This document contains overall and specific condition of the Albemarle-Pamlico National Estuary Program from the National Estuary Program Coastal Condition Report. The entire report can be downloaded from ***http://www.epa.gov/owow/oceans/nepccr/index.html***

National Estuary Program Coastal Condition Report

Chapter 4: Southeast National Estuary Program Coastal Condition, Albemarle-Pamlico National Estuary Program

June 2007

Albemarle-Pamlico National Estuary Program

Albemarle - Pamlico
National Estuary Program
North Carolina

www.apnep.org

Background

The Albemarle-Pamlico Estuarine Complex drains approximately 30,000 mi^2 of watershed and comprises the largest lagoonal estuarine system in the United States. This NEP has a 23,000-mi^2 study area that extends south from Prince George County, VA, to Carteret County, NC, and includes 7 sounds (Albemarle, Bogue, Core, Croatan, Currituck, Pamlico, and Roanoke) (APNEP, 2006).

Freshwater inputs to this system are provided by five major rivers — the Pasquotank, Chowan, and Roanoke rivers that flow into Albemarle Sound and the Tar-Pamlico and Neuse rivers that flow into Pamlico Sound. This region features a variety of habitat types, including significant pocosins (southeastern shrub bogs), pine savannahs, hardwood swamp forests, bald cypress swamps, salt marshes, brackish marshes, freshwater marshes, and beds of SAV (Martin et al., 1996). On the eastern side of the Albemarle-Pamlico Estuarine Complex, a chain of islands forms a barrier with the Atlantic Ocean. The Complex is uniquely characterized by random wind-driven tides, which result in less-predictable variations in water circulation and salinity patterns (Focazio, 2006a). Economically, this estuarine

system represents the Southeast region's key resource base for commercial fishing, tourism, recreation, and resort development. Economic benefits are also derived from the use of the area's natural resources for mining, forestry, and agriculture (APNEP, 2006).

The Albemarle-Pamlico National Estuary Program (APNEP) was among the first NEPs established by EPA in 1987. The central focus of the APNEP is to work closely with citizens' groups, businesses, researchers, local governments, and state and federal agencies to implement the key objectives of the APNEP's *Comprehensive Conservation and Management Plan* (APNEP, 1994) through the APNEP's Advisory Board and committees. Recent APNEP projects have illustrated new methods of environmental protection and restoration, including conservation easements, stormwater-runoff control systems, greenroofs, composting techniques that turn agriculture and crab-processing waste into fertile soil, and the development of new fishing gears that reduce the unintended capture of non-target species such as sea turtles. Other APNEP projects include opening historic spawning areas for shad and herring that had previously been blocked by dams and roads and replenishing scallop beds that were decimated by a red tide event in 1987 (APNEP, 2006).

Environmental Concerns

The issues of environmental concern for the APNEP are water quality, habitat quality, and fishery resources. Impairment of waters in the Albemarle-Pamlico Estuarine Complex can primarily be attributed to non-point sources of pollution, of which agricultural and urban runoff are the most prevalent. A smaller, but still significant amount of water quality impairment in the system can be attributed to point-source discharges along the rivers flowing into the Complex. Ecological stressors, including nutrient pollution, phytoplankton growth, exotic species growth, and other factors, place viable habitat areas in the region at risk, and the extent of wetland habitat in the region is considerably diminished relative to historical distributions due to changes in land-use patterns. Downward trends in commercial landings are indicative of declining stocks of local populations of finfish and shellfish species, including Atlantic croaker, Atlantic sturgeon, Eastern oyster, red drum, striped bass, summer flounder, weakfish, and herring. The overall CPUE from these estuaries is also declining, despite improvements in fishing gear and methods. In general, overfishing and habitat loss are believed to be major causes of the declines in catch; however, a variety of other factors, including habitat alteration, weather events and seasonal cycles, and water quality degradation, may also play a role (APNEP, 2006).

