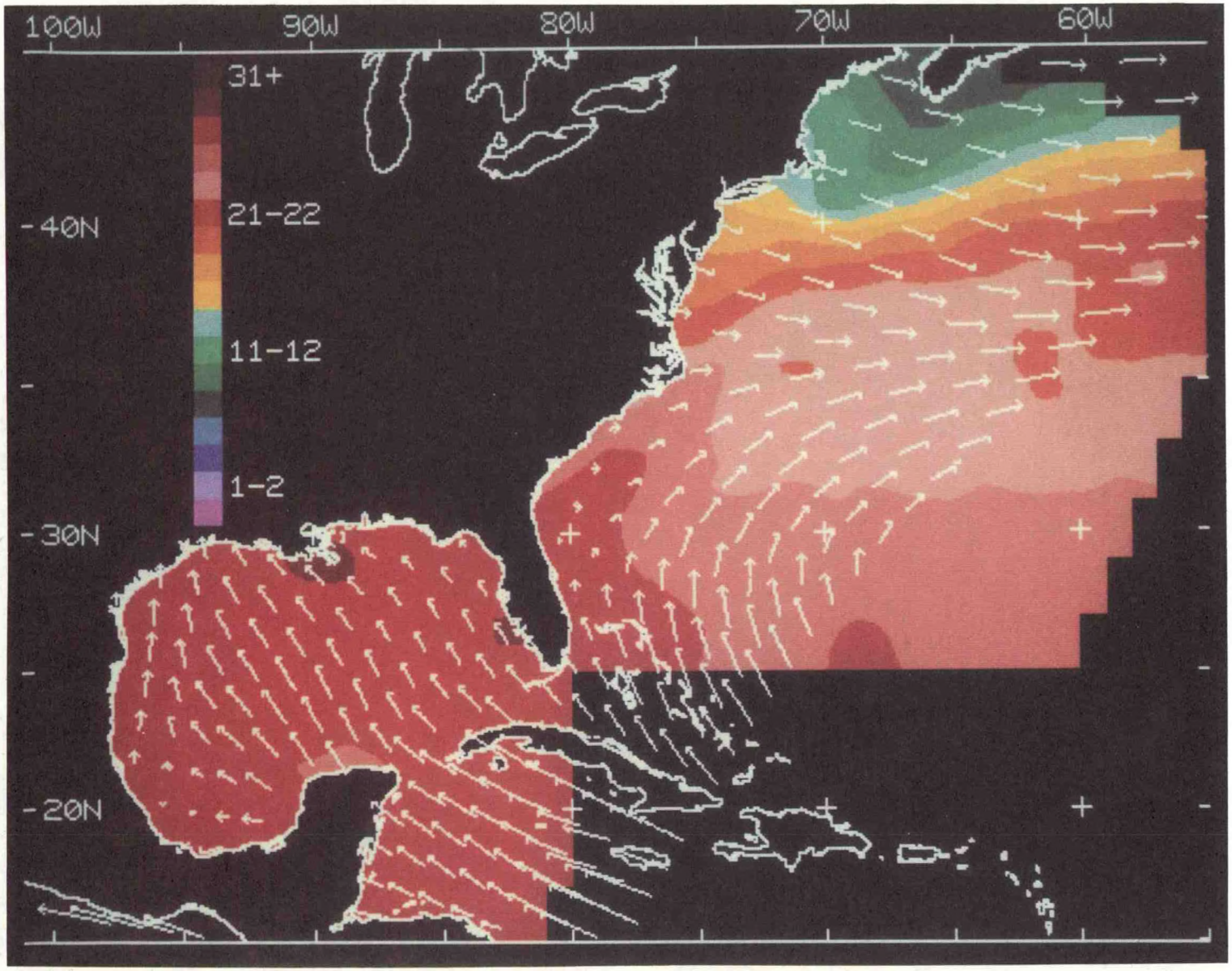


Figure 4.6 (f) June 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

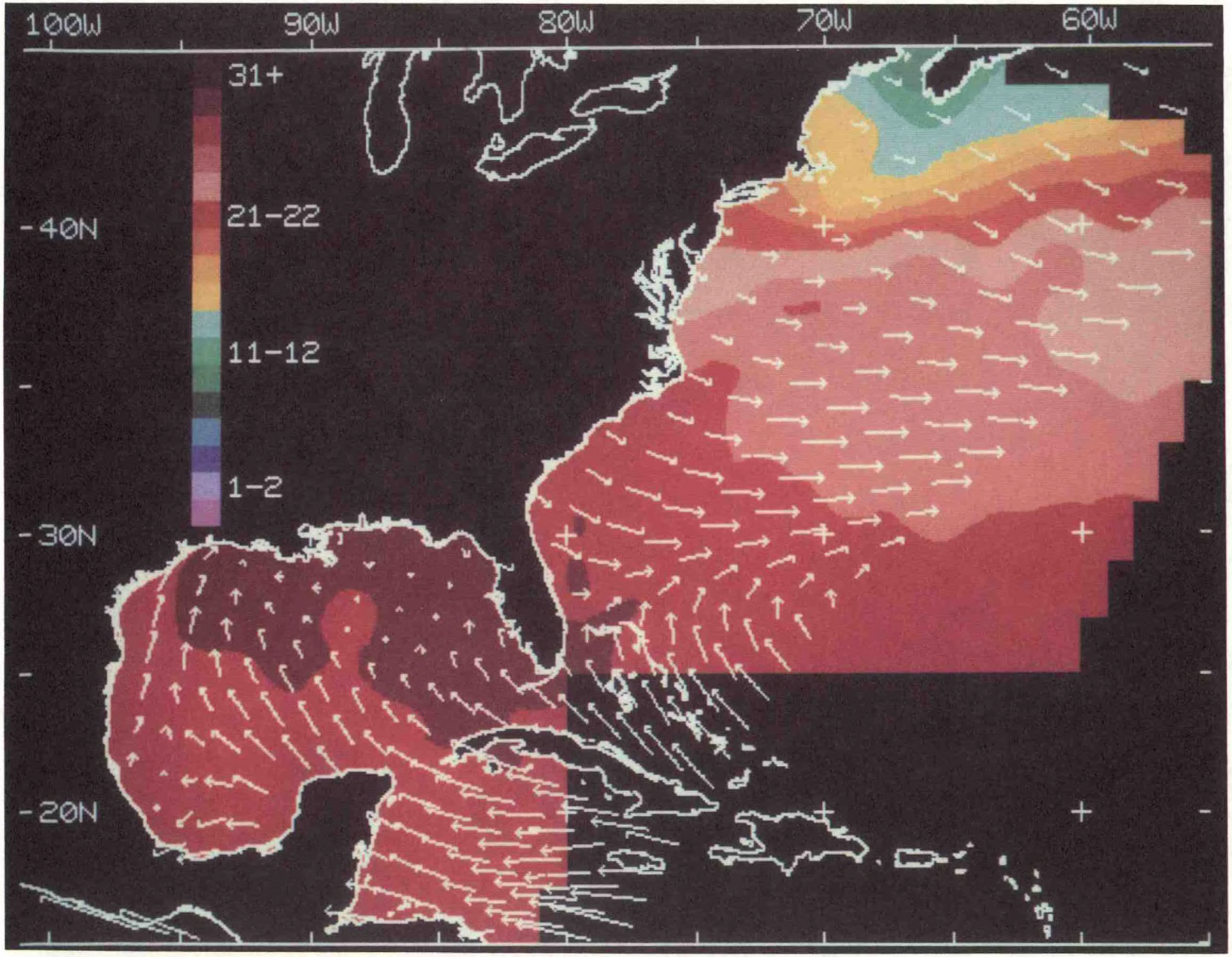


Figure 4.6 (g) July 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

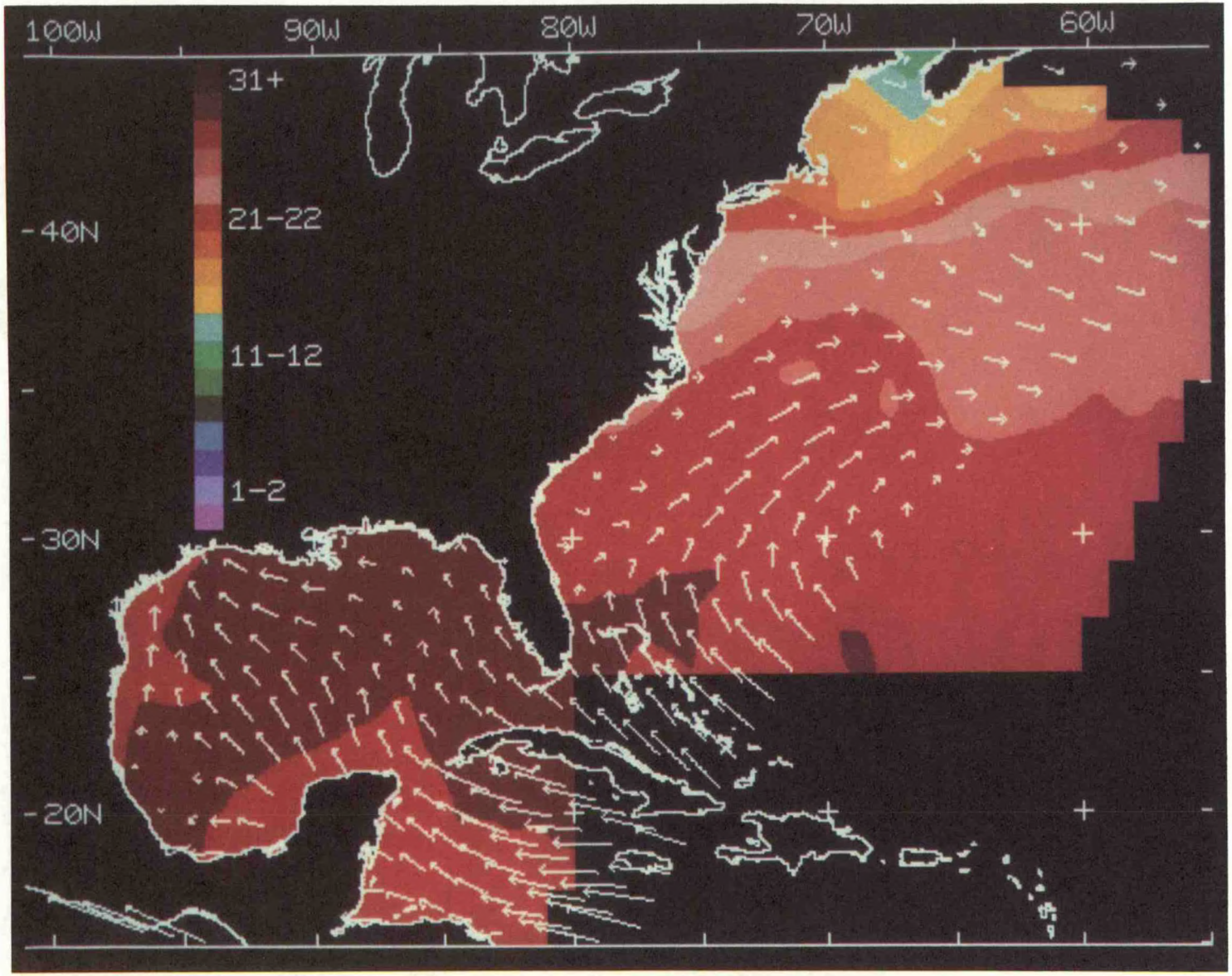


Figure 4.6 (h) August 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

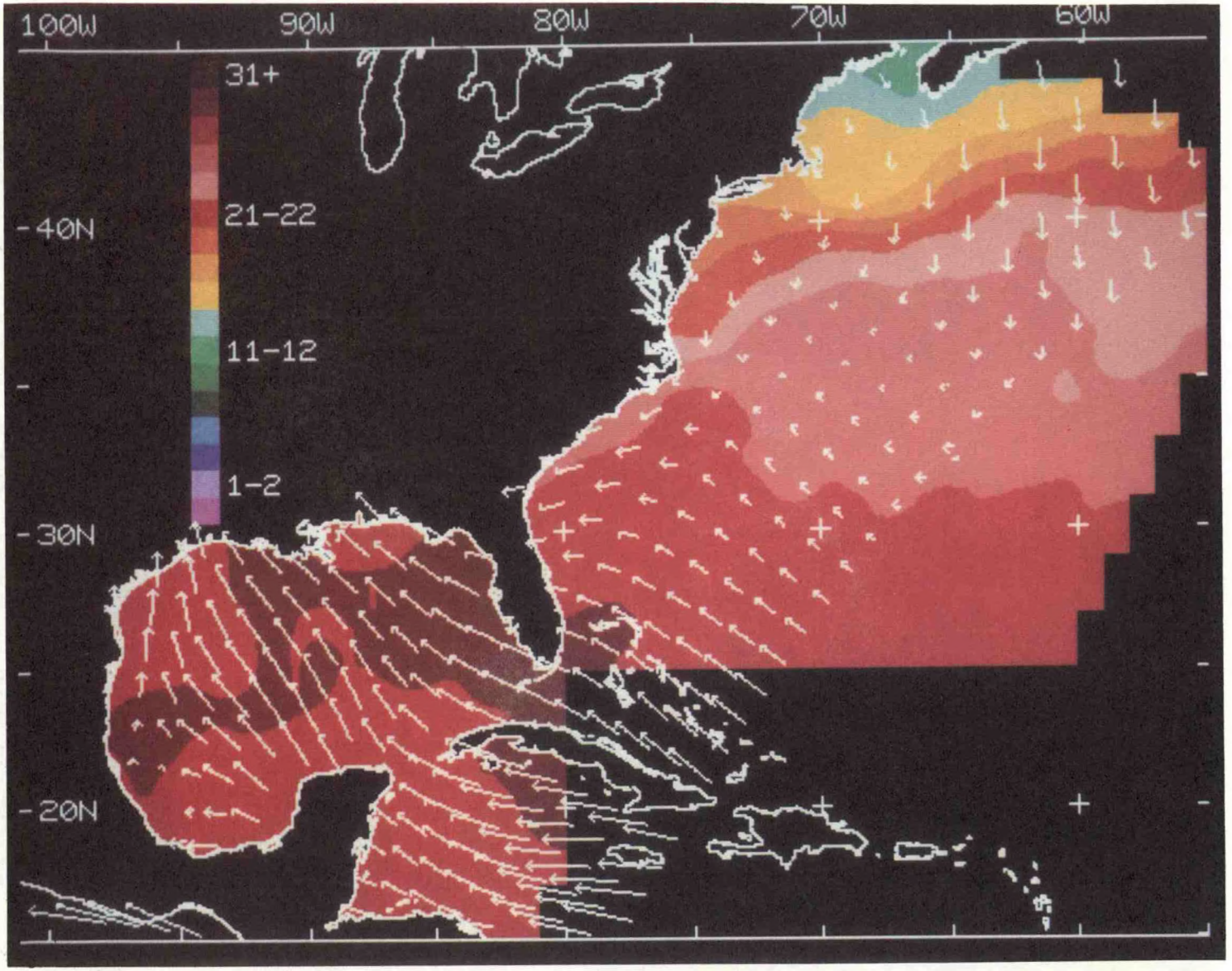


Figure 4.6 (i) September 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

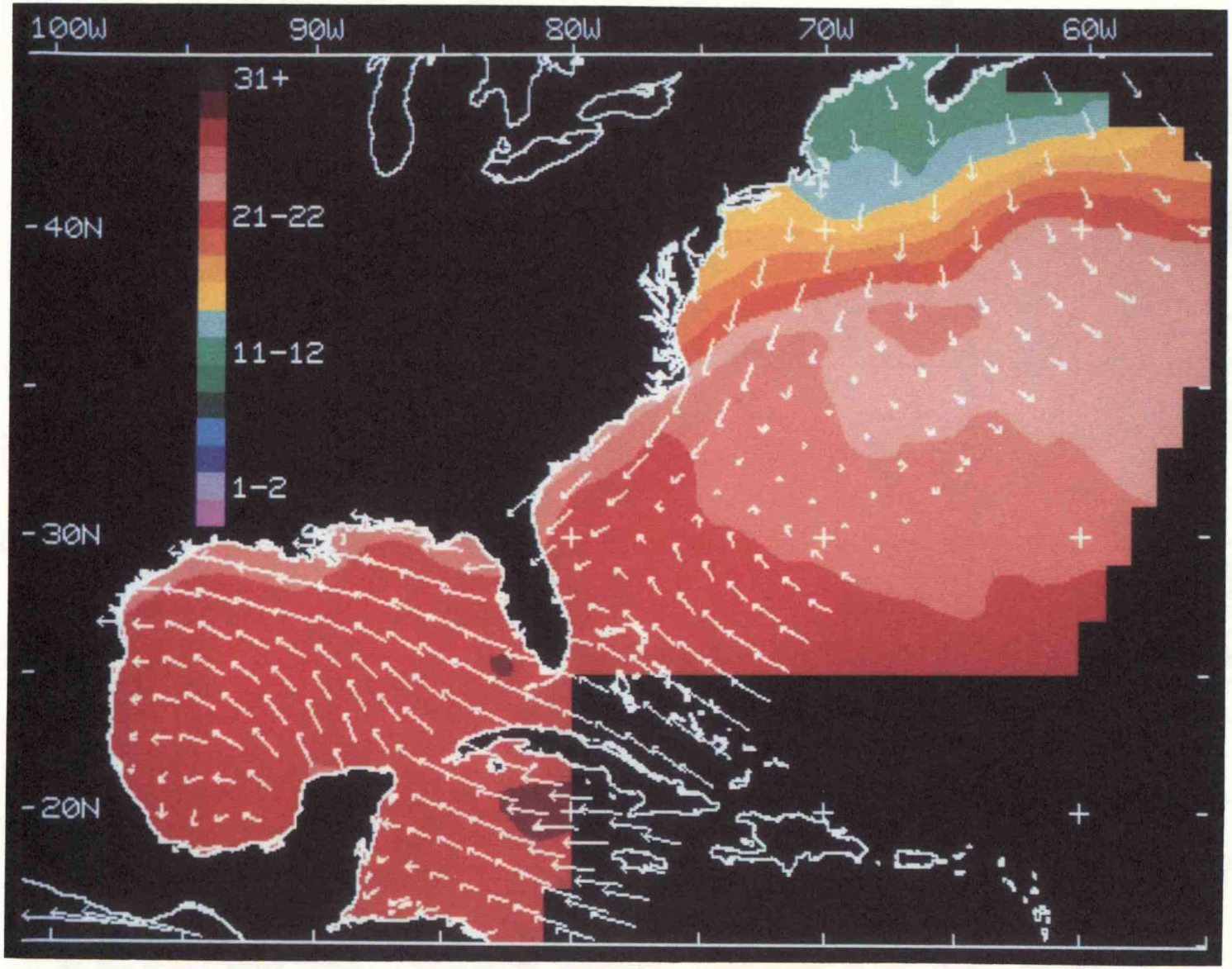


Figure 4.6 (j) October 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

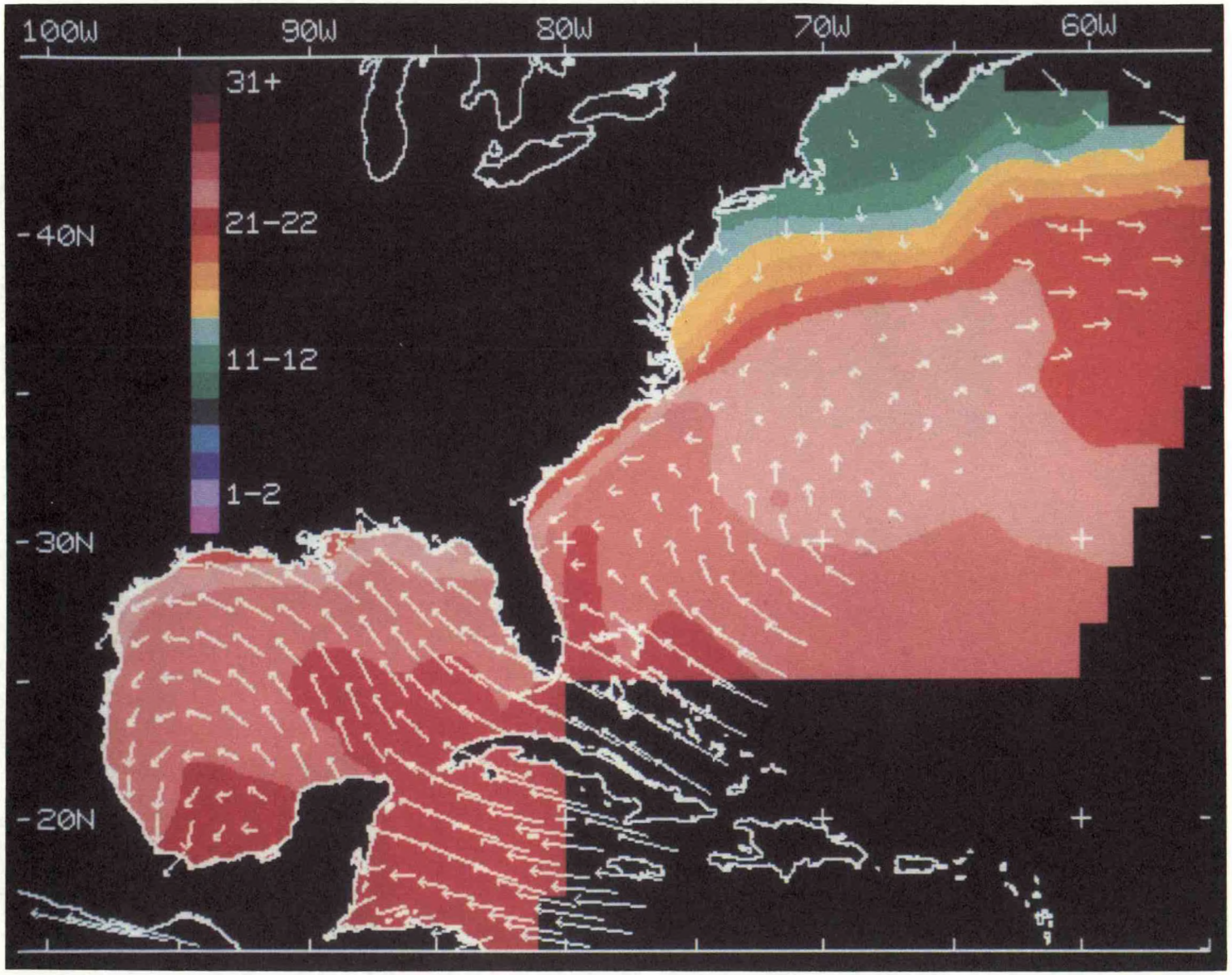


Figure 4.6 (k) November 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

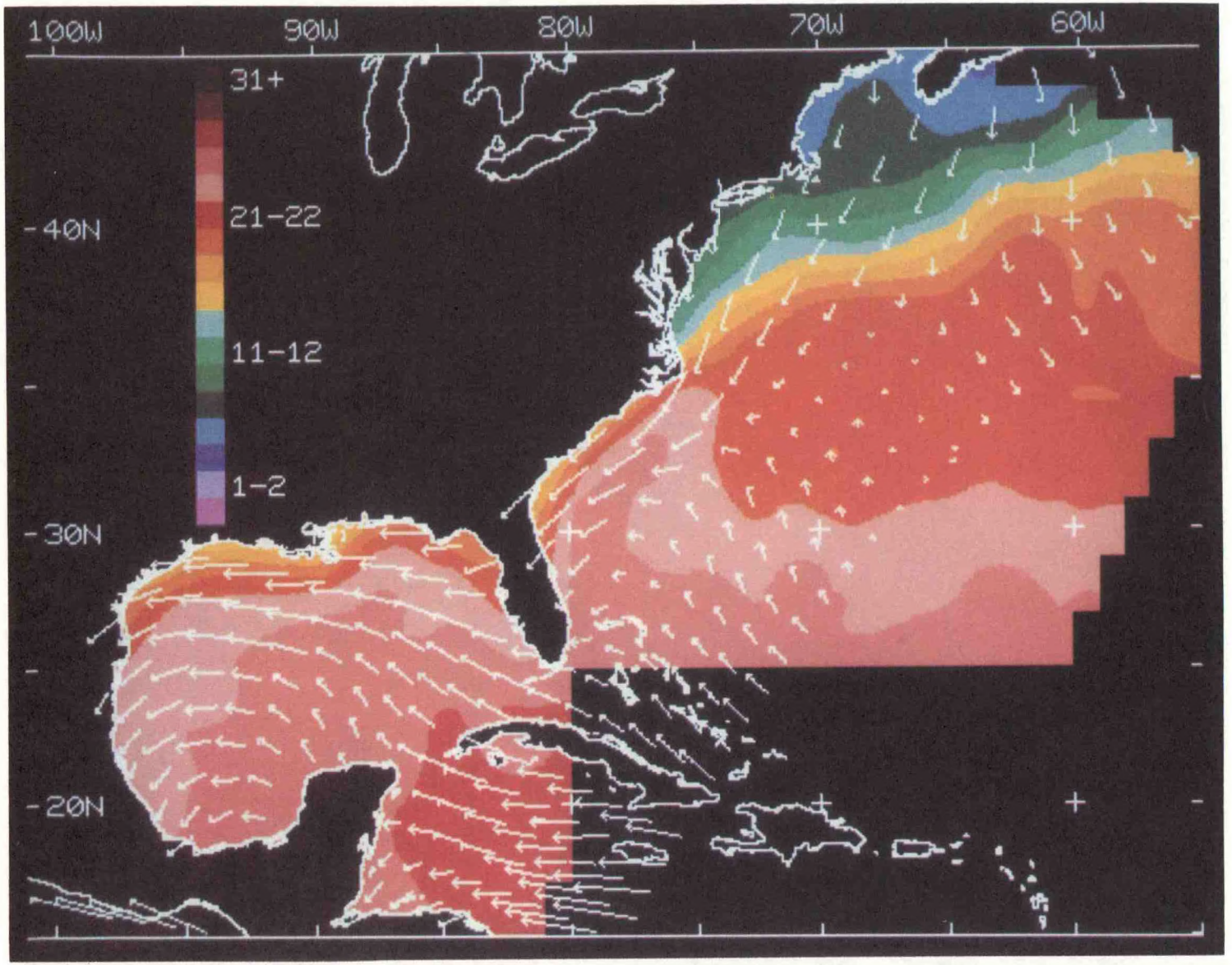


Figure 4.6 (1) December 1986 monthly mean sea surface temperature field with monthly mean wind-induced mass transports. A one-quarter inch arrow length equals 4 cubic meters/sec per meter.