Population Pressures

The population of the 35 NOAA-designated coastal counties (25 coastal counties in North Carolina and 10 in Virginia) coincident with the APNEP study area increased by more than 71.1% during a 40-year period, from 1.1 million people in 1960 to 1.8 million people in 2000 (Figure 4-11) (U.S. Census Bureau, 1991; 2001). This rate of growth for the APNEP study area is low compared to the population growth rate of 131.4% for the collective NEP-coincident coastal counties of the Southeast Coast region. In 2000, the population density of this study area's 35 coastal counties was 125 persons/mi^2, slightly lower than the population density of 168 persons/mi^2 for the collective NEP-coincident coastal counties of the Southeast Coast region (U.S. Census Bureau, 2001). Population pressures for the APNEP study area may be slightly lower than for other NEPs, in part because a large amount of the state and federal land surrounding this estuary is designated for protection as national seashore, wildlife areas, or forests. As a result, development is concentrated in the remaining non-federal or non-state areas.

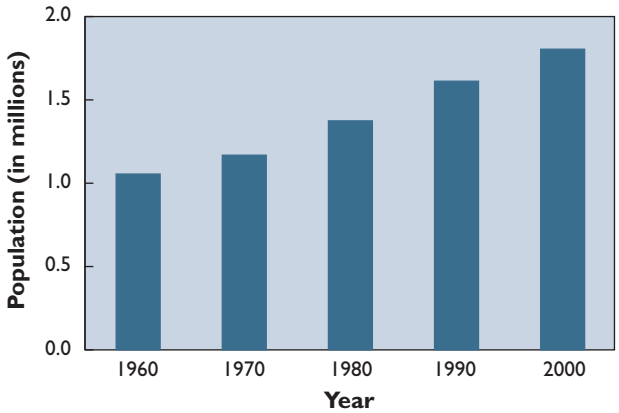

Figure 4-11. Population of NOAA-designated coastal counties of the APNEP study area, 1960–2000 (U.S. Census Bureau, 1991; 2001).

NCA Indices of Estuarine Condition—Albemarle-Pamlico Estuarine Complex

The overall condition of the Albemarle-Pamlico Estuarine Complex is rated good to fair based on the four indices of estuarine condition used by the NCA (Figure 4-12). The water quality index for the Complex is rated good, the sediment quality and fish tissue contaminants indices are rated good to fair, and the benthic index is rated fair. Figure 4-13 shows the percentage of estuarine area rated good, fair, poor, or missing for each parameter considered. This assessment is based on data collected by EMAP from 66 NCA sites sampled in the APNEP estuarine area in 2000 and 2001. Please refer to Tables 1-24, 1-25, and 1-26 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

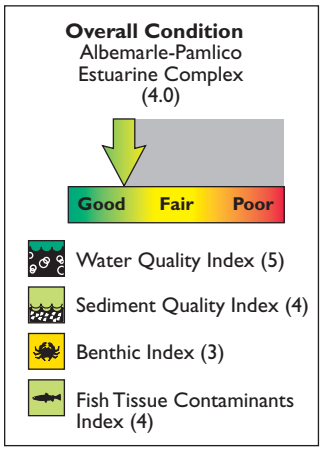

Figure 4-12. The overall condition of the APNEP estuarine area is good to fair (U.S. EPA/NCA).

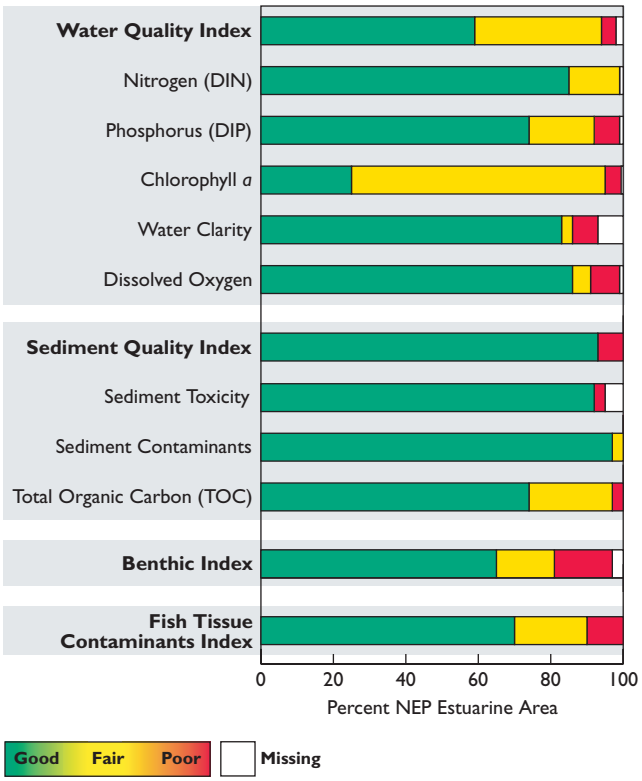

Figure 4-13. Percentage of NEP estuarine area achieving each rating for all indices and component indicators — Albemarle-Pamlico Estuarine Complex (U.S. EPA/NCA).

Water Quality Index

The water quality index for the Albemarle-Pamlico Estuarine Complex is rated good (Figure 4-14). This index was developed using NCA data on five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. Only 4% of the Complex's estuarine area was rated poor for water quality; however, 35% was rated fair.

Dissolved Nitrogen and Phosphorus

The Albemarle-Pamlico Estuarine Complex is rated good for DIN and DIP concentrations. Eighty-five percent of the estuarine area was rated good for DIN concentrations, 14% of the area was rated fair, and none of the area was rated poor. Similarly, 74% of the estuarine area was rated good for DIP concentrations, 18% of the area was rated fair, and 7% of the area was rated poor.

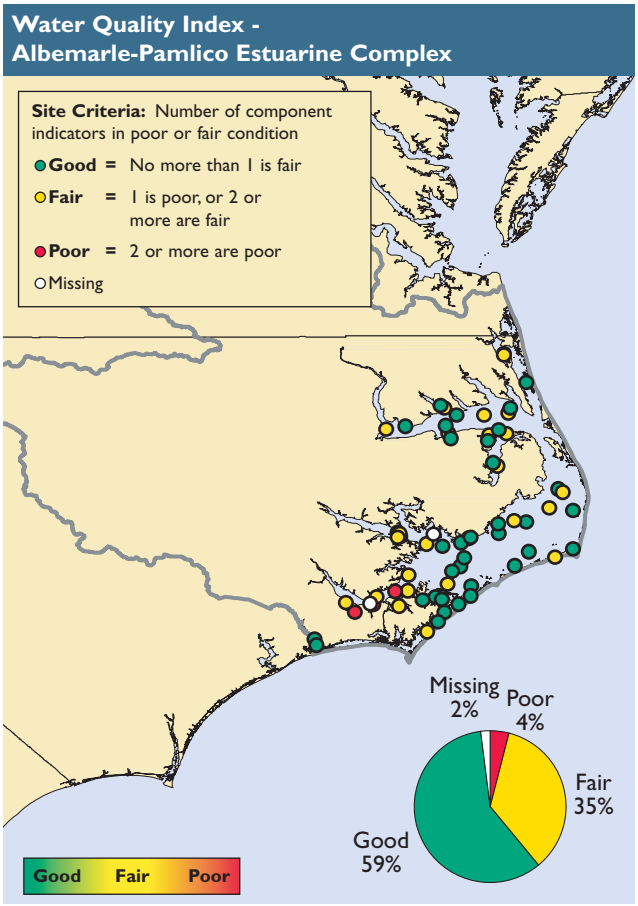

Figure 4-14. Water quality index data for the Albemarle-Pamlico Estuarine Complex, 2000–2001 (U.S. EPA/NCA).

The measured DIP values used in this assessment are an approximation because these values were based on filtered, acid-preserved phosphorus, which provides a measure of total phosphorus, not of DIP only. Literature suggests that DIP represents about 97% of the total phosphorus measurement for estuaries of the Southeast Coast region (Van Dolah et al., 2002).