Cape Hatteras usually provides a physical barrier to the southward advection of the cooler waters of the Mid-Atlantic Bight southward. With the eastward bulge of the coast at Hatteras and the narrowing of the shelf width, surface water temperature contours are more closely packed in the Mid-Atlantic Bight (north of Cape Hatteras) as compared to the Southeast Region (south of Cape Hatteras). Slight variations in the location of the contours north of Cape Hatteras can result in large fluctuations in surface water temperature; in the Southeast large temperature variations are less likely to occur.

Monthly sea surface temperature data

January begins the calendar year but is at the mid-point of the winter cooling cycle. Minimum temperatures in the 11-12°C range were at the coast and temperatures increase offshore and southward to a maximum of 23-24°C (Figure 4.6). Winter minimums of 11-12°C occurred in February 1986 with a large area of cooling noticeable off of Georgia and northern Florida.

Spring warming begins in March with minimum temperatures increasing to the 12-13°C range. April saw a dramatic (5°C) increase in the minimum temperatures to 17-18°C while the maximum temperatures were still 23-24°C. The April range in temperatures was reduced from the January-March levels as the cooler coastal waters warmed while the maximum temperatures remained unchanged. The rate of warming in May is slightly reduced compared to April with minimum temperatures of 21-22°C.

With the approach of summer the delineation of the Gulf Stream and coastal waters becomes increasingly difficult due to the uniformity of the SST field. July is the first month when the temperature contours are perpendicular (zonal) to the coast. August saw a reduction in the minimum temperature to 25-26°C. The temperature contours followed the coastline from Cape Hatteras to the Santee River area while south of the Santee they were perpendicular to the coast. September's minimum temperature was the same as in August while its areal coverage increased. The higher temperatures of southern Florida were perpendicular to the coast.

Fall cooling in October brought minimum temperatures of 23-24°C, with contours parallel to the coastline. The increasing thermal contrast between the coastal and offshore waters makes for easier delineation of the Gulf Stream. Cooling intensifies in November with minimums in the 19-20°C range while December had 17-18°C minimum temperatures.

4.4 Wind-Induced Ocean Circulation

The Assessment and Information Services Center computes estimates of wind-induced mass transports using the Norden Huang Model (1979) from twice daily estimates of surface wind speed and

direction from the Limited-Area Fine Mesh Model II (LFM II). An extended regional approach (the Northeast Atlantic and Gulf of Mexico) is used since the interaction of the North Atlantic Low (NAL) and the North Atlantic Sub-Tropical High (NASH) determines the wind-induced mass transports for the Caribbean northward into the Mid-Atlantic Bight. The possible transport of larvae from spawning grounds in the Caribbean into the Southeast Region and occasional flow of Mid-Atlantic waters southward past Cape Hatteras are each dependent upon the regional wind fields.

The LFM II is a hemispheric weather model developed by the National Weather Service and became operational in September 1977. The lowest 50 millibar wind data produced from this model are used as inputs to the Huang model. We do not attempt to correct the LFM II model wind data for the ocean boundary layer frictional effects of veering and reduction in magnitude as the sea surface is approached. A vector mean (climatological) data set of estimates of the wind-induced mass transports are produced from an archive of 1977 - 1985 LFM II data and these in turn are compared with the 1986 estimates of mass transports.

The Huang mass transport model assumes that the vertically integrated mass transport is 45^{o} to the right of the wind in the northern hemisphere and there is no influence of the bottom. Hence for near-shore coastal regions, effects of the bottom on veering of the transport vectors and reduction in magnitude of the flow by frictional forces are not considered.

We assume the wave field is fully developed and the fetch is unlimited. The interaction of the wind-generated effects of mass transport with bottom friction, local density currents, and major ocean currents must be considered when interpreting these charts. Bottom frictional forces are not considered, thus vectors in shallow water regions must be considered less reliable than those vectors in the Sargasso Sea region where wind-driven surface currents may be the major movement present except for meso-scale eddy motion. In regions of the major ocean currents the wind-induced mass transports are not significant when compared to the magnitude of these currents. Knowledge of the regional circulation and bottom topography aid in the analysis and understanding of these wind-induced mass transport products.

Data summary

The southward wind-induced transport of waters past Cape Hatteras appear possible during the fall months, October - December (Figure 4.6). There are no months when the wind-induced transport of waters northward past Cape Hatteras appears to occur in this monthly averaged data. This does not rule out the possibility that short-term events of 3-4 days duration could result in the advection of significant quantities of water either northward or southward past Cape Hatteras. Monthly mean conditions favor southward transport around the Cape only during the fall of the year.

Monthly summary of mass transport data

The wind-induced mass transports for January 1986 were similar to the mean. Slightly stronger than the mean downcoast flow off the Southeast Region rotated clockwise under the influence of the NASH to be more westward for the region of the Florida Straits. Reduced and random flows were predicted for the region northeast of the Bahamas probably resulting from the variability (shifting) of the wind field due to the interplay of the NAL and the NASH.

Strong offshore flows for the Southeast Region were predicted for February instead of the moderate downcoast flows seen in the mean data. Reduced westward flows were predicted for the Florida Straits region. Eastward flows were predicted for the region northeast of the Bahamas instead of weak westward flow. NAL extended further south and eastward than in the mean thus displacing the confluence of the NAL and NASH to the southeast of its usual location.

Moderate downcoast flows were predicted for the Southeast Region in March 1986 compared to the slight offshore mean flows. The westward flows resulting from the NASH continues to prevail in the Florida Straits and in the Bahamas. The confluence of the NAL and NASH to the region northeast of the Bahamas was again present in the March 1986 and mean data.

The wind-induced mass transports for the Eastern Seaboard were dramatically different in April 1986 compared to the mean. Moderate south-southeastward flows for the Southeast Region did not compare with the slight eastward flows predicted by the mean flows. These southeastward flows which rotated clockwise to be westward by the Florida Straits were predicted in the mean to be more of a northwestward flow. The region northeast of the Bahamas was under the influence of a low located off the Mid-Atlantic States thus having southeastward flows veering clockwise due to the NASH to become westward flow for the southern vectors. This flow regime in the Bahamas and to its northeast was in sharp contrast to the mean of moderate/slight northwestward flow. If this April 1986 flow pattern persisted then a reduction in the inflow of waters from the region south and east of the Bahamas into the Gulf Stream might result.

Slight insignificant offshore flow for the coastal LFM sites between Cape Fear and northern Florida were predicted in May 1986 as well as in the mean. The eastward flow off Cape Fear continued to be predicted to the east and merged into the region of the confluence (slight and variable flow) of the NASH and the atmospheric low located to the north. Onshore flows were predicted for the coastal sites from northern Florida to the Straits of Florida. This northwestward flow intensified to the east and south of northern Florida. This northwestward flow agreed with the 1977-1985 mean flow and could result in strong advection of waters into the Gulf Stream system located north of

the Bahamas. This strong northwestward flow would be advantageous to the advection of Caribbean larvae westward into the Bahamas and the Southeast Region of the U.S.

June 1986 saw a return to the mean circulation (directional) pattern except most of the LFM sites showed increases in magnitude. The coastal Southeastern Region saw slight offshore flows while offshore a more northeast to north-northeastward flows were predicted. The onshore flows of May for southern Florida are more upcoast directed in June and reduced in magnitude. The region of the Florida Straits had northwest to north-northwestward flows which agreed with the mean. This flow regime remains favorable to the advection of Caribbean larvae into the Southeast Region. Northeast of the Bahamas stronger than normal north-northwestward flows were predicted. The confluence region between the NASH and NAL is not present in the June 1986 data or in the 1977-1985 mean data due to the northward withdrawal of the NAL and the intensification and northward movement of the NASH.

Offshore flows were predicted for the entire Eastern Seaboard except southern Florida in July 1986. The Southeast coastal and offshore LFM sites had a more southward set to the offshore directed vectors and increased magnitude compared to the mean. Southern Florida and the Bahamas region had more northward directed mass transports. There remains no area of reduced and variable flow to the northeast of the Bahamas and the entire Eastern Seaboard is under the influence of the NASH.

The August 1986 wind-induced mass transports field for the entire region compared favorably to the mean in flow magnitude and direction. Compared to the July mean and 1986 data, direction of flow for both months are similar while August has significant reductions in the magnitudes of the flows. Increased offshore flow was predicted for the Southeast coastal sites compared to the mean while northeast to north-northeastward flow was predicted for the more offshore regions. The entire study region was under the influence of the NASH, thus resulting in clockwise rotating flows.

A major shift (fall transition) in the monthly mean wind field for the East Coast occurs in the month of September. The mean wind-induced mass transport field and the September 1986 data are comparable in direction and magnitude. The confluence of the NASH and NAL occurs off the Mid-Atlantic Bight at approximately 36N 65W. Moderate onshore flow dominates the Southeast coastal sites. Moderate northwestward flow to the northeast of the Bahamas was predicted for September 1986 and in the mean.

The NAL has an increasing influence on the wind-induced mass transports in the month of October with the confluence of the NAL and NASH moving southward from its September position to 30N 73W. The October 1986 flow data compare favorably to the mean. The

coastal sites of the Southeast Region had moderate downcoast flow which rotated clockwise to be onshore flow in southern Florida. The region northeast of the Bahamas continues to show northwestward flow but increasing clockwise rotation in the flow vectors indicates that the confluence of the NAL and NASH was again approaching this region of the ocean.

October is the first month that the wind-induced mass transports are favorable for the flow of Mid-Atlantic Bight waters past Cape Hatteras into the Southeast Region. This occurrence is dependent on the location of the Gulf Stream offshore of Cape Hatteras. If the Gulf Stream is close to shore then the dynamics on the shelf are probably controlled more by the Gulf Stream than the regional wind-induced mass transports. Thus, this transport southward would not occur.

The November wind-induced mass transports for 1986 and in the mean showed a reduction in the magnitude of the flows compared to the October data. Moderate coastal downcoast and onshore flows were predicted from Cape Hatteras to north of Cape Canaveral. Northwestward flows were predicted south of Cape Canaveral through the Florida Straits. Moderate northwestward flows, not the mean westward flows, were predicted for the region northeast of the Bahamas.

The December 1986 data showed marked differences in magnitude and direction of flow compared to the mean. Strong downcoast flow, not the mean moderate downcoast flow, characterized the Southeast Coastal Region. South of Cape Canaveral to southern Florida saw the expected (mean) moderate onshore directed flow. The flows to the northeast of the Bahamas were more northward directed than the mean but again rotated counter-clockwise to merge with the southwestward flow seen at the coastal sites. Strong downcoast, south-southwestward flow was predicted in December for the Mid-Atlantic Bight with the possibility of advection of waters past Cape Hatteras into the Southeast Region. The confluence of the NAL and NASH apparently shifted northward in 1986 compared to the mean.

4.5 Waves, Tides, and Storm Surge

Waves play a significant role in maintaining the shape of the beach from the action of the high-energy storm waves of winter or occasional tropical storm or hurricane in summer and fall months which erode the higher portions of the beach and pile up sand bars in areas a short distance seaward of the shoreline to the gentle waves and swells of summer months which carry the sand from the bars back upon the beach again. Their actions are being continuously studied by the U.S. Army Corps of Engineers at a facility along the northern portion of the Outer Banks. Here the relationship between wave heights and periods and directions of approach are being systematically investigated in conjunction with the erosion and accretion pattern seen to be taking place in

the adjacent beach. Table 4.3 lists the periods and measurement for occasions in 1986 when wave heights exceeded 2 meters above mean sea level at the Corps of Engineers Field Research Facility at Duck, NC.

Tides, storm surge, and waves combine their effects when a large storm moves ashore, the elevated water levels permitting the waves to dissipate their energies high on shore. This may result in areas of beach disappearing and the undermining or destruction of structures on shore. Along the Southeast Coast winter storms on occasion can be just as damaging to shorelines through their prolonged attacks as hurricanes. The destructive interaction of tides, waves, and storm surge was evident in the storm which moved along the coast of South Carolina at the end of 1986. An alignment of the sun, moon, and earth occurred at that time which is termed a "syzygy." This syzygy was predicted to result in higher than normal tides and the possibility for flooding of low-lying areas, particularly if a storm were to occur during this situation. A storm did develop in the Gulf of Mexico late on December 31 and subsequently moved up the Southeast Coast bringing heavy destruction to beach property in

Table 4.3 Periods during which wave heights exceeded 2 meters (6.56 feet) above mean sea level and maximum height noted. Numbers in parentheses are hours. Data from U.S. Army Corps of Engineers.

Period	Height (meters)	Remarks
11 Jan (0300) - 11 Jan (0900)	2.10	Weak coastal storm
23 Jan (2200) - 25 Jan (2000)	2.70	Winds behind cold front
25 Feb (0900) - 25 Feb (1400)	2.13	Winds behind cold front
7 Mar (2200) - 8 Mar (0300)	2.53	Storm center over Maine
21 Mar (0400) - 21 Mar (1500)	2.53	NNE winds from Mid-west
22 Mar (0700) - 22 Mar (1300)		high pressure system
18 Apr (1100) - 21 Apr (0200)	3.17	Slow moving storm over Chesapeake Bay
9 May (0600) - 12 May (0500)	3.10	Long period (16 sec) waves
12 May (1900) - 13 May (1700)		from storm in N. Atlantic
17 Aug (1000) - 17 Aug (1800)	3.41	Hurricane Charley
10 Oct (0900) - 12 Oct (1500)	3.25	NE winds behind cold front
18 Oct (1800) - 19 Oct (1700)	2.35	Strong high pressure in wake of weak storm
1 Dec (0000) - 3 Dec (0800)	3.13	Classic northeaster from Gulf of Mexico. Winds exceeded 33 mph 22 hours
24 Dec (1700) - 25 Dec (0000)	2.65	Storm from Gulf of Mexico moving along Appalachians

South Carolina and farther north. Tides are normally high in this area of the coast and it is thought that the special heightening due to the syzygy in conjunction with the storm contributed to its destructive quality.

4.6 Erosion

Erosion is of particular concern in the Southeast where the protection and management of beaches must proceed simultaneously with growth in the coastal zone. Erosion affects land configurations, roads, housing, recreation, and tourism. Erosion is most noted following some particularly devastating storm which may remove a large chunk of beach, undermine roads, and destroy houses.

Erosion events and their management

In South Carolina such destruction was most evident following the New Year's Eve storm which damaged structures and other beach development. The estimated losses from this storm about $13 million, not considering the erosion itself. This storm followed by only a month a coastal storm whose damage to structures and bulkheads in the Myrtle Beach area was estimated at about $3 million. No other storms affecting the coast during 1986 were regarded as having had any significant erosion effect.

Efforts to manage erosion vary in the Southeast. Where development is in place and erosion rates in general quite stable, the response may take the form of repair of the damage and preparation for the next event. In South Carolina's Grand Strand area rebuilding of the dunes and beach had proceeded following the December 1 storm, but this had not become sufficiently established before the devastation of the New Year's eve storm. As an emergency protective measure rebuilding dunes was authorized by the South Carolina Coastal Council. In the Key Biscayne area of Florida, following an extended study of alternatives, the U.S. Army Corps of Engineers will undertake to halt erosion to exposed shores through sandbagging. In other places, such as along North Carolina's Outer Banks, such measures would have little value. There the response to the threat of erosion is a policy of setbacks and control of further beach and shore development and use. Florida follows somewhat a similar course with its Coastal Construction Control Lines.

Erosion rates

Exercising controlled use of shoreline entails knowledge of coastal or shoreline stability. The important parameter in this is the annual average erosion rate. In North Carolina the annual erosion rate is now being determined for segmented sections of shoreline by annual aerial photography and comparison with detailed maps. Florida monitors erosion through periodic and post-storm surveys referenced to closely spaced coastline

markers.

Estimates of average annual erosion rates for the Southeast are not uniformly collected nor are they available for all of the states of the region. North Carolina has reported an average rate of 3 feet per year for its entire coast and a rate of 4.7 feet per year for the Outer Banks (Cape Hatteras to the Virginia line). The U.S. Army Corps of Engineers has estimated that the average annual rate along the South Carolina coast is 0.5 feet per year while that along the south Florida coast is 0.3 feet per year.

Individual areas within two miles of the formation of new inlets have high erosion rates. This is particularly true along the Outer Banks of North Carolina. For example, North Rodanthe, has erosion of up to 9 feet per year, Pea Island of up to 14 feet per year, and the Seagull area of Currituck Banks of up to 13 feet per year.

Southfacing portions of capes along the North Carolina have been accreting rather than eroding over the past 40 years while northern portions which face east or northeast, have been eroding somewhat faster than the average for the entire coast.

Actual erosion for a given stretch of shoreline will tend to vary from year to year because of the sporadic nature of erosion as a result of individual storms or stormy seasons. In some years there will be significant erosion whereas in others there will be a substantial rebuilding of beaches.

5. FISHERIES AND BIOLOGICAL RESOURCES

5.1 Introduction

Characterization of the fishery

The wide variety of habitats along the Southeast Coast supports diverse populations of finfish and shellfish. This is an area of great transition, ranging from the temperate climate in the north to tropical conditions in the south. The Southeast fishery includes species caught in the rivers and estuaries, inshore along the coast, and offshore in the open ocean.

The National Marine Fisheries Service (NMFS) reports estuarine-dependent species constitute 68 percent of the weight and 58 percent of the value of the total U.S. commercial landings. NMFS studies show this proportion to be generally higher in the Southeastern U.S., where, for example, about 90 percent of the North Carolina commercial landings and 50 percent of recreational landings are composed of estuarine-dependent species. The largest estuarine system in the Southeast is the Albemarle-Pamlico complex in northeastern North Carolina.

Commercial fisheries in the Albemarle Sound area have traditionally concentrated on spring runs of anadromous species such as river herring (alewife and blueback herring). According to the North Carolina Division of Marine Fisheries, catches from these spring runs account for the majority of anadromous fish landings in North Carolina. Loss of habitat, pollution, and overfishing have been cited as factors contributing to a decline in landings in some anadromous species since the 1960's.

The most valuable commercial coastal fishery in the Southeast is for penaeid shrimp; brown, white and pink. Penaeid shrimp are caught largely inshore along the coast in all four states of the Southeast. Blue crabs and menhaden are the highest in total poundage. Other commercially important inshore species are clams, oysters, croaker, spot, seatrout, and flounder.

Coastal pelagic species in the Southeast include king and Spanish mackerel, bluefish, cobia, jacks, squid, and sharks. Oceanic pelagics such as swordfish and other billfishes, tunas, sharks, dolphin, wahoo, and other species provide both a popular offshore recreational and commercial fishery. Species which are also considered recreational are discussed in Section 6.

In recent years the fishery for reef and hard-bottom fishes such as black sea bass, snappers, groupers, and porgies has expanded considerably in the Southeast. These areas are fished using a variety of methods including traps, trawls, and handlines.

The marine and estuarine species utilizing the varied

habitats in the Southeast respond to environmental conditions during certain stages of their life cycles for spawning and migration of adults, or drifting of larvae (Figure 5.1). Gulf Stream transport enables larvae of warm-water species to move north occasionally to colonize suitable habitat on hard-substrate or "live-bottoms" scattered offshore the Southeast coast on an otherwise depauperate sand bottom. Hard substrates such as rocky outcrops favor the accumulation and concentration of attached organisms such as soft and hard corals, algae, and sponges. Various pelagic finfish and marine turtles are known to associate around live-bottoms in the Southeast.

Estuarine-dependent species include shrimp and menhaden which spawn offshore, have their larvae transported to the estuary to grow; blue crabs which release larvae inshore to be carried offshore by currents to later return to the estuary; and oysters which complete their entire life cycle in the estuary.

Marked seasonal biological changes are less evident in the warmer-water areas where water temperature extremes are smaller. Larvae of some species in the Southeast occur during a relatively short period in some areas, but for extended periods in other areas. For example, blue crab larvae peak in abundance for three to four months off the Albemarle-Pamlico Sound area, though off southern Florida, blue crab larvae are abundant for about nine months of the year.

Responses to temperature differences are manifested in finfish migrations when coastal waters of the Southeast warm in the spring and cool in the fall. Bluefish and other migratory species prefer certain temperature ranges, as they follow their preferred temperature band up the coast in the spring and down the coast in the fall. Temperature extremes are critical to species such as white shrimp which overwinter in the nearshore areas, making them vulnerable to abnormally cold temperatures that can occur during the winter months.

Relating environmental changes to fisheries is complex. In many cases, establishing a clear relationship between a single environmental parameter and a change in abundance of a particular species is very difficult. Other variables, ranging from predator-prey interactions to market demand also must be considered to determine the ultimate effect an environmental event has had on a given species. Pollutants, habitat alterations, and overfishing have reduced the historical abundance of some species in the Southeast as has occurred in other areas of the U.S. that have experienced increased demand on both the environment and fishery resources.