Chlorophyll a | The Albemarle-Pamlico Estuarine Complex is rated fair for chlorophyll *a* concentrations, with 25% of the estuarine area rated good for this component indicator, 70% of the area rated fair, and 5% of the area rated poor.

Water Clarity | The Albemarle-Pamlico Estuarine Complex is rated good for water clarity. Water clarity was rated poor at a sampling site if light penetration at 1 meter was less than 10% of surface illumination. Eighty-three percent of the estuarine area was rated good for water clarity, 3% of the area was rated fair, and only 7% of the area was rated poor. NCA data on water clarity were unavailable for 7% of the APNEP estuarine area.

Dissolved Oxygen | The Albemarle-Pamlico Estuarine Complex is rated fair for dissolved oxygen concentrations. Although 86% of the estuarine area was rated good for this component indicator, 8% was rated poor, and 5% was rated fair.

Sediment Quality Index

The sediment quality index for the Albemarle-Pamlico Estuarine Complex is rated good to fair, with 7% of the estuarine area rated poor and 93% of the area rated good for sediment quality condition (Figure 4-15). This index was developed using NCA data on three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

Sediment Toxicity | The Albemarle-Pamlico Estuarine Complex is rated good for sediment toxicity. Ninety-two percent of the estuarine area was rated good for this component indicator, and only 3% of the area was rated poor. NCA data on sediment toxicity were unavailable for 5% of the APNEP estuarine area.

Sediment Contaminants | The Albemarle-Pamlico Estuarine Complex is rated good for sediment contaminant concentrations, with 97% of the estuarine area rated good, 3% of the area rated fair, and none of the area rated poor.

Total Organic Carbon | The Albemarle-Pamlico Estuarine Complex is rated good for sediment TOC. Twenty-three percent of the estuarine area was rated fair for this component indicator, 74% of the area was rated good, and the remaining 3% of the area was rated poor.

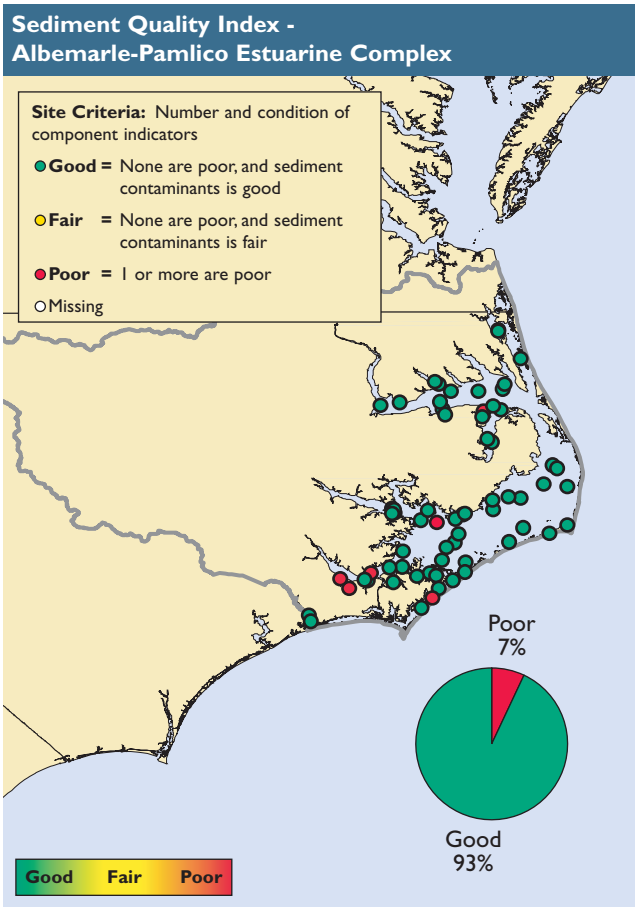

Figure 4-15. Sediment quality index data for the Albemarle-Pamlico Estuarine Complex, 2000–2001 (U.S. EPA/NCA).

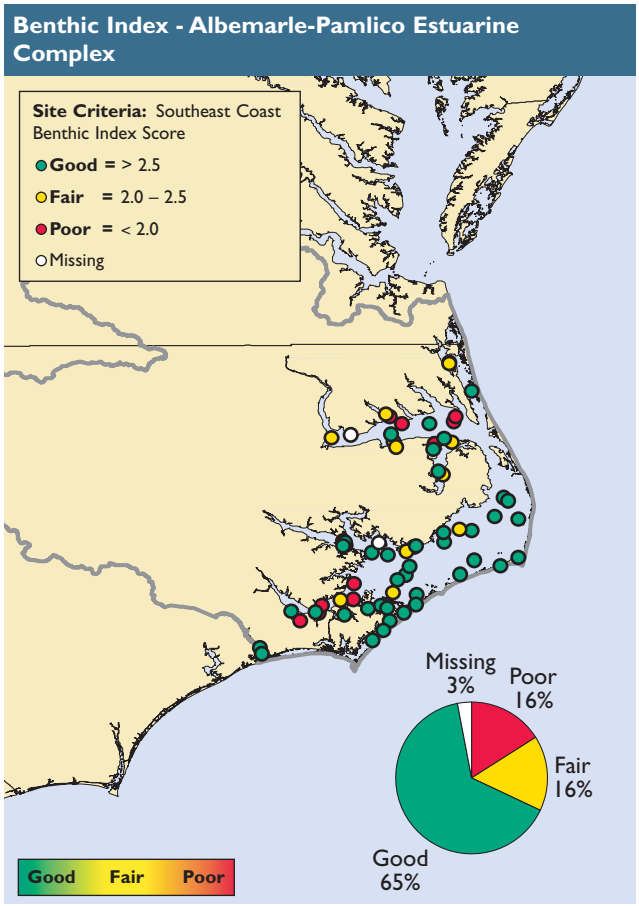

Figure 4-16. Benthic index data for the Albemarle-Pamlico Estuarine Complex, 2000–2001 (U.S. EPA/NCA).

Benthic Index

As measured by the Southeast Coast Benthic Index, benthic condition for the Albemarle-Pamlico Estuarine Complex is rated fair. Sixty-five percent of the estuarine area was rated good for benthic condition, 16% of the area was rated fair, and 16% of the area was rated poor (Figure 4-16), with sites rated poor located in portions of the Neuse River and Albemarle Sound.

Although only 16% of the estuarine area exhibited degraded benthic condition, 92% of the sampling sites representing this degraded area were also associated with some measure of adverse water quality or sediment quality (Figure 4-17). Poor benthic condition co-occurred most frequently with degraded sediment quality (75% of sites with poor benthic condition).

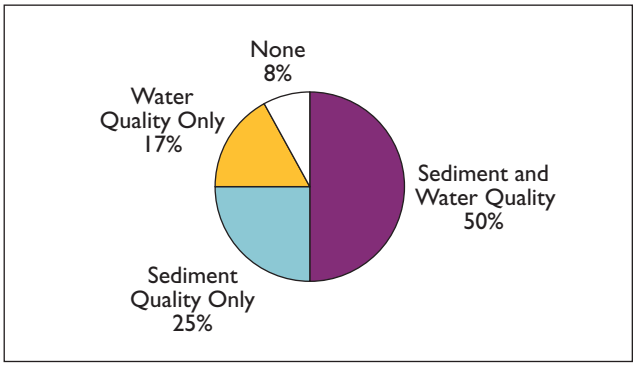

Figure 4-17. Percent of sampling sites in the Albemarle-Pamlico Estuarine Complex where poor benthic condition overlaps with other indices rated poor (U.S. EPA/NCA).

Fish Tissue Contaminants Index

The fish tissue contaminants index for the Albemarle-Pamlico Estuarine Complex is rated good to fair. Figure 4-18 shows that 10% of stations sampled where fish were caught exceeded risk-based EPA Advisory Guidance values using whole-fish contaminant concentrations and were rated poor, 20% of the stations were rated fair, and 70% of the stations were rated good. The only contaminants measured with elevated concentrations in fish tissues were total PAHs and total PCBs.