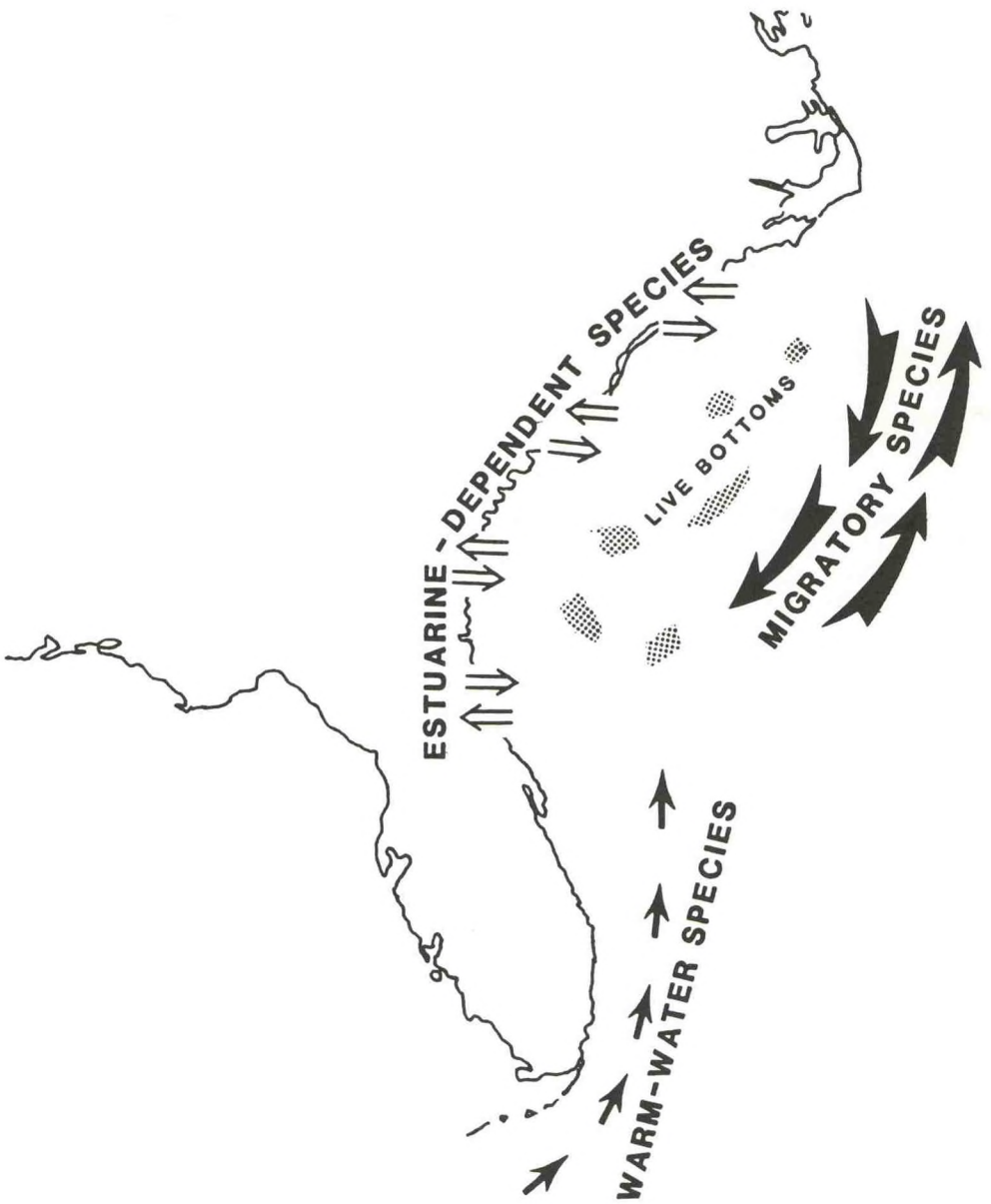


Figure 5.1 Schematic of coastal fisheries of the Southeast.

Historical landings in the Southeast

The South Atlantic fishery experienced a steady growth in the late 1970's. Most commercial species in the Southeast are presently fully utilized as a fishery. Record high landings in the Southeast were 543.0 million pounds in 1981. In 1981, landings were high for croaker, flounder, gray sea trout, and blue crabs, in combination with relatively high menhaden landings. Total landings in the Southeast have decreased over the last three years to 248.6 million pounds in 1986 (Figure 5.2). The 1986 landings are the second lowest in the last 36 years, the lowest of record being 240.1 million pounds in 1973. Important species which contributed to the decline in total Southeast landings in 1986 were menhaden, alewives, hard blue crabs, hard clams, flounder, and gray sea trout.

The total value of Southeast fishery landings remained constant for 1950-64, increasing during the period 1965-77, with a sudden surge in 1978 and 1979 (Figure 5.2). Value showed a slight dip in 1981, then a large increase in 1982, followed by the record high reported in 1983 at $172.6 million (Figure 5.2). Despite radically reduced landings in the Southeast in 1985-86, value remained relatively constant, reflecting an increase in value of many of the Southeast species, with most of the decreases occurring in catch of species such as menhaden which bring a lower price per pound.

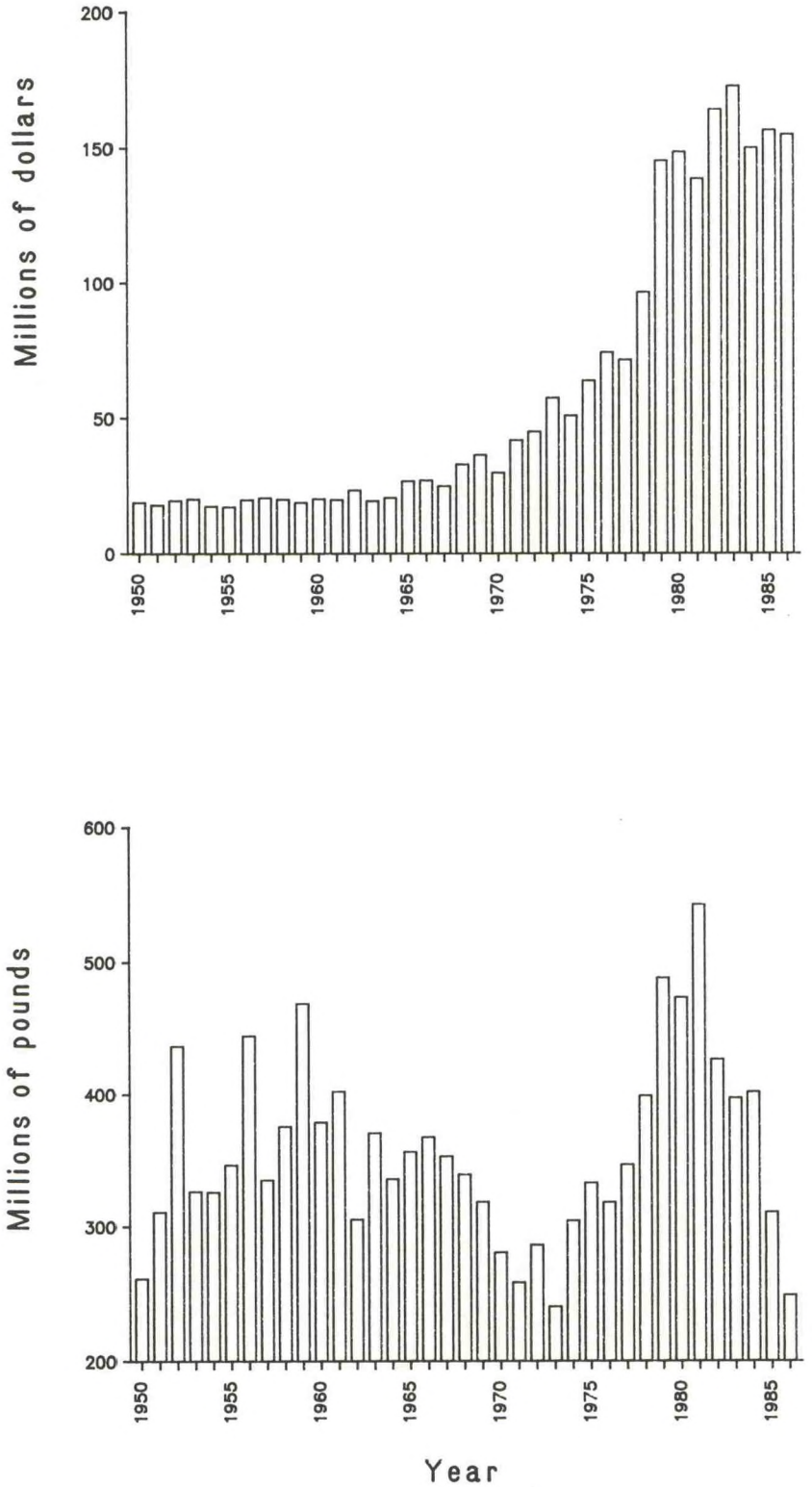


Figure 5.2 Historical finfish and shellfish landings and value for the South Atlantic Region, 1950-1986. Data from NOAA, National Marine Fisheries Service. Data include Florida inland lakes; 1978-86 data are preliminary.

Ports

Four ports in the Southeast rank as major U.S. fishery ports with above ten million dollars in landings: Key West, FL; Beaufort-Morehead City, NC; Cape Canaveral, FL; and Wanchese-Stumpy Point, NC (Table 5.1). While total values for all the major ports combined in Table 5.1 remained relatively constant at near $80 million, several ports showed more variation in their individual values. The largest change in 1986 at any of the major Southeast ports was at Cape Canaveral which reported only $15.9 million in value of landings in 1986. The large drop is attributed to the decline in calico scallop landings for this port. Key West had the highest dollar value at $27.4 million in 1986.

Table 5.1 Value of landings at the major ports of the South Atlantic Region. Data from NOAA, National Marine Fisheries Service.

	Million dollars		
Port	1984	1985	1986
Key West, FL*	21.8	23.3	27.4
Beaufort-Morehead City, NC	21.6	22.7	24.7
Cape Canaveral, FL	26.2	21.2	15.9
Wanchese-Stumpy Point, NC	10.8	13.3	12.3
TOTAL	80.4	80.5	80.3

*Includes Atlantic and Gulf of Mexico landings.

Processing and wholesaling

There were 657 seafood processing and wholesaling operations in the South Atlantic Region in 1985, the most recent year statistics are available from the National Marine Fisheries Service. The number of processors and wholesalers has shown a relatively steady increase over the 15-year period 1970-85 in the South Atlantic, from 432 plants in 1970 to the 657 reported in 1985. Of the two regions adjacent to the South Atlantic, the number of plants in the Gulf of Mexico increased during the 1978-85 period, though the number of plants in the Mid-Atlantic area declined. An increase in blue crab meat-picking plants in North Carolina from 1978-present and expansion of fishery specialty products were major contributors to the increase in the South Atlantic Region.

5.2 Summary of Activities

Finfish and shellfish landings in the Southeast States totalled 248.6 million pounds, worth $154.7 million in 1986 (Table 5.2).

Table 5.2 Total finfish and shellfish landings for the Southeast States of North Carolina, South Carolina, Georgia, and Florida East Coast (in thousands), 1985 and 1986. Data from National Marine Fisheries Service, NOAA.

	1985		1986	
	Pounds	Dollars	Pounds	Dollars
North Carolina	214,871	$64,589	168,885	$63,435
South Carolina	12,827	$13,941	16,788	$25,064
Georgia	17,241	$20,887	15,476	$24,501
Florida, east coast	53,156	$48,215	47,485	$41,681
Total, SE states	310,720	$156,330	248,634	$154,681
Total, all U.S.	6,257,642	$2,326,237	6,030,634	$2,762,823
SE states as percent of U.S. total	4.97%	6.72%	4.12%	5.60%

These landings, while important to the individual state economies of the Southeast, represent only about 4 percent of the total U.S. landings by weight in 1986, a relatively small portion of the six billion pounds landed from all U.S. waters. The Southeast landings, important to the local economies, are small compared to the much higher landings of the mid-Atlantic and Gulf of Mexico, and Pacific regions. Menhaden landings are much higher in the Gulf and in Virginia, which accounts for more menhaden landed than in all the Southeast States combined. There are only three vessels fishing for menhaden in the Southeast States, while there are 121 in Virginia and 73 in the Gulf of Mexico. Pacific landings of cod, mackerel, and sea herring are also much higher than landings of Southeast species. Landings in 1986 were about 62 million pounds lower than 1985 in the Southeast States, though total value of the landings decreased by only $1.6 million.

North Carolina accounted for 41 percent of the value and 68 percent of the weight of total landings of the Southeast States in 1986 (Figure 5.3). Florida followed as second highest in the Southeast in both value and weight, 27 percent and 19 percent, respectively, of the total for the region. Georgia and South Carolina ranked even in value at 16 percent, and close in weight (6 and 7 percent, respectively). The large percentage weight of landings in North Carolina reflects the menhaden harvest, which is used for fish meal and oil production rather than direct human consumption. Many of the warmer-water species (such as the spiny lobster in Florida) bring higher dockside prices, also bolstering the dollar percentages for Florida, South Carolina, and Georgia.

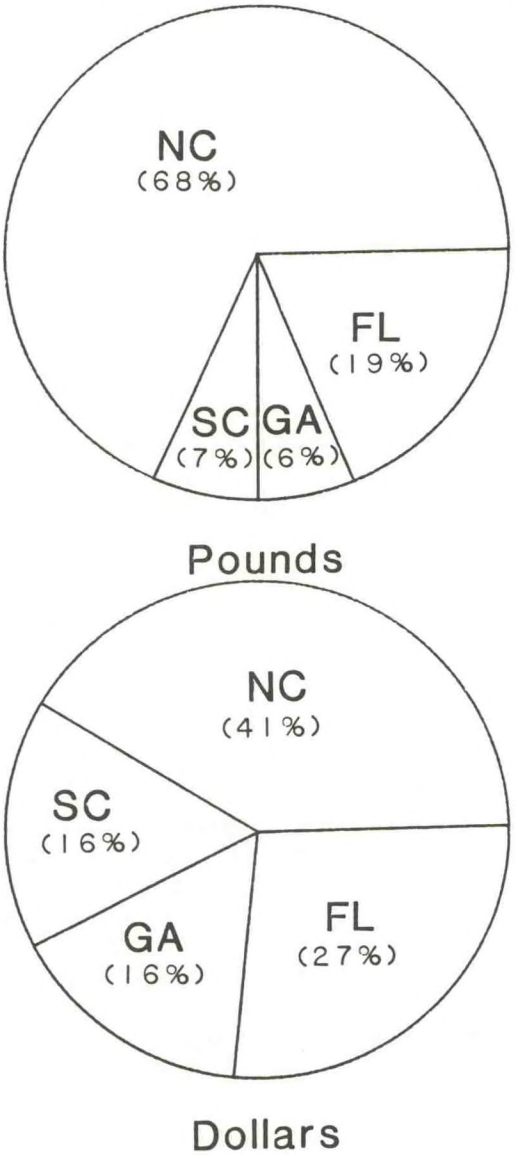


Figure 5.3 Proportional finfish and shellfish landings by State in 1986 for the South Atlantic Region. Data from NOAA, National Marine Fisheries Service.

5.3 Finfish and Shellfish

North Carolina

Major commercial finfish and shellfish species landed in North Carolina in 1985 and 1986 are listed in Table 5.3. Eight finfish species had landings over one million pounds in North Carolina in 1986: menhaden, weakfish (gray sea trout), croaker, flounder, alewives, bluefish, mullet, black sea bass, and mackerel (king and cero). Shellfish landings over one million pounds were blue crabs, shrimp, and hard clams.

Shrimp landings were 6.2 million pounds, worth $14.0 million, making shrimp the most valuable category of landings of the State. Brown, white, and pink shrimp are the three main commercial species in North Carolina. Over the previous 20-years, brown shrimp landed in North Carolina contributed an average of 70 percent of total shrimp landings, followed by pink and white shrimp at 24 and 7 percent, respectively. Annual brown shrimp production in North Carolina is strongly influenced by temperature and salinity variations, according to the North Carolina Division of Marine Fisheries. In Pamlico Sound, salinities were high in both 1985 and 1986 in April and May. Brown shrimp landings were the highest in 30 years in 1985 in North Carolina. Landings in 1986 were near average. Warm water temperatures and high salinities in 1985 provided favorable conditions for brown shrimp. A period of cooler water temperatures in 1986 may have contributed to the lower landings in 1986 for brown shrimp.

Menhaden were the highest by weight in 1986 at 66.4 million pounds, though menhaden landings were 31.3 million pounds lower than the 97.7 million pounds landed in 1985. Menhaden landings decreased by 226.8 million pounds (29 percent) in the Atlantic States and decreased by 121.3 million pounds (6 percent) in the Gulf States compared with 1985. The National Marine Fisheries Service (NMFS) reported that menhaden spawning stock sizes had improved somewhat since the population crashed in the early 1960's, though the magnitude and distribution of current fishing efforts would be likely to prevent short-term landings from becoming much higher than over the last several years. The decline in menhaden landings is also related to reduced effort resulting from closure of Standard Products, Inc. processing plants in Beaufort, NC and Southport, NC.

Of the other major finfish species in North Carolina, croaker, mackerel (king/cero), mullet, and gray sea trout showed increases in quantity landed in 1986 over 1985, while alewives, bluefish, flounder (fluke), and black sea bass showed declines. Yellowfin tuna landings increased in 1986 over 1985 in North Carolina and also in the other Southeast States. Commercial landings of yellowfin tuna are relatively low at 359 thousand pounds, though this species is also an important recreational species for offshore Gulf Stream fishing.

Table 5.3 Finfish and shellfish landings for the State of North Carolina (in thousands), 1985 and 1986. Data from National Marine Fisheries Service, NOAA. All data are preliminary.

	1985		1986	
	Pounds	Dollars	Pounds	Dollars
Alewives	11,548	846	6,814	647
Bluefish	3,604	582	3,450	477
Bonito	1	(1)	1	(1)
Butterfish	159	53	186	73
Croaker	8,714	2,947	9,567	3,119
Flounder, blackback	6	2	36	14
Flounder, fluke	19,964	9,545	8,953	9,562
Flounder, yellowtail	0	0	38	12
Flounder, Atl./Gulf	9	1	4	1
Groupers	725	959	771	1,142
Mackerel, king/cero	833	897	1,006	930
Mackerel, Atl.	253	29	472	57
Menhaden	97,738	2,330	66,378	1,591
Mullet (bl. & s.)	1,487	312	1,932	426
Scup or porgy	1,031	734	460	427
Sea bass, black	1,219	1,002	1,098	980
Sea trout, gray	9,795	3,879	14,309	4,196
Sea trout, spotted	109	93	191	146
Shark, dogfish	1	(1)	0	0
Sharks, unclass.	116	29	131	32
Snapper, red	19	43	32	85
Snapper, other	493	921	537	1,036
Mackerel, Span.	173	67	232	81
Striped bass	280	223	189	190
Swordfish	78	225	94	324
Tilefish	51	46	18	30
Tuna, bigeye	0	0	30	66
Tuna, bluefin	(1)	1	0	0
Tuna, little	75	5	76	5
Tuna, yellowfin	66	76	359	245
Tuna, unclass.	39	49	30	30
Whiting	64	6	12	3
Fish, other	20,715	3,088	17,244	3,503
TOTAL FISH	170,365	28,990	134,650	29,430
Crab, blue	29,621	6,434	23,506	6,064
Shrimps	11,683	21,130	6,165	13,942
Clam, hard (meat)	1,393	5,654	1,356	7,522
Oysters (meat)	545	1,037	746	1,452
Scallop, bay (meat)	456	1,072	306	838
Scallop, sea (meat)	13	56	974	3,952
Squid	1	(1)	696	70
Shellfish, other	794	216	486	165
TOTAL SHELLFISH	44,506	35,599	34,235	34,005
GRAND TOTAL	214,871	64,589	168,885	63,435

(1) Less than 500 lbs. or $500.

Blue crabs were the highest quantity of shellfish landed in 1986 in North Carolina, at 23.5 million pounds, worth $6.1 million. Blue crabs support a very important commercial fishery in terms of landings, value, numbers of fishermen, processing, and employment combined in North Carolina. North Carolina blue crab landings declined in 1986 by over 6 million pounds. North Carolina blue crab (hard) landings have declined each year from the record 38.3 million pounds in 1982 (Table 5.4).

Table 5.4 Blue crab landings (millions of pounds) for the four Southeast States, 1978-86. Data provided by Georgia Department of Natural Resources[1].

Year	North Carolina	South Carolina	Georgia	Florida (east coast)	Total Southeast
1978	23.6	9.4	10.6	3.8	47.4
1979	26.6	7.4	11.3	3.5	48.8
1980	34.4	6.2	10.1	4.6	55.3
1981	38.0	6.3	13.0	3.5	60.8
1982	38.3	6.3	12.5	5.4	62.5
1983	34.7	5.6	11.1	7.0	58.4
1984	32.5	4.4	10.2	6.7	53.8
1985	29.3	4.6	8.3	3.7	45.9
1986	23.1	5.5	6.4	3.5	38.5

[1] Landings figures in this dataset may be slightly higher or lower than blue crab landings in other tables due to updates.

A possible decline in abundance of blue crabs along the Southeast Coast and Chesapeake Bay is under study by researchers in several states though causes for a decline are presently unknown.

North Carolina experienced a record oyster harvest in 1986 following high spatset three years ago in Pamlico Sound. Oyster drills and boring sponges also showed increases following high salinities in the dry years of 1985 and 1986.

South Carolina

South Carolina finfish and shellfish landings in 1986 totalled 16.8 million pounds worth $25.1 million (Table 5.5). These landings, while small compared to landings in other coastal states, are important to local areas within South Carolina, supporting local watermen and tourism, and paralleling the growing recreational fishery in the State. Blue crabs were the

highest in quantity at 6.6 million pounds in 1986, with a dockside value of $3.0 million. Shrimp is the most important species in value in South Carolina, with 5.9 million pounds landed in 1986 worth $14.9 million. Shrimp landings were up considerably in 1986 following two low years in 1984 and 1985.

After two disastrous years (1984 and 1985) resulting from temperature-related overwintering mortality, white shrimp stocks recovered to a slightly less-than-normal year in 1986. In addition, brown shrimp stocks remained above-average in 1986 after a banner year in 1985. Warm temperatures and high salinities in spring contributed to favorable conditions for brown shrimp recruitment and growth, according to the South Carolina Marine Resources Division.

White shrimp, which overwinter along the Carolina Coast, show mortalities when water temperatures drop to 48 degrees Fahrenheit or lower. The rate of drop in water temperature is also important in determining whether mortalities will occur i.e., a rapid drop in water temperature to the critical temperature may be more detrimental than a gradual drop. White shrimp caught in May and June are the spawners for the fall crop, harvested primarily from September to December. The spawners which overwintered were subject to temperature mortalities in January 1984 and December 1984, affecting the harvest of shrimp in September to December 1984, and September to December 1985, respectively. The effect of cold water temperatures may be seen in landings for South Carolina, notably in 1984 and 1985 (Table 5.6).

White shrimp landings show large fluctuations, and water temperature is an important factor in determining their annual abundance. Environmental conditions in the estuaries other than water temperature may also be important in determining the survival and catch rates of white shrimp.

White shrimp mortalities also occur in North Carolina, though white shrimp make up a much smaller portion of the overall shrimp catch, with brown shrimp the dominant species in the landings. In South Carolina, white shrimp constitute most of the total shrimp catch. In Georgia, white shrimp also constitute most of the total shrimp harvest (70 to 80 percent--depending on the amount of brown shrimp landed in a given year), though white shrimp stocks are somewhat less affected in Georgia due to warmer water temperatures. In Florida, white shrimp are an important part of the overall shrimp harvest, though water temperature is less likely to be important as a winter kill factor.

Oyster landings showed a large decline in 1986 in South Carolina. Oyster stocks have been affected by disease, notably in the area between Charleston, SC and Beaufort, SC (See Section 5.4 Disease).

Table 5.5 Finfish and shellfish landings for the State of South Carolina (in thousands), 1985 and 1986. Data from National Marine Fisheries Service, NOAA. All data are preliminary.