Humans can be exposed to toxic chemicals by eating contaminated fish (John Theilgard).

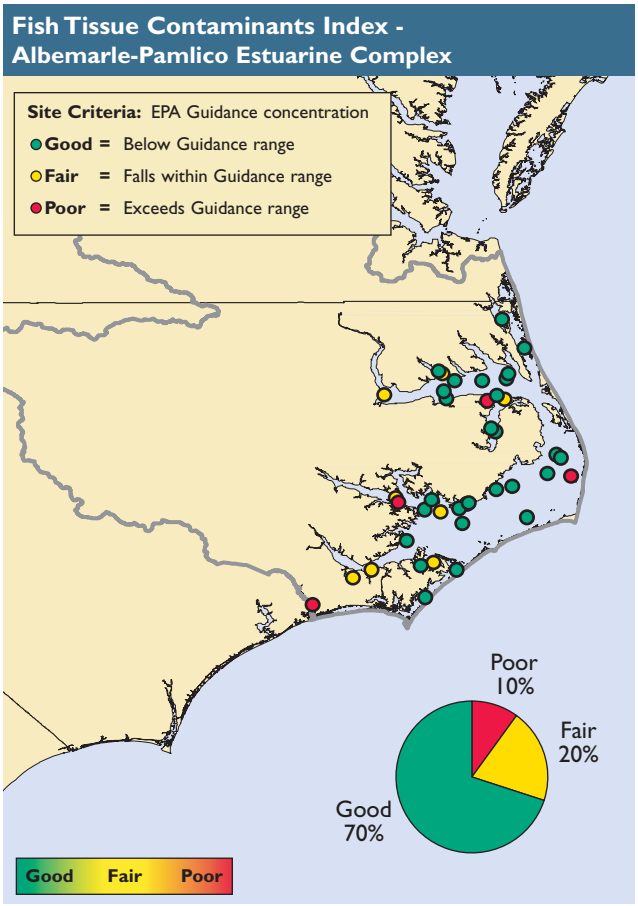

Figure 4-18. Fish tissue contaminants index data for the Albemarle-Pamlico Estuarine Complex, 2000–2001 (U.S. EPA/NCA).

Albemarle-Pamlico National Estuary Program

HIGHLIGHT

FerryMon
UNC-CH / DUKE / NCDENR / NCDOT

The FerryMon Project

The Albemarle-Pamlico Estuarine Complex provides critical foraging and nursery habitats for finfish and shellfish populations along the mid-Atlantic and southeastern coasts of the United States. Changes in water quality, precipitated by rapidly changing land uses in tributary watersheds and the increased frequency of tropical storms, have emphasized the need for predictive modeling to guide policy and management decisions regarding ecosystem response to those stressors. Compounding this need is a relative lack of monitoring data despite the importance of the habitat.

To address this problem, the University of North Carolina at Chapel Hill's Institute of Marine Sciences in Morehead City, NC; Duke University's Marine Lab in Beaufort, NC; and others joined ranks to found the FerryMon project. The goals of the project are the following:

- Determine ecosystem response to excess nutrient inputs
- Quantify the relationships between the land-use activities, hydrologic processes, and ecological response of receiving waters
- Assess and predict ecosystem response and the relationships between nutrient inputs, phytoplankton blooms, and associated water quality changes
- Provide information critical to long-term water quality management.

FerryMon, a ferry-based water quality monitoring project, utilizes North Carolina Department of Transportation (NCDOT) ferries that traverse the Neuse River and Pamlico Sound on three routes (see table below), following a regular schedule 365 days a year. The ferries are fitted with automated water quality monitoring equipment that measures temperature, conductivity, pH, dissolved oxygen, turbidity, and chlorophyll fluorescence in surface water. Subsequent measurement of nutrients, diagnostic algal pigments, colored dissolved organic material, and suspended solids is made possible by a refrigerated grab sampler, and

Information about the Ferry Routes in the FerryMon Project (FerryMon, 2006)

Ferry Route	1	2	3
Initiated	November 2000	February 2001	May 2001
Origination	Cherry Branch	Cedar Island	Swan Quarter
Destination	Minnesott Beach	Ocracoke Island	Ocracoke Island
Ferry Name	*Floyd Lupton*	*Carteret*	*Silver Lake*
Average Speed (knots)	8.0	10.7	10.4
Number of Crossings/Day	40	4	1
Number of Data Points/Day	300	200	200–300

logged data are downloaded at the laboratories via a cellular telephone modem. Use of the ferries to monitor water quality offers an economy of scale for the rapid construction of databases not provided by conventional monitoring platforms (Buzzelli et al., 2003).