	1985		1986	
	Pounds	Dollars	Pounds	Dollars
Alewives	25	3	235	45
Bluefish	4	1	8	4
Croaker	1	(1)	1	(1)
Flounder, fluke	31	17	37	28
Groupers	489	782	607	1,158
Mackerel, king/cero	93	94	91	93
Mackerel, Span.	1	1	1	1
Mullet (bl. & s.)	102	50	112	63
Scup or porgy	201	201	220	246
Sea bass, black	137	118	0	0
Sea trout, spotted	1	1	1	1
Sharks, unclass.	73	26	85	41
Snapper, red	40	101	36	90
Snapper, other	192	293	194	400
Swordfish	(2)	(2)	140	528
Tilefish	171	184	327	541
Tuna, unclass.	(2)	(2)	21	25
Fish, other	1,239	2,106	969	716
TOTAL FISH	2,800	3,978	3,085	3,980
Crab, blue	4,977	1,451	6,622	3,053
Shrimps	3,373	6,480	5,862	14,877
Clam, hard (meat)	181	618	270	1,211
Oyster (meat)	1,429	1,372	918	1,924
Squid	7	3	7	5
Shellfish, other	60	39	24	14
TOTAL SHELLFISH	10,027	9,963	13,703	21,084
GRAND TOTAL	12,827	13,941	16,788	25,064

(1) Less than 500 lbs. or $500.
(2) Landings included in Fish, other in 1985.

Table 5.6 South Carolina white shrimp landings (heads off) for May and June 1983-86 with annual totals. Data from South Carolina Marine Resources Division.

	May	June	Annual total	
	Pounds		Pounds	Dollars
1983	78,022	149,319	2,349,670	$9,878,931
1984	146	1,180	312,368	1,340,696
1985	1,368	1,089	415,925	1,690,950
1986	0	15,116	3,315,686	9,795,267

Georgia

Georgia's combined finfish and shellfish landings totalled 15.5 million pounds with a value of $24.5 million in 1986 (Table 5.7). Catches of some coastal pelagics and offshore reef fishes were higher in 1986 than in recent years in Georgia. A doubling of dock space may have contributed to the increases of these fishes, according to the Georgia Department of Natural Resources.

Shrimp were the most valuable category of the landings with 7.4 million pounds landed at a value of $21.3 million. Blue crabs were second in value and quantity, with 6.5 million pounds and a value of $1.9 million.

Blue crab landings in Georgia have greatly declined since 1982, reflecting an overall decline seen in the total Southeast blue crab catch since 1982 (Table 5.4). The 6.4 million pounds landed in Georgia in 1986 are only about one-half the landings in 1981-82.

There is an oyster mortality problem in Georgia due to the suspected disease organism, Dermo (See Section 5.4 Disease). Some oyster beds in Georgia recently showed up to 100 percent mortalities. Nearly all oysters consumed in Georgia (about 95 percent) are caught in South Carolina, with a very minor catch reported in Georgia. Georgia has fewer oysters due to high tidal ranges and resulting silt loads.

Florida

Thirty-nine million pounds of finfish and shellfish were landed along Florida's east coast in 1986, worth $37.8 million. Compared to 1985, this represents a decline of 14.1 million pounds and $10.4 million in value. Species which showed large declines included blue crab, shrimp, hard clams, and scallops (Table 5.8).

Mackerel landings were 2.5 million pounds in 1986, though fishery management quotas set to sustain this fishery kept cero and king mackerel catches lower than would have otherwise been without the quotas.

Calico scallop landings were down considerably in Florida, from 12.3 million pounds in 1985 to only 1.6 million pounds in 1986. This fishery has shown large fluctuations since it began in the 1960's off Cape Canaveral. Harvesting locations where scallops are dredged vary because the distribution and abundance of this resource varies widely. In 1984, Calico scallop landings in Florida reached a high of 39.1 million pounds. Reasons for the large fluctuations in the scallop fishery in Florida are unclear at present.

Grouper and red snapper landings remained relatively low for

Table 5.7 Finfish and shellfish landings for the State of Georgia (in thousands), 1985 and 1986. Data from National Marine Fisheries Service, NOAA. All data are preliminary.

	1985		1986	
	Pounds	Dollars	Pounds	Dollars
Bluefish	0	0	1	(1)
Flounder, fluke	86	43	48	31
Groupers	148	222	206	324
Mackerel, king/cero	94	86	169	127
Scup or porgy	154	138	104	87
Sea bass, black	14	11	8	7
Sea trout, spotted	7	8	9	10
Sharks, unclass.	8	7	6	5
Snapper, red	34	82	23	62
Snapper, other	171	255	136	224
Mackerel, Spanish	1	1	2	(1)
Tilefish	5	3	19	16
Tuna, yellowfin	0	0	2	3
Tuna, unclass.	0	0	2	2
Fish, other	606	440	749	265
TOTAL FISH	1,328	1,296	1,485	1,163
Crab, blue	7,776	1,874	6,500	1,872
Crab, other	2	1	14	48
Shrimps	7,739	17,404	7,394	21,335
Clam, hard (meat)	4	17	16	49
Oyster (meat)	34	56	4	8
Shellfish, other	358	239	63	26
TOTAL SHELLFISH	15,913	19,591	13,991	23,338
GRAND TOTAL	17,241	20,887	15,476	24,501

(1) Less than 500 lbs. or $500.

Table 5.8 Finfish and shellfish landings for the State of Florida East Coast (in thousands), 1985 and 1986. Data from National Marine Fisheries Service, NOAA. All data are preliminary. Landings for inland lakes are not included.

	1985		1986	
	Pounds	Dollars	Pounds	Dollars
Bluefish	616	126	1,084	206
Bonito	8	1	5	1
Croaker	128	61	160	63
Flounder, fluke	320	208	180	155
Groupers	637	1,030	748	1,342
Mackerel, king/cero	2,597	2,857	2,453	2,821
Menhaden	6,900	106	7,987	316
Mullet, (bl. & s.)	1,579	343	1,600	384
Scup or porgy	109	97	220	226
Sea bass, black	42	41	42	30
Sea trout, gray	125	60	110	62
Sea trout, spotted	315	299	290	290
Sharks, unclass.	940	498	1,155	566
Snapper, red	152	369	135	339
Snapper, other	278	445	285	428
Spanish mackerel	2,923	778	3,849	1,078
Swordfish	2,001	5,247	1,268	3,449
Tilefish	901	1,117	975	1,336
Tuna, albacore	2	2	5	6
Tuna, bluefin	74	142	23	43
Tuna, yellowfin	127	146	167	277
Tuna, unclass.	221	301	330	521
Tuna, bigeye	73	147	115	243
Fish, other	5,144	2,424	5,500	3,029
TOTAL FISH	26,212	16,845	28,686	17,211
Crab, blue	5,421	1,843	3,500	1,400
Crab, other	1	2	1	1
Lobster, spiny	286	749	207	581
Shrimps	5,175	9,406	3,699	9,359
Clam, hard (meat)	3,698	6,915	1,275	6,018
Oyster (meat)	9	17	30	65
Scallop, Cal. (meat)	12,309	12,350	1,616	3,087
Squid, loligo	17	6	14	5
Shellfish, other	28	82	24	74
TOTAL SHELLFISH	26,944	31,370	10,366	20,590
GRAND TOTAL	53,156	48,215	39,052	37,801

Florida's east coast in 1985 and 1986. Apparently, some of the fishing effort for these species and swordfish may have shifted to yellowfin tuna, a species now widely targeted as a large and relatively abundant species in the Gulf of Mexico.

Landings for the State of Florida inland lakes are not included in the finfish and shellfish landings in Table 5.7. These landings are reported by the Florida Game and Freshwater Fish Commission at 8.4 million pounds and $3.9 million in value in 1986.

5.4 Disease

A major disease problem has been occurring in estuarine finfish species of the Southeast Region over the last several years. The disease is manifested primarily in skin lesions which are heavily colonized by fungal mycelia. Extremely high incidences of this disease are being found in the mouth of the St. Johns River in Florida, and in the Pamlico River in North Carolina. Occasional occurrences of the disease have been reported along the coast in the area between the St. Johns River and Pamlico Sound, notably in Charleston Harbor. The heaviest infestation appears to be in the Pamlico River, where 90 percent or more of some menhaden trawl samples by the North Carolina Division of Marine Fisheries show evidence of the disease. Other affected estuarine species are croaker, seatrout, flounder, and silver perch. The cause of the outbreak and its continuance is not known, but environmental factors, pollution, and water-flow changes are possible inductive or exacerbating factors.

Oyster mortalities from Dermo disease (Perkinsus marinus) were reported from South Carolina and Georgia in 1986. The major area of oyster dieoffs was from Charleston, SC to Beaufort, SC, according to the South Carolina Wildlife and Marine Resources Department. Dermo is usually present in oyster populations in South Carolina, and in normal years mortality rates are low. The dieoffs in 1986 occurred following the high temperatures and drought in 1986. Reduced runoff in 1986 and the resultant reduced nutrients combined with high water temperatures may have contributed to poor oyster condition, making them more susceptible to disease.

5.5 Blooms

The major bloom event in the Southeast in 1986 occurred in Lake Okeechobee in south Florida. Minor blooms were reported in some areas in 1986. Recurrent nuisance blooms in the coastal Southeast occur periodically in the Neuse River and in the Chowan River in North Carolina. Blooms such as occurred in North Carolina in summer 1983 in the Neuse River did not occur in 1986.

Extensive blooms of blue-green algae (sometimes designated cyanobacteria) occurred in 1986 in Lake Okeechobee, covering more than 100 square miles of the lake. This freshwater lake covers an area of about 720 square miles and is critical to the water resource network of South Florida. A large area of the Intracoastal Waterway along the coast of South Florida receives fresh water from Lake Okeechobee via the Palm Beach Canal, Hillsboro Canal, and the North New River Canal. Lake Okeechobee also drains into the Indian River via the St. Lucie Canal. The water quality of the Lake has an important influence on the coastal areas receiving its drainage. Patches of the bloom were first reported on July 25. The highest concentrations of the blue-green algae were reported August 11-15, 1986, clumped along marshes in the northwest part of the lake. The bloom spread from east to west in the lake, and was identified by the Florida Department of Environmental Regulation as comprising primarily two species of algae, Anabaena circinalla and Raphidiopsis curvata. Anabaena has not been observed previously in the lake at such high concentrations. Heavy rains and a shift in wind direction helped break up the bloom, which coated a 100 square mile area of the lake. A second smaller bloom was detected on October 8 in the lake.

Algal blooms are a seasonal occurrence in Lake Okeechobee and other sub-tropical lakes in Florida during the summer. The high concentrations of the algae over such a large area caused concern over the potential impacts of deterioration in water quality of Lake Okeechobee. Other smaller lakes in Florida have previously "died off." Algal blooms can result in oxygen depletion of the water, causing fish kills and deterring recreational use. Algae photosynthesize using sunlight to produce oxygen. During the night and when it is cloudy the algae consume more oxygen, causing a drop in dissolved oxygen levels. (Usually, the oxygen liberated by photosynthesis in the daytime is greater than oxygen consumed by respiration). The most critical period of oxygen depletion, however, is when the algae decay. No major fish kills were reported in association with the 1986 bloom, though there remains concern over the health of the lake which has a prolific stock of freshwater fish, especially speckled perch, bass, and catfish.

5.6 Wetlands

Coastal wetlands in the Southeast account for 37.3 percent of the total wetland area of the U.S. (Table 5.9). Wetlands in the Southeast include salt and fresh water marshes, tidal flats, and swamps, the latter of which also includes mangrove wetlands in Florida. Estuaries and associated wetland areas are of critical importance in the coastal zone, providing habitat and nursery areas to fish and shellfish, and acting as a filter for agricultural and industrial waste. They serve as buffers against erosion, minimizing damage from freshwater flooding, waves, and hurricanes. Wetlands are used extensively for recreational

Table 5.9 Coastal wetlands of the Southeast States. Data from NOAA, National Ocean Service.

	Wetland Acres (X 100 acres)					
	Salt Marsh	Fresh Marsh	Tidal Flats	Swamp	Total	(% U.S. Total
NC	1,588	920	N/A	21,075	23,583	(20.8)
SC	3,695	645	N/A	N/A	4,340	(3.8)
GA	3,743	315	95	2,860	7,013	(6.2)
FL	959	3,834	N/A	2,590	7,383	(6.5)
Total	9,985	5,714	N/A	N/A	42,319	(37.3)

(N/A = Not available; Florida data include Atlantic side only)

purposes, but have experienced great demand in recent years for residential and industrial development along the coast.

A wetlands trends study by the U.S. Fish and Wildlife Service (FWS) shows that during the period 1955-75, total wetlands loss for all types of wetlands in the Southeast was 14 percent. The FWS loss estimate includes states in the Southeast from Louisiana to North Carolina. Eighty-five percent of the losses of estuarine wetlands in the U.S. during this period were in this area.

The FWS study showed a slightly higher loss rate for marshland than the estuarine wetlands loss. The average annual net loss rates for the Southeast during the 1955-75 study period were 0.70 percent for all wetlands, 0.35 percent for estuarine wetlands, and 0.45 percent for estuarine intertidal emergents (marshland).

Wetlands in the Southeast were affected by the dryness in 1985 and 1986, continuing into 1987. Three years of dryness in the Southeast may have contributed to more use of some areas fringing wetlands for farming and timber operations.

6. RECREATION

6.1 Summary of Recreational Activity

The Southeastern States are undergoing an expansion in recreational activity which has accelerated over the past ten years. Following a national trend toward coastal development, a recreational expansion is underway which extends not only to use of marine parklands and beaches but also to increasing amounts of residential building near the shores which attracts people seeking a leisure- and outdoor-oriented lifestyle. Florida is well known for having this type of development. North Carolina, South Carolina, and Georgia are also experiencing a surge in both tourists and permanent coastal residents. While both climate and weather vary widely from the Currituck Sound at the northern tip of North Carolina to Biscayne Bay along the southern tip of Florida, recreational development is similar throughout the region.

Beaches are a key feature in the recreational dynamics of the region. The entire Southeastern coastline is characterized by its barrier-island structure and sandy beaches. During the colder months of the year, the southern part of North Carolina has water temperatures above 50°F (10°C) and moderate air temperatures. This has led to the development of beach areas there for year-round vacationing. Midsummer ocean water temperatures range near 80°F (27°C) along the North Carolina coast. As you move south of North Carolina, water temperature changes tend to correspond with weather changes. While water temperatures at the northern range may not be suitable for swimming from November through March, by late April they have warmed enough for water activity. The farther south one goes, the longer the swimming season.

The variety of landscape features in the coastal zone of the Southeast make it an attractive place for recreation. Rivers, deltas, swamps, bays, lagoons, sounds, inlets, creeks, marshes, forests, and lakes occur all along the coast. These features support a variety of ecological systems popular with people seeking to enjoy and understand nature. Four National Marine Sanctuaries are located along the Southeast Coast. Swimming, sunning, snorkeling, walking along the beach, surfing, boating, fishing, bird-watching, hunting, camping, and nature appreciation are among the activities that may be enjoyed. SCUBA diving and spearfishing along both natural and artificial reefs and live-bottom areas are among the more unique recreations that take place.

The coastal areas of the Southeastern States have a long and rich historical background making them popular with tourists who like to visit historic sites, monuments and buildings, and attend outdoor pageants and plays. This history extends from earliest colonial times to the present and attractions in the region range

from the site of the Lost Colony in North Carolina to Fort Sumter National Monument to the Kennedy Space Center.

Remains of maritime history exist along the coast. Sunken wrecks of Spanish treasure fleets abound off the Florida coast. Wrecks associated with American colonial development and U.S. economic development are frequent along the continental shelf. Wreck-diving is a growing activity with a small but enthusiastic following in the region. Maritime monuments, lighthouses, and collections of maritime memorabilia are located along the entire shore. The National Oceanic and Atmospheric Administration administers the site of the remains of the Civil War ironclad, U.S.S. Monitor, sunken in a storm off Cape Hatteras, NC. This site was named the first U.S. National Marine Sanctuary in 1975.

The popularity of the Southeast coastal zone for recreation has induced private enterprise to provide other commercial attractions for the public's consumption. Theme parks, seaquariums, wild-animal preserves, and general marine amusement parks located near the ocean are parts of this development.

Summary of 1986 weather impacts

Weather in 1986 had no discernible negative impacts overall on recreation in the region. Leading recreational indicators for the Southeast Region (Figure 6.1) show expansion in recreational

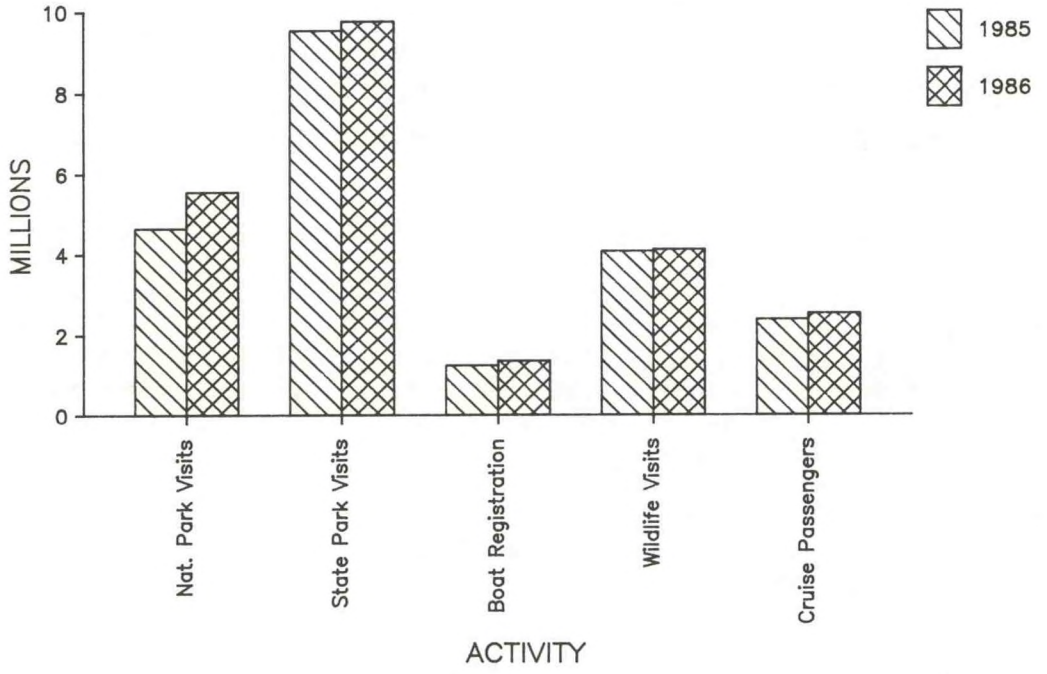


Figure 6.1 Leading recreational indicators, Southeast Region, 1985 and 1986.

activities. National park visits rose by about 20 percent for the region from 1985 to 1986. State park visits rose throughout the region by 2 percent despite a large decline in South Carolina. Although coastal areas did not suffer from the drought to the extent the interior did, the severity of the drought in South Carolina appears to have cut down on the number of visitors to coastal areas. The January freeze in northern Florida and the small number of weak tropical cyclones in the fall all along the Southeast Coast had minor impacts on recreational usage. Boating registration rose a strong 9 percent. Wildlife refuge attendance rose less than 1 percent. Number of cruise passengers carried from Port of Miami rose 6 percent. Overall 1986 continued the trend toward recreational expansion in the Southeast.

6.2 Park and Visitor Center Attendance

National parks

The strong rise over 1985 in visitor attendance at national parks selected for this study was not shared by all of the sites (Figure 6.2 and Table 6.1). The big gainers were Wright Brothers National Memorial (41 percent), Fort Pulaski National Monument (26 percent), Cape Hatteras National Seashore (25 percent), and Canaveral National Seashore (22 percent). The only two parks with declining attendance in 1986 were Cape Lookout National Seashore (-5 percent) and Cumberland Island National Seashore (-6 percent). The two parks with declining attendance were also the two parks with the smallest volume of attendance in the group. The Wright Brothers National Memorial and Cape Hatteras National Seashore are located in an area of North Carolina that has become increasingly popular with tourists from Northern and Midwestern States. This coastal area experienced relatively good spring and summer weather in 1986 unlike some of the western and southern areas of the state that suffered from drought conditions. Fort Pulaski National Monument, located near the mouth of the Savannah River in Georgia did not experience severe drought conditions. Canaveral National Seashore had a strong yearly surge in attendance possibly due to the renewed interest in the Kennedy Space Center as a result of the Challenger disaster of late January.

Four national parks in the Southeastern Region were selected to examine seasonal patterns of attendance at various locations along the coast. In general, these seasonal patterns are the same from year to year, although weather or important events in any location may alter them somewhat. At the four selected locations in 1986 these patterns were maintained for three of the four sites. Cape Hatteras National Seashore experienced modestly rising attendance in March and April which accelerated to a peak in July. By October attendance had dropped back by a third before dropping sharply in the winter months. Canaveral National Seashore, located midway on the Atlantic Coast of Florida, had some of its lowest attendance of the year in the cooler months of

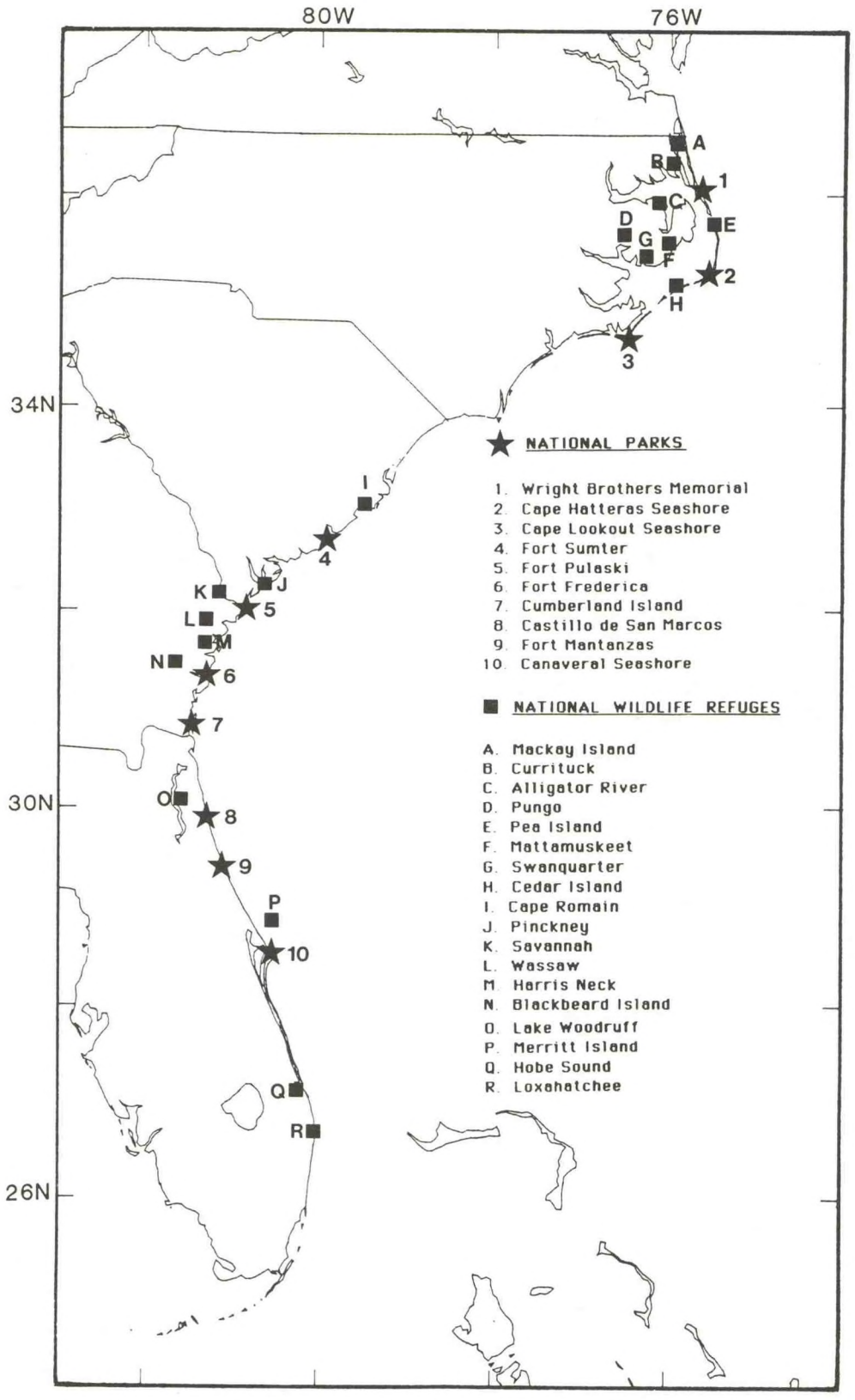


Figure 6.2 Location of selected national parks and wildlife refuges used in this study. Data from National Park Service and U.S. Fish and Wildlife Service.