Although the FerryMon project only monitors surface waters along the route of each ferry, the project's observing platform does have several advantages, including the following:

- High spatial and temporal resolution
- Repetition in time and space
- Capturing of base, diel, tidal, synoptic, seasonal, annual, and interannual scales
- Reliable data collection (i.e., data collection ceases only when wind velocity is greater than 40 knots or during times of dense fog)
- Professionally maintained, high-quality ferries (U.S. Coast Guard-certified to carry passengers for hire)
- Free use of ferries (i.e., low-cost analysis).

An initial return on the investment of retrofitting the ferries has been the availability of an intensive temporal and spatial water quality baseline data set for an area holding the distinction of being the largest estuary in the United States for which there is the least available data. The availability of data from the FerryMon project allows for rapid analysis of the Sound's status and trends, thus supporting the wisest and most sustainable use of the resource. Monitoring results and additional information about the project are available at http://www.ferrymon.org.

The *Carteret* collects water quality measurements along its route between Cedar Island and Ocracoke Island (NCDOT).

Albemarle-Pamlico National Estuary Program Indicators of Estuarine Condition

Although the APNEP does not currently have a set of formalized indicators to determine estuarine condition, the APNEP STAC is expected to complete the development of indicators in 2006. Currently, agencies that work in partnership with the APNEP use a group of informal indicator measures to evaluate environmental conditions in the Complex. In addition, more detailed information on environmental indicators is collected and reported on a basin-wide level and by individual subbasins in the Albemarle-Pamlico region. Some stressors that have been evaluated to compare the subbasins of the Albemarle-Pamlico Estuarine Complex (in support of past EPA studies) include total non-point source loadings (kg/yr) to each subbasin and the numbers of fish consumption advisories, HAB occurrences, Superfund and hazardous waste sites, coastal marinas per subbasin, and water quality exceedances. The following section will describe some of the recent trends and environmental measures studied on a Complex-wide basis, as compiled by state partners managing the Albemarle-Pamlico region for water and sediment quality, fish and wildlife, and habitat conditions.

Water Quality and Sediment Quality

Data on the water quality condition of the Albemarle-Pamlico Estuarine Complex are collected by a number of APNEP partners. The North Carolina Department of Environment and Natural Resources' (NCDENR's) Division of Water Quality (DWQ) samples ambient stations for nutrients, dissolved oxygen, pH, conductivity, temperature, metals, turbidity, hardness, fecal coliform bacteria, and total suspended solids. The North Carolina DWQ also analyzes algal samples to document HABs and to investigate the causes of fish kills (NCDENR, 2006). Water quality data is also collected by the FerryMon project (see Highlight article).

Although trends in nutrient concentrations in the Complex appear to be very site-specific, the waters of these estuaries are generally rich in phosphorus and relatively nitrogen-limited (Harned and Davenport, 1990; APNEP, 2006). Water quality measurements and trend analysis conducted across the entire Albemarle-Pamlico Estuarine Complex demonstrated some noticeable long-term patterns between 1945 and 1988, including the following:

- Increased dissolved oxygen levels (in general)
- Increased pH (in general)
- Decreased levels of suspended solids
- Increased chlorophyll *a* levels (Harned and Davenport, 1990).