Table 6.1 Annual visits to selected Southeastern national parks, 1985 and 1986. Data from National Park Service.

	1985	1986
FLORIDA		
Canaveral National Seashore	931,769	1,136,380
Castillo de San Marcos	699,248	732,882
Fort Mantanzas	333,170	368,794
GEORGIA		
Cumberland Island	30,077	28,165
Fort Frederica	231,010	262,653
Fort Pulaski National Monument	381,616	480,859
NORTH CAROLINA		
Cape Hatteras National Seashore	1,224,687	1,535,913
Cape Lookout National Seashore	100,380	95,575
Wright Brothers National Memorial	448,677	630,779
SOUTH CAROLINA		
Fort Sumter	262,019	277,588
TOTAL, ALL SITES	4,642,653	5,549,588

January and February. Visits to the seashore rose sharply in March and reached a peak in April, the height of the Easter vacation season. Attendance then dropped slightly in May and remained at about the same level over the summer months until dropping over the fall and winter months. This pattern was somewhat different from other years when high attendance was achieved in the summer rather than the spring. This change of pattern may be attributed to increased attendance at the Kennedy Space Center which is near Canaveral Seashore. The Center normally has an attendance rise during the spring vacation season. March attendance at Canaveral in 1986 rose 98 percent from the 1985 level and April attendance rose 162 percent despite average March and April monthly mean temperatures in 1986 being -2.2°F and -4.5°F below normal. Both Fort Sumter near Charleston, SC, and Fort Pulaski in Georgia experienced high attendance months from April through August (Figure 6.3).

State parks

The slightly warmer, dryer weather in coastal areas in 1986 had a positive effect on state park visits in three of the four Southeastern States. Florida's Atlantic Coast parks experienced a 14 percent rise in visits in 1986 over those in 1985. The increase in Georgia in state park attendance was 12 percent and in North Carolina it was 9 percent (Table 6.2). Only in South Carolina, where the adverse effects of the drought that began in early spring and lasted through the fall were felt strongly, did state park visits actually decline. Here the drop in 1986 visits from 1985 was 16 percent. Of the four coastal parks in South Carolina, only Edisto Beach showed an increase. Myrtle Beach State Park, which is by far the state park with the largest volume of annual attendance, also had the largest decline from 1985--23 percent. South Carolina park officials believe that the decrease in state park attendance was mainly due to drought conditions throughout the state. The drought impacted incomes of state residents who might have visited the coastal parks. Adverse publicity about the drought also carried to other states from which the Myrtle Beach area draws tourists. Worries about the availability of water might have been a concern of potential tourists. The 1986 decline in South Carolina attendance is an anomalous departure from a long period of strong growth.

Figure 6.4 gives the monthly distribution of visits of four state parks in the Southeast Region. Selection was made on the basis of location; the parks do not have the same facilities. Fort Macon in North Carolina, near Atlantic Beach, has beautiful coastal woodlands and good fishing. The park is a favorite vacation spot for resident and out-of-state tourists from early spring through late fall. In 1986 peak attendance at Fort Macon was in July. Myrtle Beach State Park in South Carolina, the coastal state park with the second largest volume of attendance in the entire Southeast Region, has heavy attendance between April and September. In the peak month of July, visits to the park were nearly four times as great as those in March

Table 6.2 Annual visits, selected Southeastern state parks, 1985 and 1986. Data from Florida, Georgia, North Carolina, and South Carolina Parks Departments.

	1985	1986
FLORIDA		
Cape Florida	671,271	805,661
John Pennekamp	474,926	537,645
Flagler Beach	82,347	112,555
Fort Clinch	177,410	206,072
Fort Pierce Inlet	229,539	232,930
Hugh Taylor Birch	62,161	64,318
Little Talbot Island	115,455	124,527
Lloyd Beach	624,247	680,303
Long Key	99,739	116,502
MacArthur Beach	180,493	143,960
Sebastian Inlet	1,457,854	1,724,256
St. Lucie Inlet	970	13,465
Washington Oaks	81,761	76,544
Total, Florida parks	4,258,173	4,838,738
GEORGIA		
Crooked River	190,457	199,651
Skidaway Island	139,854	170,851
Total, Georgia parks	330,311	370,502
NORTH CAROLINA		
Carolina Beach	195,940	198,488
Fort Macon	1,079,876	1,193,854
Hammocks Beach	29,628	29,942
Jockeys Ridge	304,250	325,867
Total, North Carolina parks	1,609,694	1,748,151
SOUTH CAROLINA		
Edisto Beach	209,904	247,677
Hunting Island	801,004	699,818
Huntington Beach	535,396	485,075
Myrtle Beach	1,790,312	1,372,154
Total, South Carolina parks	3,336,616	2,804,724
TOTAL, ALL SELECTED PARKS	9,534,794	9,762,115

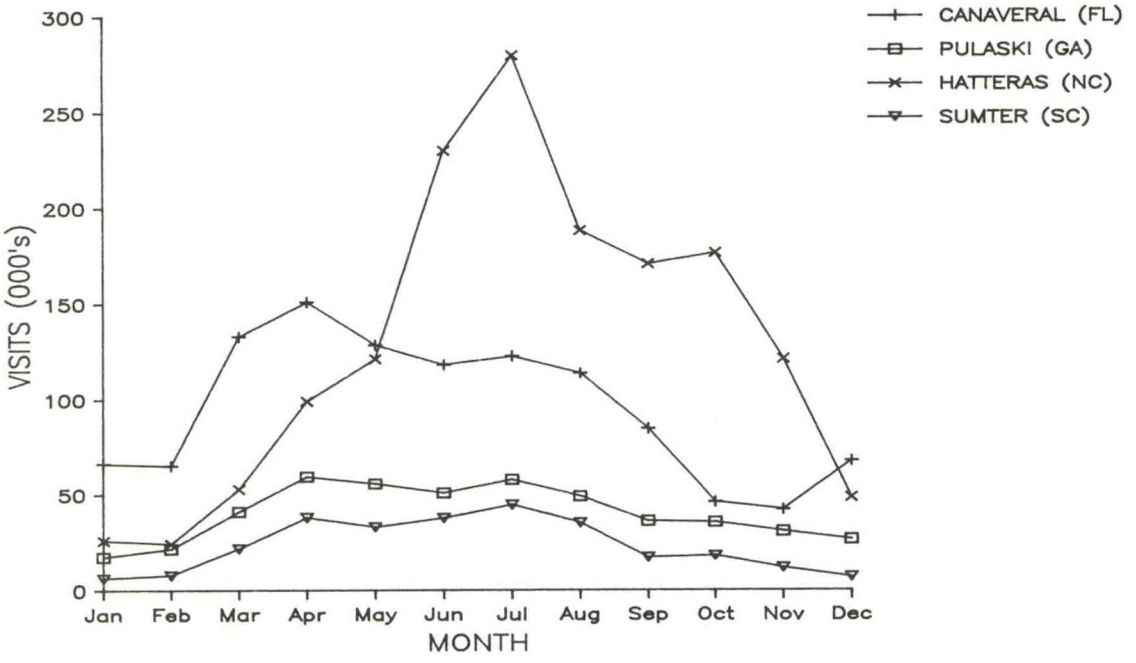


Figure 6.3 Monthly attendance at selected national parks in the Southeast, 1986. Data from National Park Service.

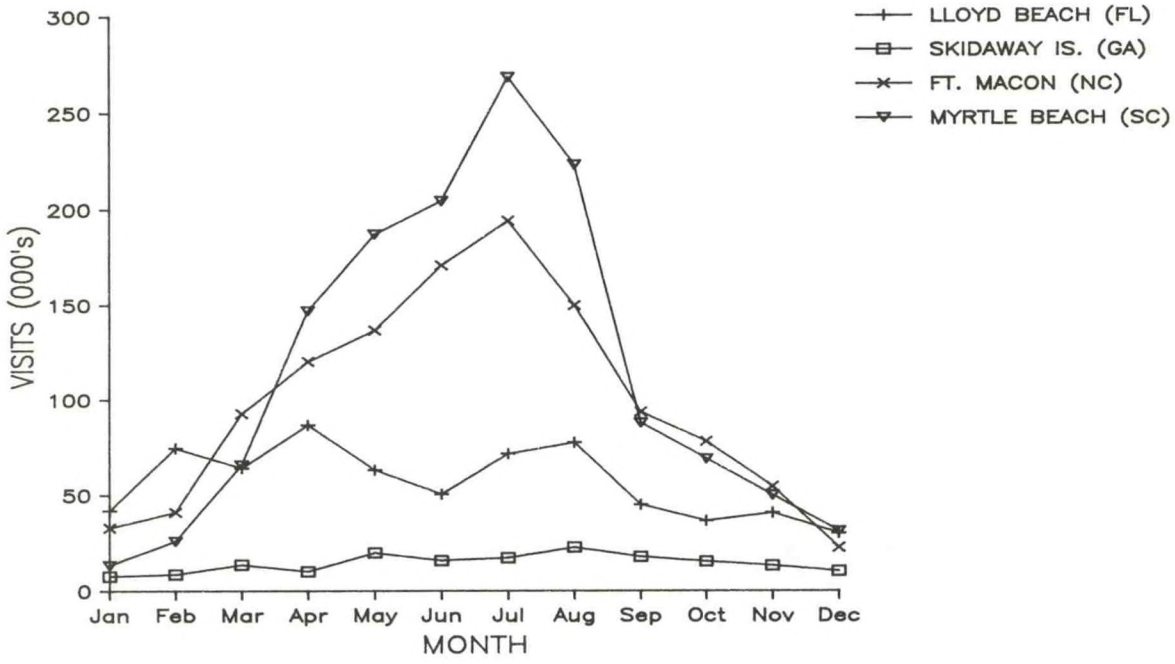


Figure 6.4 Monthly attendance at selected state parks in the Southeast, 1986. Data from Parks Departments of Florida, Georgia, North Carolina and South Carolina.

or October. Despite the fact that Myrtle Beach State Park attendance was 23 percent lower in 1986 than in 1985, the attendance pattern for 1985 was similar. Skidaway Island in Georgia has a fairly even attendance pattern throughout the year. May through September monthly attendance at Skidaway was slightly higher than that for other months. Lloyd Beach, near Miami, FL, with both air and water temperatures supporting a long swimming season, had its strongest attendance in 1986 from February through August. In 1986 the high month of April coincided with the height of the spring vacation season in Florida as it has in other years.

Kennedy Space Center

Kennedy Space Center, located on Cape Canaveral, is the hub of the nation's space operations. Because of interest in the space program and the location of the Center near many popular tourist attractions, it receives many visitors. Two-hour paid tours of the Center are conducted regularly. Ironically, the disaster of the Space Shuttle Challenger on January 28 set off a new wave of interest in the Center. Total attendance for 1986 exceeded that for 1985 by 19 percent (Table 6.3).

Table 6.3 Monthly visits to Kennedy Space Center, FL, 1984-1986. Data from Kennedy Space Center.

	1984	1985	1986
January	88,846	84,160	108,065
February	123,561	125,474	152,165
March	159,345	151,252	196,600
April	149,610	151,167	148,849
May	93,720	91,906	111,280
June	140,122	142,965	170,417
July	173,033	176,952	218,465
August	146,846	152,617	183,683
September	62,154	57,597	70,654
October	80,384	81,334	98,431
November	82,510	80,752	96,814
December	94,229	120,923	126,926
Total	1,394,360	1,417,099	1,682,349

6.3 Recreational Fishing

The variety of marine fishes available to Southeastern fishermen is large. Northern species such as cod and Atlantic mackerel can be found in the ocean off North Carolina during the winter. Warm-water species such as pompano and tarpon are also found there. Along the entire Southeast Coast, freshwater species including catfish, sunfish, and white bass occur in the upper reaches of tidal estuaries. Anadromous species, migrating from saltwater to freshwater to spawn, include striped bass, American shad, white perch, and hickory shad. Diadromous species, living in both freshwater and saltwater without regard to spawning, include tarpon and snook off Florida. Estuarine-dependent species use these estuaries as spawning, nursery, or feeding grounds but are found as adults along the continental shelf. The drum family is the dominant estuarine-dependent group in the South Atlantic zone. Demersal fish such as sea basses, snappers, grunts, and groupers may be found on the bottom near shore or at reefs offshore depending on water temperatures at the location in the South Atlantic zone. Pelagic species such as yellowfin tuna and king mackerel are caught in the open ocean, while bluefish are caught along the coast. Recreational shellfishing species include shrimp, oysters, clams, and blue crabs along the entire coast and spiny lobsters and stone crabs off the southern part of Florida.

Finfishing

In 1985, according to National Marine Fisheries Service marine recreational fishing statistics in Table 6.4, there were 2.4

Table 6.4 Summary of marine recreational fishery statistics, South Atlantic States (FL Atlantic coast, GA, NC, SC), 1982-1986. Data from National Marine Fisheries Service, NOAA.

Year	Estimated number of fish caught (thousands)	Estimated number of participants (thousands)	Estimated number of fishing trips (thousands)
1982	76,844	2,404	15,648
1983	69,418	2,142	15,928
1984	77,955	2,481	17,840
1985	79,523	2,423	19,840
1986	59,047*	1,656*	14,783*

* Data do not contain number of fish, number of participants, and trips of headboat fishery included in previous years.

million fishermen in the region who took nearly 20 million trips and caught almost 80 million fish . Figures for 1986 show sharp declines from these numbers. However, 1986 figures are not directly comparable to those for 1982-1985 since headboat catch, headboat angler participation, and headboat trips were not included in the standard survey results published in Marine Recreational Fishery Statistics, Atlantic and Gulf Coasts, 1986. NMFS officials believe that the apparently large decline in recreational fishing as indicated in the statistics for 1986 shown in Table 6.4 may not be real.

A separate headboat survey for the Southeast was conducted and the results are available from the NMFS Beaufort Laboratory. For the Beaufort survey, a headboat was defined as a commercial boat carrying 15 or more fishermen for a fee. Headboats normally select reef locations for their trips and thus catches are dominated by reef species. The absence of headboat catches in the standard NMFS survey results therefore affects the species catch numbers shown in Table 6.5. An example of this is black sea bass. Reported black sea bass catch in 1986 in the Southeast was 73 percent less than that recorded in 1985.

According to NMFS statistics in Table 6.5 the most abundant species in the catches were croaker and spot. About 50 percent of the recreational catch is comprised of estuarine-dependent species, and about 54 percent of the catch was taken in the ocean less than three miles from shore. Most fish taken by Southeast recreational anglers in 1986 were caught from shore followed in number by those caught from private or rental boats.

Improved recreational fishery statistics are a concern of national and state fisheries managers, interstate fisheries councils, and fishermen. The collection of such data by NMFS began in 1979 and since that time changes have been made in type of data collected and methodology. Therefore the data over this short time span are not fully comparable. There is some feeling on the part of state officials that larger numbers of fishermen need to be surveyed. The issue of more complete data becomes critical in making fisheries allocations and in determining the disbursement of funds for fisheries management. Some states have decided to conduct their own recreational fisheries surveys on an expanded basis but in accordance with NMFS methods. A regional cooperative statistics coordinating committee exists.

Shellfishing

Harvesting of shellfish from public beds for personal consumption occurs all along the Southeast Coast. Regulations on quantity to be taken, size, gear, season, and mode vary from state to state, but, in general, licensing or permitting is not involved. For this reason, figures on the number of recreational shellfishermen in the region or amount of catch do not exist.

Table 6.5 Estimated number, in thousands, of fish caught in the South Atlantic states (FL Atlantic coast, GA, NC, SC), by recreational fishermen, by species group, 1984-1986.[1] Data for 1986 are preliminary. Data from National Marine Fisheries Service, NOAA.

Species Group	1984	1985	1986
Amberjack, greater	142	161	123
Barracudas	200	287	253
Bass, black sea	9,703	6,215	1,677
Bass, striped	--	53	--
Basses, sea	898	372	138
Bluefish	6,201	5,494	3,101
Blue runner	1,019	1,008	2,671
Catfishes, freshwater	--	--	94
Catfishes, saltwater	2,887	3,661	3,033
Croaker, Atlantic	11,275	5,869	6,088
Dolphins	845	787	603
Drum, black	326	263	403
Drum, red	1,130	1,292	553
Drums	--	811	237
Eels	97	72	--
Flounder, southern	428	593	441
Flounder, summer	2,507	2,431	1,484
Flounders	73	45	*
Groupers	437	454	156
Grunt, white	1,979	557	698
Grunts	2,323	2,145	1,036
Herrings	3,406	5,183	5,068
Jack, crevalle	1,127	1,033	2,566
Jacks	561	427	747
Kingfishes	2,026	2,461	3,271
Mackerel, king	1,090	947	592
Mackerel, Spanish	1,169	711	1,066
Mullets	2,473	4,283	1,713
Perch, silver	109	181	*
Perch, white	70	130	144
Pigfish	573	1,396	338
Pinfish	2,335	2,511	2,547
Pompano, Florida	520	836	1,830
Porgies	390	366	134
Porgy, red	1,797	238	--
Searobins	39	168	75
Seatrout, spotted	1,295	2,024	1,958
Sharks	728	648	631
Sheepshead	1,215	603	839
Skates and rays	422	437	306
Snapper, gray	511	1,082	529
Snapper, lane	290	183	210
Snapper, red	975	1,285	45
Snapper, vermilion	1,866	966	56
Snapper, yellowtail	214	404	278
Snappers	227	207	134
Spot	5,817	13,052	5,761
Toadfishes	529	436	559
Triggerfishes/Filefishes	199	283	158
Tunas/Mackerels	177	595	150
Tunny, little	409	359	655
Weakfish	833	359	1,204
Other Fish	2,093	3,159	2,694
TOTAL FISH	77,955	79,523	59,047

[1] Absence of headboat data in results affects species numbers.
-- less than 30,000 reported
* none reported

Artificial reefs

The Southeast is an area in which artificial reef development has provided increased opportunities for recreational fishing. Since natural reefs along the Southeast Coast are only a small portion of the continental shelf area, the States have been experimenting with artificial reefs to increase this type of habitat. Artificial reefs contain elements known as fish aggregating devices (FADs). Inshore, nearshore, midwater, and deepwater reefs have been located either in areas which lack hard bottoms or in areas where specific species are known to swim. The reputation of some of these reefs for good fishing is such that individual fishermen and headboats specifically select these sites. Because of the diversity of species which are attracted to these reefs, they are also used by SCUBA divers. Figure 6.5 shows the approximate location of these reefs along the Southeastern Coast.

Each state has its own approach to reef development. North Carolina, South Carolina, and Georgia have taken a directed approach to development with planning and implementation accomplished by state agencies. In Florida development of reefs has basically been at the local level with city and county governments and individual groups planning, and, upon receiving a state permit, building reefs. Reefs may be constructed of a variety of materials including Liberty ships purposely sunken, tires, concrete rubble, airplanes, and fuel storage tanks. Artificial reefs are marked by buoys.

Although the artificial reefs, when properly constructed, are impervious to damage from winds and waves, such is not the case for the buoys. The coastal storms which hit South Carolina in December 1986 appear to have been the cause of buoys found to be missing from artificial-reef sites several weeks later. One such buoy was recovered off the coast of southern Florida.

Sportfishing tournaments

Recreational fishing reaches a high point of interest and activity in the tournaments which are becoming popular along the Southeastern Coast. Over the years, both participation in the tournaments and numbers of tournaments have grown. Local fishing clubs, chambers of commerce, marinas, and other groups sponsor these contests for promotional purposes. Historically, these tournaments were for larger oceanic species like marlin and tuna but tournaments have moved to emphasizing smaller species.

Because of the importance of tournaments to local and state economies and because tournaments draw on fishery resources, the state of South Carolina has undertaken a program of working closely with the sponsors of saltwater fishing tournaments and assisting in the planning and development of these competitions. Competitions for specific species and those offering cash prizes continued to draw the largest participation. The Arthur Smith

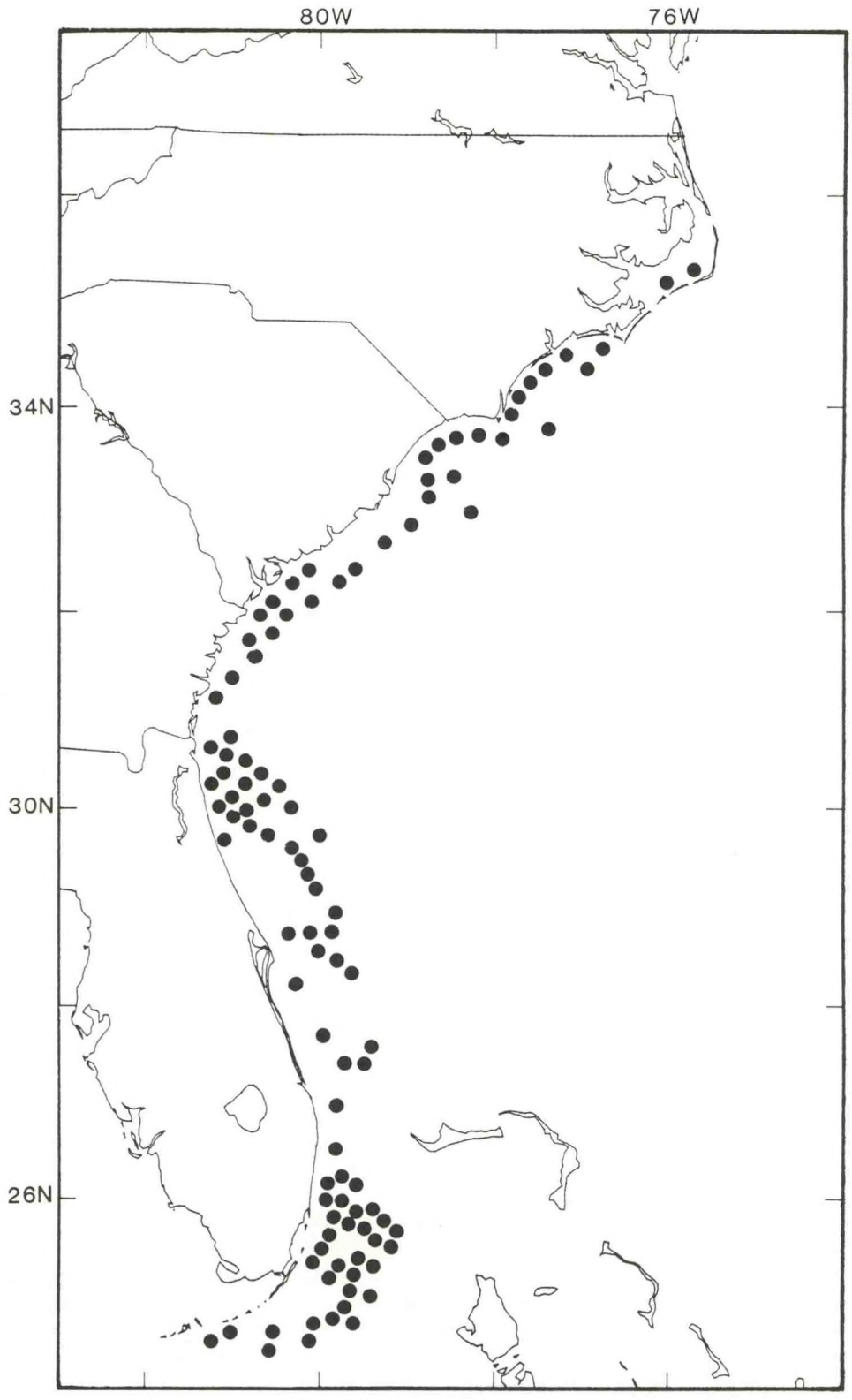


Figure 6.5 Approximate location of artificial reefs along the Southeastern Coast. Recent additions of reefs may not appear. Data from the Artifical Reef Development Center was submitted by Florida, Georgia, North Carolina, and South Carolina.

King Mackerel Tournament, held each fall in the Myrtle Beach area, offered $250,000 in prizes in 1986 and attracted over a thousand boats. So great has the expansion of tournaments been that they are considered to be a marine business.

However, the growth of tournaments has put pressure on sportfishing species causing concern for the survival and management of these stocks. King mackerel is one of the species that was particularly under pressure in 1986.

Economic value

Over the past few years increasing attention is being given to the economic value of recreational fisheries. Purchases for this recreation go far beyond rod, bait and tackle, clothing, trips to participate in the sport, and food. Recreational fishing spawns a complex of related expenditures including boats, tournaments, fishing guides, charter and partyboat fees, motel and restaurant usage, fishing clubs, and other items. The recreational fishery is significant and diverse along the Southeast Coast.

As fishery resources come under stress or decline, fisheries managers at state and Federal level are frequently called upon to allocate the allowable/sustainable catch of a fish stock between commercial and recreational fishermen or to curtail both methods and modes by which fish are taken. The king mackerel fishery in the South Atlantic has recently been under such scrutiny. In addition to establishing historical participation in the fishery, an issue that is frequently raised is the "value" of the commercial and the recreational fishery. A study published by the Florida Sea Grant College by Frederick W. Bell and others in 1982 addressed just this issue. The Economic Impact and Valuation of Saltwater Recreational Fisheries in Florida found that in 1980-1981 the value of the recreational fishery in all of Florida was between 5.6 and 6.5 times the value of the commercial fishery. The commercial fishery was found to have primary economic impact of between $288 and $332 million while the impact of the recreational fishery was valued at $1.87 billion.

6.4 Recreational Boating and Recreational Cruises

Boating

Recreational boating is popular in the Southeast. A fairly long boating season from southern North Carolina southward, relatively calm seas much of the year, and the lure of good fishing enhance the attractiveness of this recreation in the region. The growth of boating in the Southeast for the period 1976 to 1986 was 44 percent, or 1.5 times the national growth rate of 29 percent (Table 6.6). Population growth and recreational development in the coastal zone contribute to this increase. Florida, one of the fastest-growing states in the nation, has almost half the registered boats in the Southeast

Table 6.6 Boating registrations, in thousands, Southeastern States, 1976 and 1984-1986. Data from U.S. Coast Guard.

	1976	1984	1985	1986	Percent Change 1976-1986
Florida	436.3	517.4	537.7	613.5	41
Georgia	174.3	225.8	242.0	248.5	43
North Carolina	163.5	202.9	218.0	229.8	41
South Carolina	160.3	168.3	233.9	249.1	55
Total Southeast	934.4	1,114.4	1,231.6	1,340.9	44
Total U.S.	7,671.2	9,415.0	9,583.7	9,876.2	29

Region. In 1986 boating registrations in the region grew 9 percent over those of 1985. This was three times the national rate, but Florida boat registration grew 14 percent. In 1986, according to Coast Guard figures, South Carolina had the highest ratio of boats per 1000 people of any of the Southeastern States. South Carolina also showed the largest rate of boating growth in the region over the decade 1976-1986--55 percent.

Although expenditures for maintenance, usage, and trips are part of the impacts from the recreation that may even exceed boat and equipment purchases, boating sales form a significant area of impact on the regional economy. For example, for 1985, the National Marine Manufacturers Association reported that boat, motor, trailer, and accessory sales in the Southeast totaled nearly $1.1 billion. Florida was overwhelmingly the nation's leading state in sales of boats, outboard motors, and boat trailers. In sales of marine accessories it was fifth.

In the Southeast there are strong linkages between the ownership and use of recreational boats and participation in recreational fishing and SCUBA diving. Along the Florida Keys, SCUBA diving is a major recreation with important economic impacts particularly resulting from clothing, gear, and equipment purchases.

Marinas

Marinas in the Southeast are most commonly developed in locations near fishing and diving areas. In North Carolina the largest number of marinas are situated in Carteret County. In

South Carolina, marinas tend to be concentrated in the Grand Strand area (Myrtle Beach-Georgetown), the Charleston area, and Hilton Head. There is strong development of marinas all along the Atlantic Coast of Florida, but the most intense development is from Cape Canaveral southward. There are 129 marinas on the Indian River in Florida accommodating about 36,000 boats.

Marina development in the Southeast has taken place in a variety of ways. Marinas may be commercially-owned offering services to all who wish them. Marinas may be publicly built and operated by city or county governments. Increasingly, there is a trend to land developers building marinas as a part of residential construction, thereby providing a whole recreational complex with their service. Finally, there are totally private marinas operated by clubs or others.

Marina developers seek locations which minimize exposure to damaging storms. However, the most critical factor in the siting and permitting of new marinas is their projected impact on water quality and potential effects on shellfish beds as well as direct impacts on shallow-water nursery habitats and wetlands. In Florida, for example, water depth and projected impacts on seagrass and mangrove habitats must be evaluated in environmental impact statements concerning the development of marinas as must projected impacts on the endangered Florida manatee.

Boating weather

Small craft advisories, gale warnings, and storm warnings are indicators of weather in an area that may curtail boating activity. A complete record for 1986 of small craft advisories, gale warnings, and storm warnings is unavailable because of the way the National Weather Service now issues marine advisories pertinent to recreational boats. Analysis of the monthly data for 1985 through May 1986, the last month for which these data were available, reveals a clear pattern of boating weather along the Southeast Coast.

Table 6.7 gives a summary of these data for issuances by the Raleigh-Durham forecast office which provides forecasts for the entire coast of North Carolina and the Miami forecast office which issues warnings for coastal areas as far north as Savannah, GA. Information on marine advisories issued by the Columbia, SC forecast office was not available in the format based on windspeed presented in the table. Although the total number of marine advisories issued by Raleigh-Durham office was higher for January 1985 through May 1986 than for Miami, the Miami office issued more higher-intensity warnings (gale and storm). The Raleigh-Durham area showed a consistently high number of advisories issued from mid-fall through early spring. In Miami, December and January seemed to have the worst marine weather.

Table 6.7 Summary of small craft warnings, Miami, FL, and Raleigh-Durham, NC forecast offices, January 1985-May 1986.[1] Data extracted from Automation of Field Observations and Services (AFOS) Inventory, National Climatic Data Center.

	Miami			Raleigh/Durham		
Month	SCA	Gale	Storm	SCA	Gale	Storm
1985						
January	17	1	26	31	1	0
February	4	1	1	17	0	0
March	11	3	2	31	0	0
April	9	0	0	18	0	0
May	3	0	0	23	0	0
June	1	0	0	18	0	0
July	0	2	0	11	0	0
August	7	1	0	8	0	0
September	9	0	0	11	0	0
October	0	4	0	28	0	0
November	4	1	0	27	0	0
December	21	1	0	30	0	0
Total, 1985	86	14	29	253	1	0
1986						
January	15	0	16	32	0	0
February	14	0	0	29	0	0
March	14	0	12	2	0	0
April	0	0	0	0	0	0
May	11	0	0	15	0	0

[1] Columbia, SC advisories were not available in the table format.

SCA = small craft advisory (wind 25-34 knots)
Gale = gale warning (wind 34-47 knots)
Storm = storm warning (wind 47-64 knots)

Search and rescue (SAR) operations

Statistics on search and rescue operations conducted by the U.S. Coast Guard are an indirect indicator of the degree of boating activity in any month. The greater the number of boats on the water, the greater is thought to be the likelihood of need for the assistance of the Coast Guard. The available data indicate the caseload in 1986 was slightly below that of 1985 (Table 6.8). A 5 percent drop occurred between 1984 and 1985 and is part of a nationwide trend in declining SAR cases. Data on monthly caseloads indicate strong activity between December and July, possibly reflecting the unpredictability of spring weather coupled with seasonal desire to get out on the water with the earliest warm weather. The lowest number of SAR cases appear from September through November. The SAR operations in the Southeast are heavily dominated by boating south of Cape Canaveral in Florida, where the majority of cases occur.

Table 6.8 Recreational Search and Rescue caseload and property lost, Atlantic Coast waters, Southeastern States, 1984-1986.* Data from U.S. Coast Guard.

Month	1984		1985		1986	
	Cases	Property (000 $)	Cases	Property (000 $)	Cases	Property (000 $)
January	421	85	474	142	394	332
February	572	333	622	682	466	356
March	607	384	606	390	533	490
April	618	204	590	404	619	173
May	661	1,427	575	117	464	177
June	419	129	390	233	398	144
July	496	151	402	405	384	68
August	339	387	324	300	345	282
September	258	88	311	158	190	211
October	239	77	215	233	N/A	N/A
November	232	417	267	610	N/A	N/A
December	443	333	254	245	N/A	N/A
Totals	5,305	4,015	5,036	3,919	N/A	N/A

* Fiscal year from October 1 through September 30.

N/A - Not available

Recreational cruising

Recreational cruising involves the enjoyment of the marine environment aboard ships that might be called floating resorts. Miami, FL is the number one cruise port in the world. Miami's location at the convergence of the Atlantic, the Caribbean, and the Gulf of Mexico, its year-round warm climate, and its proximity to other recreational areas have made it an attractive port from which to embark and debark. Economic impacts extend beyond the cruise industry to businesses like airlines bringing cruise passengers, hotel and motels in the Miami area, food services supplying ships, port and terminal businesses, and gasoline stations serving passengers who come by auto.

Cruise passengers using Port of Miami in 1986 numbered over 2.5 million (a round-trip passenger is counted once at embarkation and debarkation), which was an increase of about 6 percent over the number of 1985 passengers. Port Everglades and Port Canaveral also have substantial cruise businesses. Over a half million passengers passed through each port in 1986.

Figure 6.6 indicates that cruising is an all-year recreation with the peak interest during the spring and summer. The fall months of September and October, which traditionally have the highest incidence of tropical cyclones in the region, are the months of lowest interest in cruising. In 1986 tropical cyclone activity which might affect these cruises did not develop.

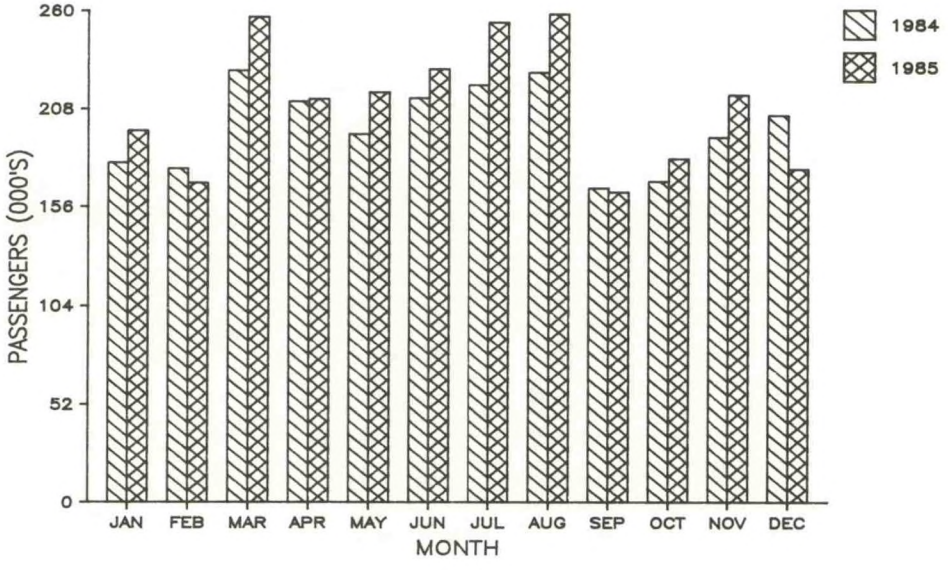


Figure 6.6 Number of cruise passengers embarking and debarking at Port of Miami, FL, 1985 and 1986. Data from Port of Miami, FL.

6.5 Wildlife Observation and Use

Preliminary results from the 1985 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation reveal that in 1985 134.7 million citizens, who were 16 years or older, actively participated in nonconsumptive wildlife-related activities such as feeding, observing, or photographing wildlife. About 105.3 million of these nonconsumptive participants took part in these activities around their homes and over 29.5 million reported taking trips for the primary purpose of observing, feeding, or photographing wildlife. Americans spent a total of over $14 billion on equipment such as binoculars, cameras, and birdfeeders, and on transportation and other costs associated with wildlife observation. National wildlife refuges operated by the U.S. Fish and Wildlife Service are among the most popular places for observing wildlife.

Nationally, about 16.7 million Americans hunted in 1985. Big game was sought by about 75 percent of these hunters; small game by about 65 percent; migratory birds, such as ducks, geese, and doves, by about 30 percent; and 17 percent reported hunting other animals including raccoons, fox, and woodchuck. In 1985 hunters spent an average of $604 per hunter for their sport. They were afield a total 335.1 million days, an average of 20 days per hunter. Approximately 1.45 million of these hunters were residents of the Southeast Region.

The Southeast is an area particularly attractive for wildlife observation and its use. The coastline, which is dominated by barrier islands, beaches, tidal marshes, bays, and deltas, provides an ideal setting for waterfowl and for shore and wading birds. Forests, savannas, and swamps provide habitat for mammals, birds, and reptiles. Participation in wildlife activities may be strongly affected by unusually cold or rainy weather or by tropical cyclones passing through the area. Habitat may be affected by drought which can cause a decline in species numbers. However the coastal areas of the Southeast do not appear to have been negatively impacted by the weather of 1986 although some minor effects from the drought appeared. These effects are seen in declines in wildlife refuge attendance in South Carolina.

Bird-watching

One of the best indicators of the popularity of this bird-watching is attendance at the many national wildlife refuges located along the coast. In 1986 attendance at selected refuges rose by about 1 percent to 4,113,590 visits after a 15 percent rise from 1984 to 1985 (Table 6.9). Attendance figures from year to year are not always comparable because of variations in counting methods at some of the refuges. The only Southeastern State showing an attendance decline in 1986 was South Carolina. The drought cut down on the number of visitors coming to the South Carolina coast.

Table 6.9 National wildlife refuge visits, in thousands, selected Southeastern coastal sites, 1984-1986.* Data from U.S. Fish and Wildlife Service.

	1984	1985	1986
FLORIDA			
Hobe Sound	109.7	151.5	151.5
Lake Woodruff	24.1	23.9	24.8
Loxahatchee	395.3	410.4	433.6
Merritt Island	1,686.6	1,808.7	1,681.8
Total, Florida sites	2,215.7	2,394.5	2,291.7
GEORGIA			
Blackbeard Island	4.5	3.6	4.4
Harris Neck	6.3	3.7	3.0
Savannah	93.4	77.3	122.4
Wassaw	23.8	27.9	34.0
Total, Georgia sites	128.0	112.5	163.8
NORTH CAROLINA			
Alligator River	not open	8.2	8.8
Cedar Island	47.1	49.8	51.0
Currituck	not open	33.9	23.6
Mackay Island	33.2	32.0	33.2
Mattamuskeet	40.4	33.8	43.3
Pea Island	954.4	1,226.2	1,338.9
Pungo	16.4	14.0	13.1
Swanquarter	8.0	9.1	6.8
Total, North Carolina sites	1,099.5	1,407.0	1,518.7
SOUTH CAROLINA			
Cape Romain	76.4	127.0	83.2
Pinckney	22.2	36.1	56.2
Total, South Carolina sites	98.6	163.1	139.4
TOTAL, ALL SOUTHEASTERN SITES	3,541.8	4,077.1	4,113.6

* Fiscal year from October 1 through September 30.

Protection and observation of endangered species

The national wildlife refuge system not only provides suitable habitat for migratory waterfowl, it also provides places where endangered species can thrive. Observation of endangered or threatened species may be restricted when it conflicts with the management of the resource.

Hobe Sound National Wildlife Refuge, located 20 miles north of West Palm Beach, FL, is a multipurpose refuge. The diverse habitats of Hobe Sound include mangrove swamps, forests, beaches, and dunes. The beaches are used for nesting by the threatened loggerhead sea turtle and the endangered green and leatherback sea turtles. Bald eagles, osprey, brown pelicans, and a variety of marsh, wading, and shore birds regularly use the refuge. The protected inland waters adjacent to the refuge have a population of the endangered Florida manatee or "sea cow." Endangered or threatened species known to be living on or using the wildlife refuges of the Southeast are listed in Table 6.10.

Table 6.10 List of endangered or threatened species known to use national wildlife refuges, Southeastern Coast, 1986. Data from U.S. Fish and Wildlife Service.

American alligator
Atlantic leatherback turtle
Eastern brown pelican
Eastern indigo snake
Florida Everglade kite
Florida manatee
Florida panther
Green turtle
Jaguarundi
Loggerhead turtle
Peregrine falcon
Red-cockaded woodpecker
Southern bald eagle
Wood (ibis) stork

Hunting

The taking of game both for sport and for food is popular throughout the Southeast and takes place in coastal areas on both public and private land. In 1986 the number of paid hunting license holders in the region was 1,157,249, down just slightly from the previous year (Table 6.11). Given the national average

Table 6.11 Number of paid[1] hunting license holders, Southeastern States, 1984-1986.* Data from U.S. Fish and Wildlife Service.

	1984	1985	1986
Florida	254,802	257,467	248,542
Georgia	371,203	386,095	397,145
North Carolina	333,020	334,169	329,633
South Carolina	200,371	201,602	201,899
Total	1,159,396	1,179,333	1,157,249

[1] A paid license holder is one individual regardless of the number of licenses the person may purchase.
* Fiscal year from October 1 through September 30.

expenditures of $604 per hunter per year, this would mean that in 1986 licensed hunters contributed nearly $700 million to the regional economy. In 1986 the gross cost to hunters for licenses and permits in the Southeast was nearly $18 million Hunting in coastal areas was not affected by any major weather events in 1986.

Migratory-bird hunting

Migratory-bird hunting in the Southeast is a popular recreation and follows national trends in the use of this resource. All States of the Southeast are in the Atlantic Flyway, the flight path along the Atlantic Coast. The number of migratory birds reaching these States is impacted by conditions on northern breeding grounds, suitable habitat within the states, and weather conditions during the time of their arrival. Over the past few years conditions on northern breeding grounds have not been good, cutting down on the number of birds arriving in the Southeast area. Estimates on the number of birds expected to arrive are usually published in newspapers in the area, allowing hunters to decide in advance whether they wish to purchase the necessary stamps and permits for migratory bird hunting.

A Federal Migratory Bird Hunting and Conservation Stamp (popularly referred to as a "duck stamp") is one of the stamps required to hunt these birds. Migratory waterfowl are usually hunted from late fall through mid-winter. For the 1986-87 hunting season, number of duck stamps sold in Southeastern States was 87,195, down less than 1 percent from the previous year (Table 6.12). However, the drop in these sales for the 1985-86

Table 6.12 Number of Migratory Bird Hunting and Conservation Stamps ("duck stamps") sold in Southeastern States, 1984-1986 hunting seasons. Data from U.S. Fish and Wildlife Service.

	1984	1985	1986
Florida	25,014	22,191	20,228
Georgia	19,024	16,943	17,145
North Carolina	31,363	29,880	30,410
South Carolina	20,726	18,650	19,412
Total	96,127	87,672	87,195

season from the 1984-85 season was 9 percent reflecting the lowered forecasts of arrival of birds which continued into the 1986-87 hunting season. Duck stamps are purchased at U.S. post offices and some of the sales are to stamp collectors. This makes the use of the data on sales somewhat unreliable in arriving at the number of actual hunters. However since the collection of these stamps has become popular, it appears that the drop in stamp sales in the Southeast over the last two seasons was caused by a decline in hunters.

Multiple-use problems on national wildlife refuges

Wildlife refuges frequently share coastal rivers and estuaries with other users such as shipping, water treatment plants, industry, agriculture, and residential building. The water quality and condition of wildlife are sensitivity measures of the degree of pollution or habitat alteration caused by these other uses or environmental change. Pollution and habitat problems may result from long-term degradation of the environment or short-term individual events.

"Activities of the U.S. Department of the Interior in Albemarle-Pamlico Estuaries, North Carolina" (1987) identified a number of problems which have developed or may develop in all of the refuges there. It cited degraded water quality and decline in available habitat as major problems and projected that as the natural vegetative cover continues to be removed, the wildlife refuges will become increasingly isolated in a developed and altered landscape. Specifically, for example, the report found the following current or potential problems at the Pea Island National Wildlife Refuge, the most popular coastal national refuge in North Carolina: discharge and runoff of toxic chemicals, sediment, and freshwater into Pamlico Sound; water quality degradation from septic tank discharge into Pamlico

Sound; oil spills; ocean overwash with subsequent land loss; saltwater contamination of impoundments; and declining waterfowl populations. The report concluded that should the current rate of encroachment continue as expected, the refuge would become subject to environmental problems which are beyond the control of refuge managers.

An oil spill in December 1986 in Savannah Harbor affected living marine resources in the Savannah National Wildlife Refuge. Oil began to spill from the Liberian tanker Amazon Venture on December 4 and eventually 500,000 gallons of diesel oil leaked into the river. The spill left an oily ring along some sections of the shore due to tidal fluctuations. Booms were deployed to prevent the spread of oil. However, strong currents and tidal fluxes carried the oil upstream into the national wildlife refuge (Figure 6.7 a). The states of South Carolina and Georgia, the U.S. department of the Interior, and the U.S. Department of Commerce were parties to a suit filed against the owners of the tanker.

Several distinct impacts resulted from oil in the Savannah River. Some birds were coated with oil (Figure 6.7 b). The refuge was closed for three weeks after the spill and several dead birds were suspected of having died because of the spill. The migratory bird hunting season was also closed in the area. Both commercial and recreational oyster and clam beds were closed. The Georgia Department of Natural Resources issued warnings about oil in the flesh of speckled (spotted) seatrout, a favorite recreational fish. Marsh grass became coated with oil. Other possible short- and long-term impacts such as contamination of sediments were investigated.

6.6 Travel and Tourism

Climate plays a large role in making Southeast coastal areas attractive for tourism and travel. It has been a significant factor in the trend toward recreational expansion in the area, including the development of new facilities. While the trend to travel-tourism expansion has been underway for a decade, weather in any one year may interfere or disrupt this trend in one or more states of the region. On the whole, weather in 1986 was conducive to the expansion of travel and tourism in the Southeast with the exception of drought impacts on South Carolina. A summary the year's developments in each of the states follows:

Florida. Despite a cold snap in January and some extension of the drought into the state, Florida weather in 1986 was mainly conducive to the expansion of travel and tourism. Total visitors to the state in 1986 were 33.7 million, an increase over 1985 of 12 percent. Travel-related employment totaled 570,800, an increase of 9 percent from 1985. Eating and drinking places were the largest travel-related employers with hotels and lodging next. In 1986 the tourism-recreation sales tax collection

Figure 6.7 (a-b) Booms deployed to control oil spilled from the Amazon Venture failed to prevent the oil from reaching the Savannah National Wildlife Refuge. (b) An oiled red-tailed hawk recuperating from its encounter.

amounted to 19.4 percent of the state tax collection, the largest single contribution to state taxes. Atlantic Coast counties hold the majority of positions of top ten travel destinations of both air and auto travelers to Florida. Orange-Osceola counties, the area in which Walt Disney World is located, was the top destination of over 25 percent of the visitors surveyed.

Georgia. While Georgia suffered extensive impacts from the drought, areas that tourists visit, many in coastal areas, maintained their attractiveness. Visitors to Georgia Welcome Centers increased about 25 percent in 1986. Travel-related employment, wages and salaries, owners' profit, and state taxes expanded slightly. While the coastal areas of Georgia are popular recreation spots, their further development is limited by the geomorphology of the region and the fact that much of the land that could be developed is held in trust.