A major source of nutrient loading to the waters of the Albemarle-Pamlico Estuarine Complex is runoff from agricultural activities (Harned and Davenport, 1990). Enhanced runoff of nutrients in the spring season has been a major contributor to nuisance HABs during the summer months. Atmospheric deposition accounts for an average of 27% of total nitrogen inputs and 22% of total phosphorus inputs to the drainage basin of the Albemarle-Pamlico Estuarine Complex (McMahon and Woodside, 1997). Major hurricanes in 1999 (Floyd) and 2003 (Isabel) had a significant impact on the water quality and growth of phytoplankton in the Complex, with salinity levels in these lagoonal estuaries decreasing dramatically after these storm events. Chlorophyll *a* levels typically increased substantially after the storm events, but eventually returned to pre-storm levels (Peierls et al., 2003).

Habitat Quality

The measures that have been used in past studies to measure habitat quality across the subbasins of the Albemarle-Pamlico Estuarine Complex include acreages of wetlands, SAV, nursery areas, and shellfish-harvesting areas. An estimated 25% to 50% of the wetlands lining the tributaries or inland areas have been lost to development, dredging, draining, or filling of marsh habitat (NCDENR, 2003). Losses and gains for the major basins of the Albemarle-Pamlico Estuarine Complex during 2002 and 2003 are presented in Table 4-1.

The extent and health of SAV in the Albemarle-Pamlico Estuarine Complex is a function of several variables, including depth, salinity, sediment texture, concentration of suspended sediments, epiphyte encrustation, weather, climate, and nutrient availability. Most of these potential stresses are natural, but some are exacerbated by human activities. Eighty percent of SAV

coverage in the estuarine area is located in southern and eastern Pamlico Sound. Eelgrass, shoalgrass, and widgeongrass dominate these environments, and such a mixture of species is unique to North Carolina. Preliminary analyses suggest that the estimated area of marine SAV in the Complex's estuarine area is approximately 200,000 acres (APNEP, 2006).

Table 4-1. Change in the Extent of Wetland Habitat in the Major Subbasins of the Albemarle-Pamlico Estuarine Complex, 2002–2003 (NCDENR, 2003)

Subbasin	Overall Change (%)
Pasquotank	4 (loss)
Chowan	0.8 (loss)
Roanoke	1.9 (loss)
Tar-Pamlico	5 (loss)
Neuse	25 gain
White Oak (eastern portion only)	6.2 gain

Living Resources

Fish and wildlife living in the Albemarle-Pamilico Estuarine Complex help serve as continuous monitors of environmental quality and increase the likelihood of detecting spills, non-point sources, or other highly variable impacts that are often missed by chemical-sampling water quality processes. The NCDENR pays particular attention to monitoring the more important commercial species of finfish and shellfish across the subbasins of the Albemarle-Pamlico Estuarine Complex to estimate the population structures and commercial value of these species. The blue crab population is monitored to help evaluate the effects of environmental stressors in different areas of the Albemarle-Pamlico region. Of the natural stressors examined, low dissolved oxygen and elevated water temperatures have correlated well with lowered concentrations of hemocyanin in blue crabs. Hemocyanin is a substance found in crab blood, and low concentrations are correlated with the crabs' increased susceptibility to parasitic infections and reproductive problems (APNEP, 2006).

Current Projects, Accomplishments, and Future Goals

The APNEP continues to work toward fulfilling the goals of its CCMP and has already seen some major accomplishments, including the following:

- Restoration of more than 1,100 miles of anadromous fish habitat through the removal of three dams
- Enhancement of interagency and interstate coordination through creation of the APNEP
- Organizational restructuring to promote region-wide interstate citizen involvement through collaboration and coordination
- Development of bycatch reduction gear (e.g., sea turtle exclusion devices) and practices to reduce fisheries impacts
- Restoration of two miles of riparian habitat along the Roanoke River through livestock fencing and riverbank-stabilization practices (APNEP, 2006).

Conclusion

Based on data collected by the NCA, the overall condition of the Albemarle-Pamlico Estuarine Complex is rated good to fair. Data collected by NCA and the APNEP partners indicate that the Complex is in good condition with respect to most indicators of estuarine health; however, factors such as chlorophyll *a*, dissolved oxygen, and sediment quality may signal declining health, especially in some tributary river areas.