North Carolina. Drought impacts were mainly felt in the western part of the state, particularly around Charlotte, and did not on the whole influence tourism in the state. Travel expenditures in the state approached nearly $5.1 billion in 1986, an increase of about 10 percent over 1985's record figure. Of these expenditures, approximately $1.4 billion was spent by state residents and $3.7 billion, or 72 percent, by out-of-state visitors. Coastal counties continue to share in this expansion. Brunswick and New Hanover in the southern part of the state and Dare, the county where the popular Nags Head and Kill Devil Hills are located, are the leading coastal counties where travel-related expenditures are made. In 1986 the number of establishments in seven sectors serving travelers was estimated at 13,100, up over 1 percent from 1985. Estimated private enterprise employment in these seven sectors rose more than 6 percent to an estimated 215,000 persons whose jobs depended significantly or entirely on travel and tourism.

South Carolina. Although the State's 9 percent travel and tourism growth in 1986 did not match the 10.2 percent of the previous year, it continued a long trend of substantial gains. Tourism is one of South Carolina's leading industries. Coastal tourism is 70 percent of the State's total. In 1986 disturbance to normal coastal travel trends was made by adverse reports on drought conditions leading potential travelers to believe there were water shortages and other problems in coastal areas. Actually the physical impacts of the drought did not extend to these areas. The leading county in the entire State in travel-related expenditures is Horry, the location of Myrtle Beach. It leads all others in number of visitors, expenditures, and payroll for jobs, reaching well over $1 billion in expenditures in 1986.

7. TRANSPORTATION

7.1 Summary of Transportation Activities

Virtually all international goods trade is transported by sea. Consequently, ocean ports and shipping services play central and essential roles in the world economy and global trade. The United States is the world's largest trading nation and international markets play an increasingly important part in the U.S. domestic economy. During the 1970's the amount of U.S. international trade in terms of tonnage nearly doubled, rising from 563.6 million short tons (mst) in 1970 to 962.9 mst in 1979. During the same time, the value of U.S. trade more than doubled. By 1985, however, rising oil prices and global grain surpluses (as well as financial difficulties in much of the third world) led to a decline in both liquid and dry bulk shipping world wide. The result was that by 1985, total U.S. waterborne foreign commerce had declined to 751.6 mst.

These national and international shifts were not uniformly felt on a regional basis, however. In 1970, the major U.S. coastal regions ranked as follows: North Atlantic (258.1 mst), Gulf (125.0 mst), Great Lakes (62.4 mst), South Pacific (40.4 mst), South Atlantic (39.8 mst), and the North Pacific (38.0 mst). By 1985, the Gulf states had overtaken the Northeast as the dominant region and the Great Lakes also suffered a decline. The remaining regions, including the South Atlantic, all experienced net increases. By then, the rankings were: Gulf (284.9 mst), North Atlantic (225.6 mst), North Pacific (67.3 mst), South Pacific (65.3 mst), South Atlantic (57.3 mst), and the Great Lakes (51.3 mst). Thus, the overall impact of these changes was a general expansion and broadening of international trade from the Northeast and the rust belt towards the south and west. The relative share passing through the South Atlantic states, however, edged up only slightly, from just above 7 percent in 1970 to 7.6 percent by 1985.

Intense competition among ports together with a declining number of steamship lines has led to the emergence of special tariff rates and contract prices which have tended to erode port earnings. Ports have responded in part by building new and modernized cargo handling facilities which in some cases has resulted in overcapacity. The introduction of new high capacity vessels in the steamship industry has resulted in overcapacity as well, leading to aggressive rate slashing and bankruptcy, as was the case with the recent financial collapse of U.S. Lines, Savannah's largest carrier.

Port development and normal maintenance require a variety of dredging activities in harbors, turning basins, and channels. In 1986, reported dredging within the Southeast amounted to 15 million cubic yards - roughly 5 percent of the nation's total -

at a cost of over $25 million.

Weather conditions in the South Atlantic are generally congenial to port operations year round. Winds are rarely high enough (35 mph or more) to cause a shutdown of crane operations and a suspension of port loading/unloading activities. However, for the 6-month period from the end of May to the first of December, the region is subject to tropical storms and hurricanes. The most likely sites to experience a hurricane are Miami, Charleston, and Cape Hatteras. The occurrence of disabling fog is very rare throughout the region.

In 1986 hurricanes or tropical storms were few and of insufficient strength to affect operations at any of the ports in the Southeast. A greater-than-normal incidence of heavy fog (that reducing visibility to a quarter mile or less) in November 1986 - 10 days versus 4 days normally in November at Charleston and 12 days versus 5 days normally at Jacksonville - resulted in economic losses from delayed docking and unloading. Delays or losses were regarded as minimal at the Port of Charleston. At Jacksonville each additional day of fog can result in 2 - 3 hours of labor lost at a cost of $10-20,000 to the vessel operator.

7.2 Shipping

The Southeastern Region's seaborne trade passes through 11 major ports -- two each in North Carolina, South Carolina, and Georgia, and five in Florida. In terms of tonnage, by 1985 the major importing ports within the region were Savannah, GA (24.2 percent); Jacksonville, FL (15.3 percent); Charleston, SC (14.1 percent); and Port Everglades, FL (12.5 percent). The major exporting ports were Savannah, GA (31.0 percent) and Charleston, SC (29.0 percent). Other important ports within the region include Wilmington, NC; Beaufort-Morehead City, NC; Georgetown, SC; Brunswick, GA; Port Canaveral, FL; Palm Beach, FL; and Miami, FL. Throughout the region, year-round temperate climate conditions serve to minimize weather delays and maximize the output of waterfront labor. Figure 7.1 shows the locations of these 11 ports and the tonnages they handled.

Major exports from the Southeast include paper, woodpulp, machinery, agricultural equipment, chemicals, tobacco, and textiles. Indeed, due in part to the fact that U.S. manufacturers have persistently been the most efficient and innovative producers of woodpulp and woodpulp products in the world, woodpulp has been the major export commodity from the South Atlantic Region. Major imports include iron, steel, metal ores, lumber, and petroleum products. Some ports such as Savannah, GA, are roughly balanced between exports and imports, while others such as Morehead City, NC; Charleston, SC; Palm Beach, FL; and Miami, FL, are predominantly export oriented.

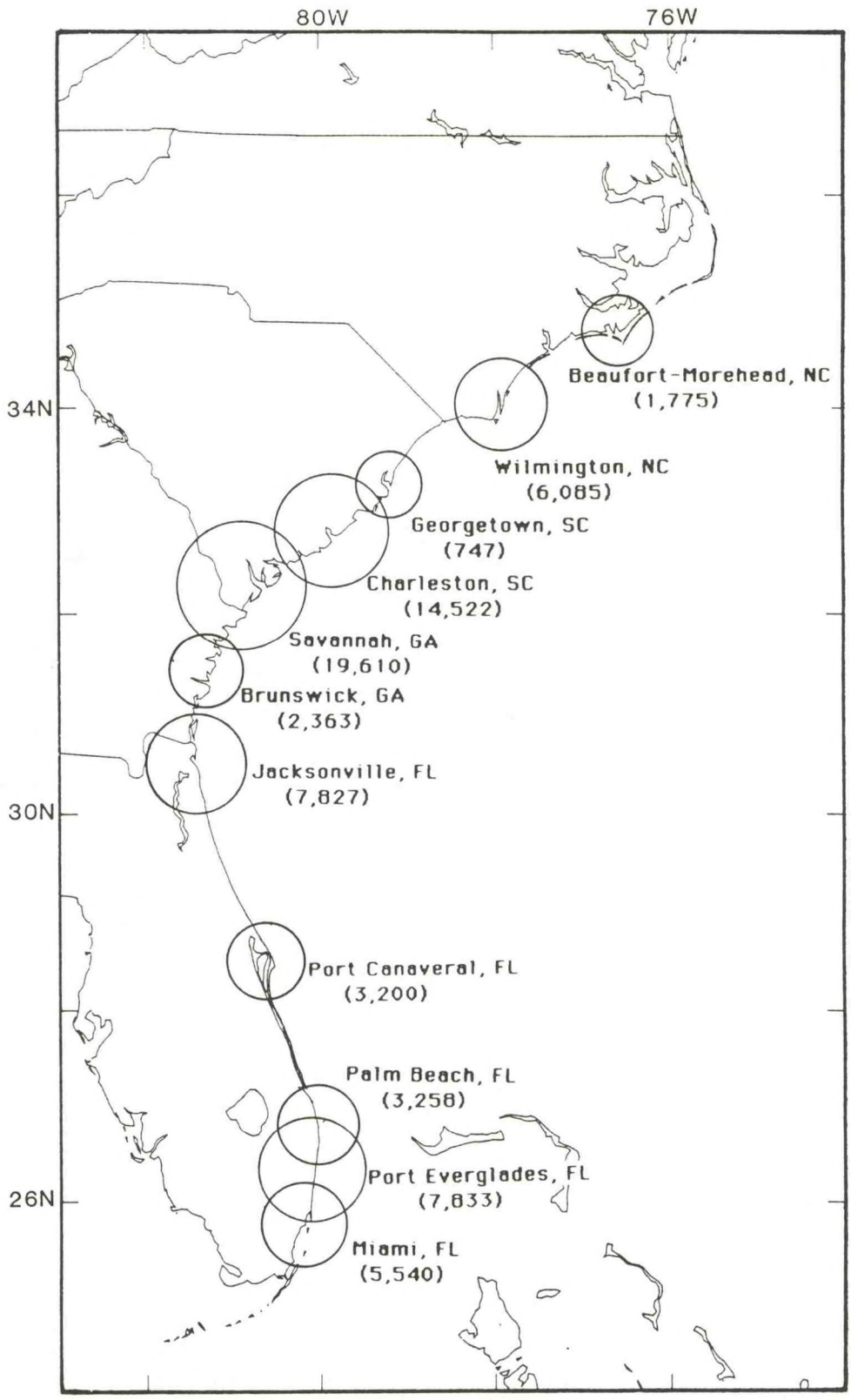


Figure 7.1 Locations of major ports of the Southeast with tonnages (in thousands) handled. Circle size corresponds to relative volumes handled at each port in 1986. Data from U.S. Bureau of the Census.

Still others such as Jacksonville, FL; Port Canaveral, FL; and Port Everglades, FL, are largely import oriented. The region's three major trade routes in terms of tonnage throughput are the Far East, Northern Europe, and the Mediterranean. A brief description of each major coastal port within the region follows.

State Port of Morehead City, NC

Morehead City terminal is situated along the Newport River and Bogue Sound, four miles from the open sea. Norfolk Southern Railway serves the port of Morehead City with a rail network linking the eastern seaboard to New Orleans, Chicago, Kansas City, and Omaha.

State Port of Wilmington, NC

The Port of Wilmington, operated by the North Carolina State Ports Authority, has been serving the state's shippers and receivers for nearly half a century. It is located on the east bank of the Cape Fear River, 26 miles from the open sea. It offers a full range of port services including containerization, breakbulk, bulk cargo, and roll-on/roll-off capabilities. The channel is maintained at 38 feet and there are 10 berths for vessel docking. Over the next five years North Carolina State Ports Authority will complete the most comprehensive development plan ever undertaken, involving nearly $45 million in capital expenditures. At Wilmington, the most significant capital improvement will be the construction of a new 900-foot container berth and the purchase of two additional container cranes. The Port of Wilmington is served by two smaller intermodal container transhipment inland ports (Charlotte and Greensboro) and the Seaboard System Railroad with direct rail links to Charlotte and access to the major intermodal hubs of Atlanta, Chicago, and the West Coast.

Port of Georgetown, SC

The Port of Georgetown specializes in and is totally dedicated to bulk and breakbulk cargo. It is one of the oldest bulk and breakbulk ports in America, having been in continuous operation for over 250 years. Seaboard System Railroad also serves Georgetown as do several interstate highways.

Port of Charleston, SC

The Port of Charleston is one of the largest container ports in the world. The Port's Wando Container Terminal has received worldwide recognition for efficiency and design. Charleston has extensive interstate and rail connections which allow cargo to come directly to Charleston from the major industrial markets of the U.S. Charleston is served by Norfolk Southern and Seaboard System Railroads and by 99 motor carriers with routes throughout the country.

The Santee River was rediverted in August 1985 in the Charleston Harbor area, which may have had a detrimental impact upon fisheries there, and a "Charleston Harbor Study" is now underway to determine what the real effects have been. Charleston Harbor is the third largest seaport in terms of volume and the largest U.S. submarine base in the world.

Port of Savannah, GA

The Port of Savannah is a large, well-protected, deep channel harbor. Savannah offers numerous facilities handling containers, general cargo, dry bulk, liquid bulk, refrigerated cargoes, and barges. It is the fastest growing port in the Southeast, with 6.8 million tons of cargo crossing the docks during 1986 - an 11.5 percent increase in total tonnages handled over the previous year's record. Liquid bulk handling set another record, with 1.3 million tons passing through the pipeline.

Containerized cargo led the port in its landmark year, reaching 3.8 million tons - a 28.5 percent increase over the previous year. Indeed, for the past five years, Savannah's containerized cargo tonnage maintained an average increase of 22.5 percent per year.

Port of Brunswick, GA

Brunswick's Colonel's Island bulk terminal boasts the latest in bulk handling on the U.S. East Coast. It utilizes a special computer to optimize its operation and computer sensors throughout the complex monitor all points of the system.

Port of Jacksonville, FL

In recent years, Jacksonville has been the leading point of entry of automobiles and trucks on the East Coast. With the exception of Atlanta, Jacksonville is the Southeast's undisputed vortex of rail and trucking connections in the South Atlantic Region. No fewer than three major railroads serve the area: Florida East Coast Railway, Norfolk Southern Corporation, and Seaboard System Railroad. Competition between the three for shipper's cargoes has served to keep shipping rates down and driven them to constantly expand and improve their services. However, few if any, import automobiles move from Jacksonville by rail. Proximity to Interstate 10 provides Jacksonville with a gateway to trucking for markets as far away as Texas and Virginia.

Periodic acid rain episodes have been experienced recently in Jacksonville. After a summer shower on August 8, 1986, the paint on 2000 BMW automobiles was pocked and scarred. The acid rain shower - the worst of 11 recorded in 1986 - dissolved the paint on some cars down to the metal, forcing BMW to suspend shipments at the port.

Port Canaveral, FL

Fiscal 1986 was a record setting year at Port Canaveral. All previous records were broken for vessel arrivals, cargo tonnage, cruise passengers, revenue, and income. The cruise industry was Canaveral's star performer, with the number of revenue passengers increasing threefold to over 586,000. Of these, 294,000 sailed on Premier Cruise Lines' three- and four-day cruises to the Bahamas. Furthermore, for the first time, cruise ships produced more revenue than cargo and layberths. Canaveral is located 70 minutes from Walt Disney World and the new EPCOT Center, Sea World, and other major attractions. It is 15 minutes away from the Kennedy Space Center's Spaceport USA, home base for the Space Shuttle fleet. It is now one of the largest cruise passenger ports in the U.S.

During the year, a number of port expansions were undertaken. Mid-Florida Warehouses completed a new 40,000 square foot refrigerated warehouse in February, bringing the total dockside refrigerated space to 140,000 square feet. In April Cruise Terminal Four was completed and Cruise Terminal Three was expanded 4,000 square feet. In July Mid-Florida Warehouses completed a new 60,000 square foot dry bulk warehouse. The booming cruise business has prompted a $150 million expansion project in the West Turning Basin, with the Federal government funding $9.5 million. The 15-year project calls for the addition of nine cruise and seven cargo berths. Port Authority officials estimate that the new business expected to be generated by the basin expansion will have an annual economic impact of $1.5 to $2 billion on the East Central Florida area.

Port of Palm Beach, FL

The Port of Palm Beach is unique among U.S. ports in that the Gulf Stream, which nearly touches the coast at Palm Beach, has carved away the continental shelf creating deep water just offshore - the Port is situated just 1.3 miles from the 37 foot contour of the Atlantic Ocean. Vessel transit time from the seabuoy to dock is normally 20 minutes. The bulk of general cargo out of Palm Beach is exported to the Bahamas, South and Central America, and the Caribbean. Molasses goes to Canada and Europe. Sugar is exported to domestic United States destinations. Major imports include fuel oil, and Bunker C from the U.S. Gulf and St. Croix, Virgin Islands. Cement is imported from Mexico and Venezuela. The Port is linked to U.S. One and Interstate 95 as well as the Florida East Coast Railway Company. It is the second largest container handling port in Florida. Aiding the delivery of waterborne cargo is the 1200-mile long Intracoastal Waterway, which bisects the Port's turning basin. The Intracoastal connects forty miles to the north with the Okeechobee Waterway, the only cross-Florida canal.

The predominance of liquid bulk petroleum imports (11.1 out of a total of 12.7 million TEUs imported in 1986) in one of the

world's most unique and beautiful beach areas has led to considerable concern that the surrounding natural resources be protected and preserved. To protect wildlife and the marine environment of Palm Beach against the risk of oil spillage, for example, a special buffer - styrofoam, plastic and stainless steel wire boom - is positioned at the end of the slip prior to discharge.

Port Everglades, FL

During the 1985-86 winter season, an international tour group based in Paris, France, established the Grand Prix Modial du Voyage, an award signifying the world's best cruise port, and Port Everglades was named recipient of the group's first award. More than a million passengers are expected to come through Port Everglades in 1987. Indeed, every American world cruise in 1987 will end up in Port Everglades, the second most popular cruise port in the world. As southeast Florida's largest port, Port Everglades is also Florida's deepest - from 43 to 47 feet. Another feature of the Port's entrance channel is its short distance, only 7300 feet from ocean shipping lanes to the turning basin. Ships are able to dock within a half hour from ocean sea buoy to berth, less time than is required at any other Atlantic port. Principal commodities are petroleum and building materials. Other cargoes are newsprint, scrap metal, steel, tiles, leather goods, furniture, and liquor.

Port of Miami, FL

Miami is the largest passenger cruise port in the world, with over 2.5 million seagoing travelers per year at the Port. Three railroad lines and a new Metrorail system serve the Greater Miami area, providing freight, passenger, and auto piggyback transportation. Tourism is a $4.5 billion industry within the region, accounting for about one out of every three dollars generated by the local economy, creating 132,000 retail trade jobs and 10,400 jobs in amusements and recreation.

Summary of port activity

During 1986, imports of 49,270 million pounds valued at $22.7 billion transited the 11 major ports of the Southeastern Region. In contrast, total exports were 25,490 million pounds valued at $12.7 billion. The percentage distribution of imports and exports among the ports of the region in 1986 are listed in Table 7.1.

The trade surplus apparent in these figures for the Southeastern ports reflects the larger national pattern of trade which has been taking place since the early 1980's as the strong dollar has made U.S. goods relatively more expensive in foreign markets and foreign goods less costly in domestic markets than had been the case for most of the post war period.

A rebalancing of world trade is now underway, however, due to the recent decline of the dollar which has been underway since early 1985. Because it takes time for established contracts to expire, market perceptions to change, and new trade contracts to be negotiated, trade normally lags for as much as two years after real exchange rate shifts occur. Hence, as Figures 7.2 (a-b) and 7.3 (a-b) show clearly, cumulative 1986 imports have continued to rise relative to the same period in 1985, while import values have also risen - reflecting, in part, the increased cost of imported goods. Conversely, cumulative export shipments declined during the same period.

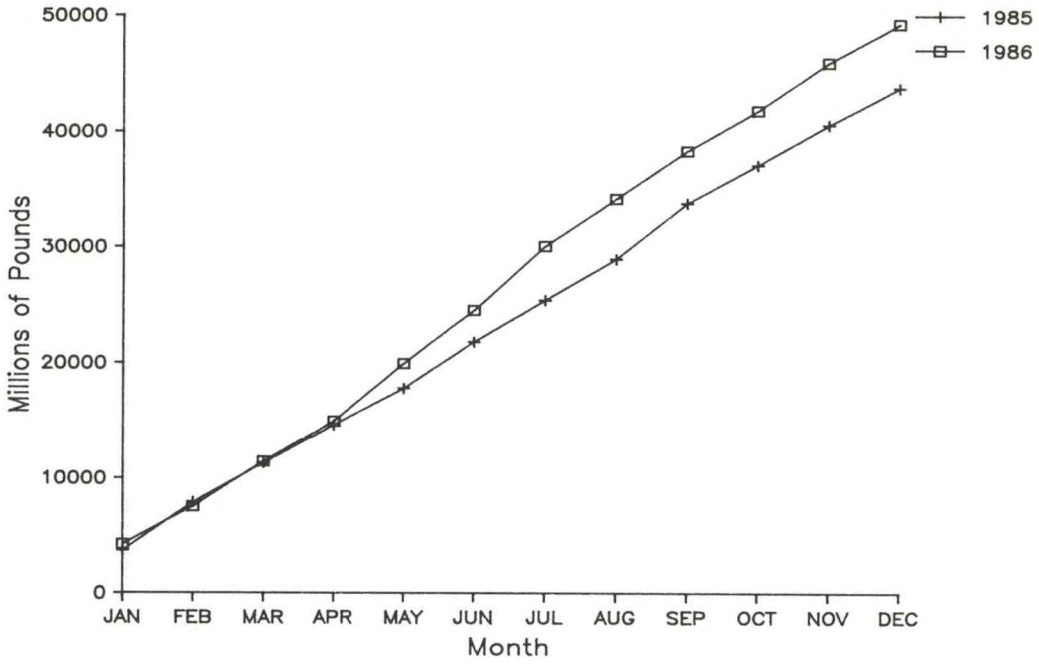
Table 7.1 Percent distribution of imports and exports by volume (millions of pounds) and value (millions of dollars) among major Southeast ports, 1986.

Port	Exports		Imports	
	Volume	Value	Volume	Value
Beaufort-Morehead, NC	2.9	2.0	2.2	0.6
Wilmington, NC	5.9	6.9	9.6	4.0
Georgetown, SC	0.0	0.0	1.5	0.1
Charleston, SC	32.1	23.2	14.2	22.7
Savannah, GA	33.6	24.7	23.8	25.7
Brunswick, GA	2.0	0.5	3.8	0.2
Jacksonville, FL	2.9	6.5	14.5	24.2
Port Canaveral, FL	1.5	0.2	5.8	1.7
Palm Beach, FL	7.0	8.9	3.1	2.0
Port Everglades, FL	2.8	3.5	14.6	7.9
Miami, FL	8.9	23.6	7.0	10.9

7.3 Dredging

Annually, dredging activities in the United States result in the removal of approximately 300 million cubic yards of sediment. The majority of these operations are classed as routine maintenance, intended to remove deposits of surficial sediments. As a result, the displaced materials are dominantly clays and silts, with lesser amounts of sand, and a moderate to high water content and organic fraction. Along several areas of the continental shelf with large estuaries, the disposal of dredged materials represents the dominant mechanism for transporting sediments from the continent to the oceans.

(a)



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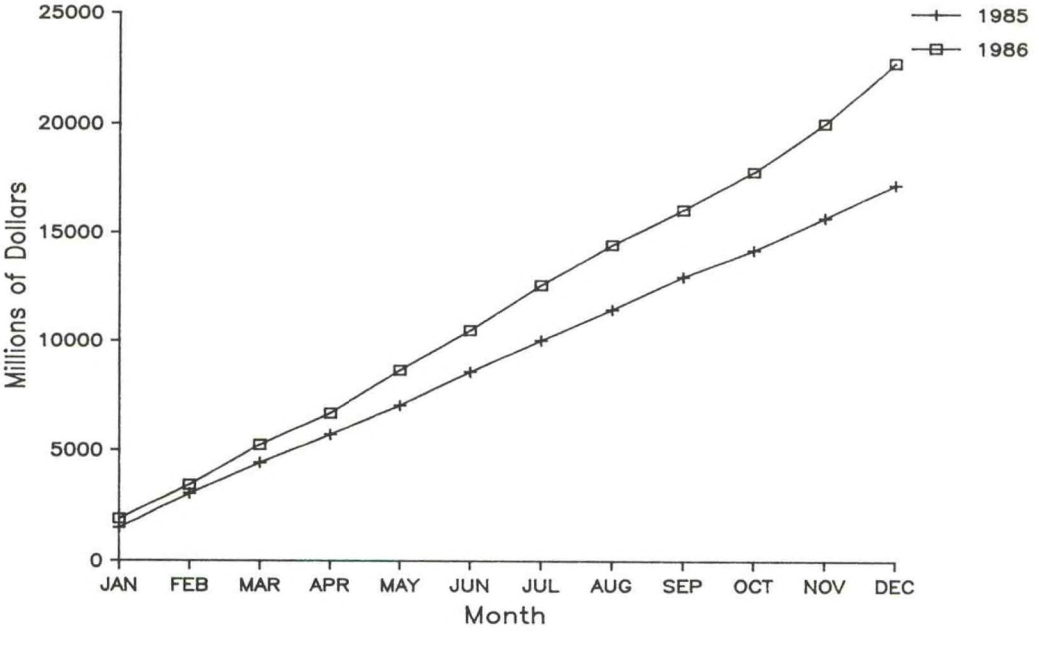
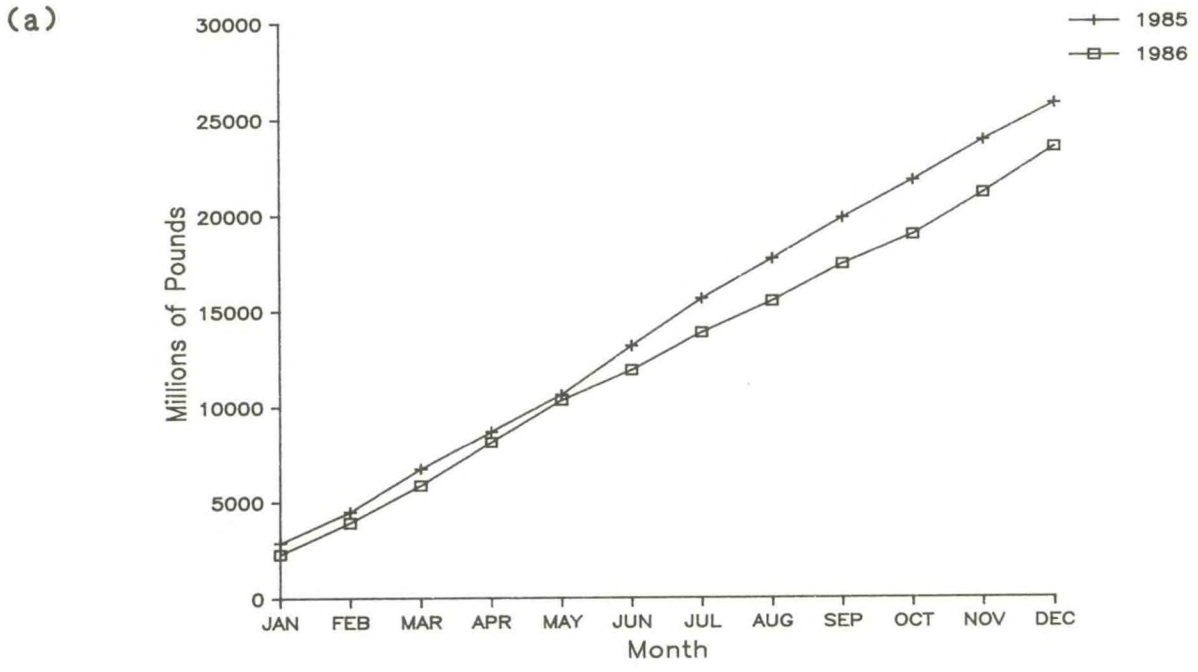


Figure 7.2 (a-b) (a) Cumulative weight of imports by month and (b) cumulative value of imports by month, Southeastern States, 1985 and 1986. Data from U.S. Bureau of the Census.



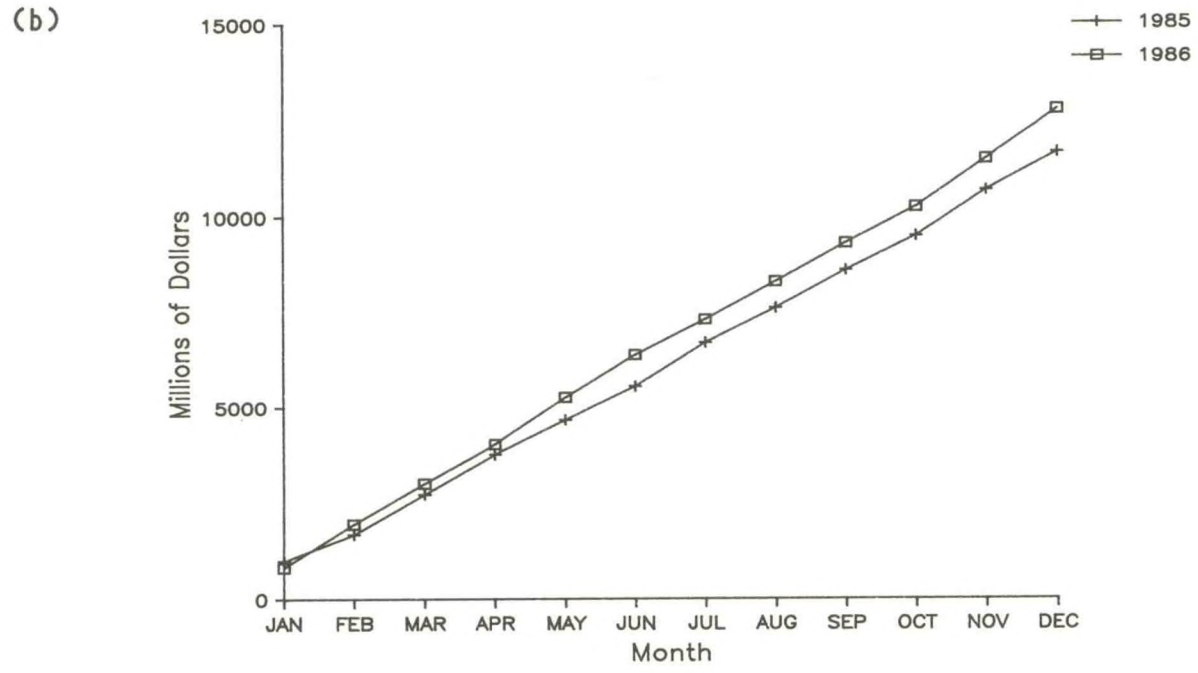


Figure 7.3 (a-b) (a) Cumulative weight of exports by month and (b) cumulative value of exports by month, Southeastern States, 1985 and 1986. Data from U.S. Bureau of the Census.

Dredging is also essential in port development and expansion and the most significant development of 1986 was the enactment of the Water Resources Development Act, which passed the House and Senate by overwhelming majorities on October 17, 1986. It was the first major deepwater port authorization measure to be enacted since 1976 and concluded years of debate on crucial issues of cost sharing between the Federal government and local and state beneficiaries. While dredging has positive impacts, there are negative ones as well. In eastern Florida, dredging for shipping and beach nourishment is believed to have destroyed reef habitat from burial and siltation.

Table 7.2 lists the dredging operations which took place within the Southeast during fiscal 1986, by major coastal port The Southeast coastal ports undertook roughly 5 percent (over 15 million cubic yards) of the U.S. total dredging activities during fiscal year 1986. The greatest volume of dredging activity (roughly one third) took place at Morehead City Harbor NC, however the largest dredging expenditure was incurred at Jacksonville, FL - $6.6 million out of a regional total of $29.9 million.

7.4 Ferries

North Carolina operates an extensive coastal ferry service involving service along seven major routes for both vehicles and passengers. Table 7.3 lists the total number of passengers and vehicles transiting each route in 1985 and 1986, as well as the percentage change between the years. Passenger traffic increased 9.6 percent overall while vehicle crossings increased 10.1 percent in 1986.Increases occurred at all routes except Pamlico River which experienced slight declines. The largest increases were at Southport/Fort Fisher. In Florida, ferry service is provided on the St. Johns River.

Table 7.2 Dredging operations in major coastal ports, Southeastern Region, fiscal year 1986.

Project Name	Depth (feet)	Start Date	End Date	Amount ($000)	Quantity (cu yds)
Morehead City Harbor, NC:					
Ocean Bar	42	5/16/86	7/17/86	618	367,681
Inner Harbor	35-40	11/8/85	12/8/85	363	255,743
Brandt Island Disposal Area	30	2/11/86	5/3/86	5,150	3,912,894
Wilmington Harbor, NC:					
Ocean Bar	40	12/4/85	2/14/86	997	804,086
Thirty-two Foot Channel	32	12/17/85	12/22/85	94	18,749
River Channel	38	10/3/85	12/15/85	607	405,997
Anchorage Basin	38	3/17/86	5/1/86	454	692,160
Charleston Harbor, SC:	35	10/85	12/85	4,575	1,183,007
Georgetown Harbor, SC:	27	10/85	9/86	3,263	1,761,000
Port Royal Harbor, SC:					
Entrance Channel	27	8/86	9/86	896	872,895
Savannah, GA:					
Middle Harbor	38	8/10/86	12/20/86	1,118	1,337,398
Upper Harbor	32-40	3/6/86	6/8/86	590	516,621
Brunswick, GA:					
Bar Channel	34	2/15/86	2/28/86	1,498	1,426,591
Turtle River	33	5/22/86	6/23/86	699	282,047
East River	32	5/1/86	5/22/86	220	310,118
Fort Pierce Harbor, FL:	27	10/31/85	11/7/85	40	11,000
Canaveral Harbor, FL:					
West Extension	36	7/21/86	8/21/87	133	2,822,000
Barge Canal	12	4/23/86	1/3/87	788	314,000
Entrance Channel	44	9/1/86	10/29/86	692	330,000
Fernandina Harbor, FL:	40	9/1/86	6/23/87	447	250,000
Jacksonville Harbor, FL:	38	10/8/86	5/21/87	6,634	996,000
Grand Total				29,876	18,869,987

Table 7.3 Passenger and vehicle traffic over ferry routes in North Carolina, and percent change, 1985 - 1986.

Number of Passengers

Route	1985	1986	Percent change
Currituck	43,706	58,074	32.9
Hatteras Inlet	604,336	614,597	1.7
Ocracoke/Swan Quarter	32,827	33,325	1.5
Cedar Island/Ocracoke	169,325	177,739	5.0
Pamlico River	137,357	134,489	-2.1
Cherry Branch/Minnesott Beach	236,753	271,488	14.7
Southport/Fort Fisher	150,961	217,984	44.4
	1,375,265	1,507,696	9.6

Number of Vehicles

Route	1985	1986	Percent change
Currituck	15,117	18,081	19.6
Hatteras Inlet	229,265	240,064	4.7
Ocracoke/Swan Quarter	12,921	13,545	4.8
Cedar Island/Ocracoke	62,779	67,291	7.2
Pamlico River	62,759	60,950	-2.9
Cherry Branch/Minnesott Beach	113,640	130,221	14.6
Southport/Fort Fisher	44,683	65,864	47.4
	541,164	596,016	10.1

8. POLLUTION

8.1 Summary of Pollution in the Southeast

Pollution is a major national problem and concern. The amounts and types of pollutants throughout the Southeastern United States varies. Many potential and actual sources of pollution exist along the coast. Sources of pollution are distinguished as point and non-point sources. A point source of pollution is defined as a discrete source, such as municipal and industrial dischargers and spill incidents. Pollution from a non-point source is that which cannot be identified as coming from a discrete location. Examples of non-point sources of pollution are urban and agricultural runoff and aerial fallout.

The major areas of concern regarding pollution, according to the National Water Summary - Hydrologic Events and Issues, issued by the United States Geological Survey, are listed by state in Table 8.1. These have been augmented by input from NOAA's National Marine Fisheries Service.

Table 8.1 Major pollutant concerns by state. Data from U.S. Geological Survey and National Marine Fisheries Service.

State	Major concerns
North Carolina	Point sources: landfills, hazardous waste sites Non-point sources: mining operations (peat and phosphate), urban runoff, agricultural discharge, aerial fallout
South Carolina	Point sources: hazardous waste sites, municipal and industrial dischargers Non-point sources: dumps, agricultural runoff
Georgia	Point sources: municipal and industrial discharges, heated water discharges Non-point sources: agricultural runoff
Florida	Point sources: municipal and industrial dischargers, hazardous waste sites, landfills, heated water discharges, fish processing plant discharges Non-point sources: agricultural and urban runoff, aerial fallout

While the opinions of experts are divided as to whether pollutant loadings from point or non-point sources represent the larger problem, the general opinion is that non-point sources are more of a problem; the pollutants from these sources are more difficult to monitor and control, and the data collected from monitoring efforts are more difficult to analyze with regards to spatial and temporal consistency and continuity.

Major non-point runoff, which contains loads of sediments, pesticides, and nutrients, has often led to severe problems of eutrophication, low dissolved oxygen levels, and changes in fishery habitats in estuaries. Several areas have been identified as candidates for suffering adverse effects from non-point pollution.

In the Neuse River, which empties into the Pamlico-Albemarle estuarine complex in North Carolina, massive blooms of blue-green algae have occurred in the summertime. These blooms have been stimulated and perpetrated by the high nutrient levels found in agricultural runoff.

Since the Cooper River was rediverted in 1985, freshwater flow into Charleston Harbor, SC, has been greatly reduced. The reduced flow into the harbor may decrease the flushing rates of pollutants introduced into the system by agricultural and urban runoff.

In the Sapelo Island National Estuarine Research Reserve in Georgia, the Georgia Department of Natural Resources is concerned as to what effect land alterations that will permit more runoff and greater concentrations of contaminants and nutrients will have. Since nutrient cycling is important to fisheries, monitoring and controlling the nutrient loadings are critical to sustaining fisheries stocks.

Along the Southeastern Coast, particularly in Florida, where commercial oystering has been reduced to less than 20 percent of the total harvest acreage, shellfish beds are being closed at an alarming rate due to pollution from runoff and point sources.

Under the Federal permitting system each state is empowered to issue and enforce discharge permits. After the sources of discharge are identified, an agreement between each state and the individual dischargers is reached as to the quality and quantity of discharge allowed. As treatment systems are updated, and the quality of the environment is evaluated, permits must be reviewed, and new agreements for discharge must be reached. The State agencies, which are understaffed, require more money for more enforcement, more monitoring, and more regulation before a suitable discharge program can be implemented.

Since discharge includes both wastewater and emissions, the requirements given above apply to point and some non-point sources of pollution. Better monitoring of pesticide

applications and more research into the effects of soil and vegetation uptake are required to ease the burden of agricultural runoff.

8.2 Spills of Oil and Other Hazardous Substances

The number of spills of oil and other hazardous substances in the Southeastern United States for 1985 and 1986 is shown in Figures 8.1 and 8.2. Although the data for 1986 are only for the first 10 months of the year, the spills from vessels showed a 63 percent increase over 1985. If the number of facility spills in November and December of 1986 were in the same ratio to the total number of facility spills in 1985 for the same months, the total number of spills is projected to have remained unchanged from 1985 to 1986.

Most spills are small. Table 8.2 lists the percentage of

Table 8.2 Percent of spills less than or equal to 50 gallons and less than or equal to 100 gallons in the Southeast, 1985 and January to October 1986. Data from the U.S. Coast Guard.

	1985		1986	
	Facilities	Vessels	Facilities	Vessels
Percent of spills ≤ 50 gallons	87	84	89	91
Percent of spills ≤ 100 gallons	93	89	94	93

total spills in the Southeast with volumes less than or equal to 50 gallons and less than or equal to 100 gallons in 1985 and 1986. As the table shows the percentage of spills from all sources with volumes less than or equal to 100 gallons was greater than 85 percent in both 1985 and 1986.

The small percentage of spills with volumes greater than 100 gallons, however, accounted for most of the total volume of spills in 1985 and the first ten months of 1986. Spills greater than 100 gallons from facilities totaled 31,445 gallons, 92 percent of the volume of spills from facilities in 1985. The volume of spills greater than 100 gallons from facilities dropped in 1986 to 7,337 gallons, 71 percent of the volume. In 1985 vessel spills greater than 100 gallons amounted to 9,160 gallons,

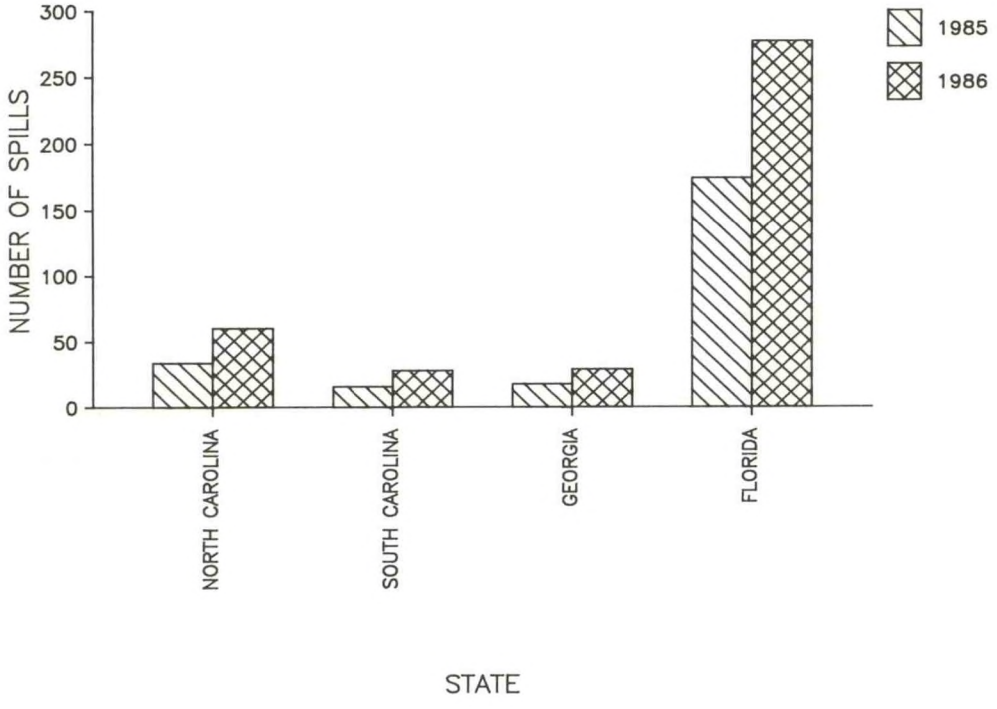


Figure 8.1 Vessel spills in the Southeast in 1985 and 1986.

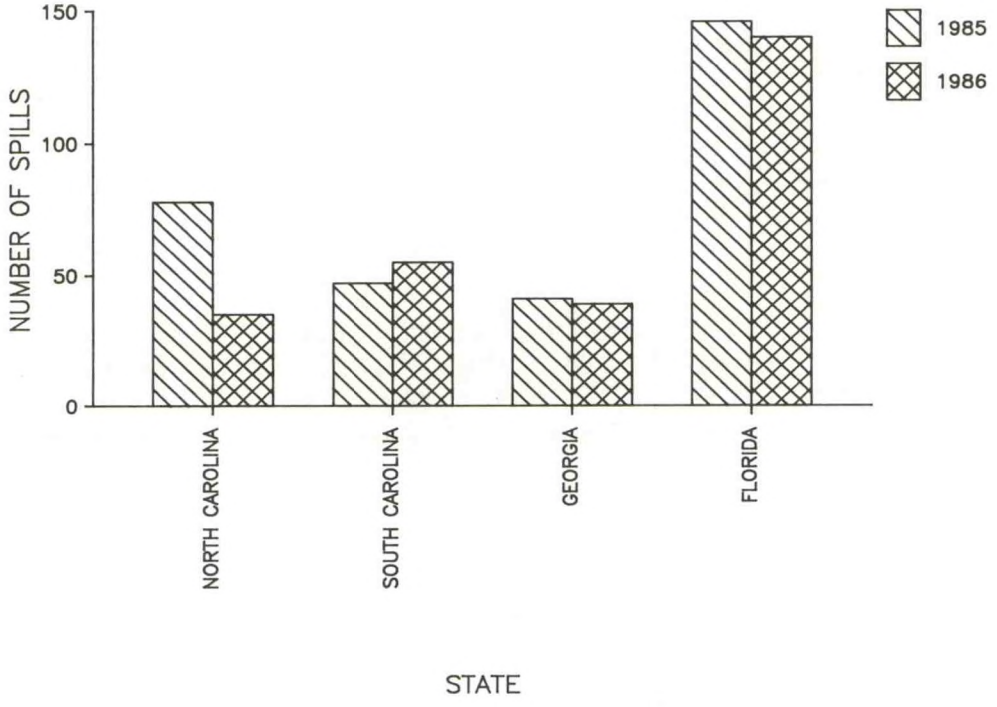


Figure 8.2 Facility spills in the Southeast in 1985 and 1986.

77 percent of the total volume of spills from vessels. The volume of spills from vessels in 1986 rose from the 1985 level to 39,662 gallons, 90 percent of the total volume of spills from vessels. More than 23,000 gallons of the 39,662 gallons from vessel spills in 1986 were from two spills. In the Intercoastal Waterway in North Carolina in March 1986 more than 13,000 gallons of fuel spilled when a tank barge suffered a hull fracture or leak. A tank overflow from a tank ship in the St. Johns River in September resulted in a spill of fuel oil of 10,000 gallons.

As can be seen, a small number of spill events with large volumes can strongly influence the spill statistics. The figures previously cited would be dwarfed, if a single major spill event occurred. In December 1986 in the Savannah area, a major spill did occur. The Amazon Venture, a Liberian tanker had several valves in its pumping system fail, releasing an estimated 2,000 gallons of oil into the water. The estimate of 2,000 gallons spilled was upgraded several times until a final figure of 500,000 gallons was reported as the volume of the spill. The effects of the spill on some sectors of the environment are described in the Recreation section of this report.

8.3 Acid Rain

Acid rain is a widely publicized environmental issue around the world. Although organized monitoring programs to determine the magnitude and extent of acid rain were established in the 1950's in northern and western Europe, the possibility that regional acid rain problems existed in the eastern United States was not recognized until the 1970's.

Acid rain is the phenomenon that exists when atmospheric water has a pH less than the pH of unpolluted precipitation, which is frequently assumed to be 5.65. The chemical compounds associated with acid rain are oxides of the elements sulfur and nitrogen (SO_x and NO_x).

Although manmade emissions frequently are blamed for acid rain, natural airborne acid rain progenators come from seaspray, volcanic eruptions, and bacterial and chemical decomposition of organic matter. The major source categories of SO_x and NO_x are stationary fuel consumption, industrial processes, and transportation. Stationary fuel consumption accounted for three-quarters of SO_x emissions and half of NO_x emissions in the United States in 1982, the last year for which the Assessment and Information Services Center has data. Transportation contributed about 40 percent of the NO_x emissions in 1982 (Table 8.3).

The effects of acid deposition on ecosystems are varied and complex and are not fully understood. Alteration of the ecosystem from the acidification of lakes and soils might chronically affect the lower trophic levels of the food chain and, ultimately, the higher levels of the food chain. Sudden

Table 8.3 Percent categorical distribution of manmade SO_x and NO_x emissions for 1982. Data from the National Emissions Data System.

Major source category	SO_x emissions (percent of U.S.)	NOx emissions (percent of U.S.)
Stationary fuel consumption	78.5	56.1
Industrial processes	18.2	3.4
Transportation	3.1	38.9

changes in pH resulting from acid precipitation might caught immediate fish kills.

Acid precipitation can have an adverse effect on materials, structures, and manmade objects. It has been documented over the last 30 years that the pH of the precipitation in the Southeast has been decreasing to the levels of acid rain. The effects of several incidents of the acid rain in 1986 in Florida on some sectors of society are described in the Transportation section of this report.

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