

Subtidal Region Long Range Oyster Conservation Plan – 2008 to 2018
What would we like to accomplish in the next three to five years?
In the next decade?

Introduction

Over the winter of 2006-2007, a subcommittee of the Northern Oyster Work Group began drafting a long-range conservation plan for native oysters in North Carolina's subtidal waters. Members of the group included Jan DeBlieu (NCCF), Jeff DeBlieu (TNC), Craig Hardy (DMF), Sara Mirabilio (NC Sea Grant), Aaron McCall (TNC), and Chuck Wilson (USACE). Preliminary elements of the plan were presented to a meeting of the full oyster work group on May 4, 2007.

Subcommittee members subsequently incorporated the group members' comments into the plan, expanded it, and presented it at the August 28 Encore for Oysters Summit in Pine Knoll Shores. Additional comments and critiques have been incorporated into this final report.

The subtidal region is by far the largest of the three regions evaluated in this coastwide process. It is comprised of Croatan Sound, Roanoke Sound, Pamlico Sound, all the bays just off the sounds, and the brackish reaches of the Long Shoal, Pungo, Pamlico, and Neuse rivers. The region includes NC Shellfish Growing Areas F1 through F8, G1 through G11, and H1 through H6. Historically many of the beds were concentrated in shallow waters; however, deep water reefs did exist.

The large areas of open water in the subtidal region present an unusual challenge, in that little is known about currents or dispersal and recruitment of spat. The recommendations for land- and water-based restoration projects contained in this report are founded on our knowledge of where oysters grew in the past, based on the Winslow surveys of 1885 to 1886, and where recruitment continues today. We also include recommendations for future research that could provide information about dispersal and help sharpen the process of selecting future restoration sites.

Our group was fortunate, in that our work coincided with the writing of a Conservation Action Plan (CAP) for the Outer Banks and Sounds, spearheaded by The Nature Conservancy. The two efforts complemented each other, and the recommendations for future actions in this report were heavily influenced by the findings of the CAP. Partly because of the CAP, we were able to set goals for the amount of land- and water-based projects that we believe should be carried out both in the short term and over the next decade. Our recommendations for expanding education about oysters and oyster conservation in the region are also long-term.

The report is divided into seven sections: a summary of general stresses to the ecosystem, distilled from the CAP; a summary of ongoing research and restoration projects; a summary of current education initiatives; a list of potential future restoration projects; recommendations for future projects and initiatives, including land- and water-based

restoration, environmental education, and research; a summary of needed resources to achieve the goals set forth in this report; and an appendix with a description of the current status of individual Shellfish Growing Areas in the subtidal region. Readers should pay particular attention to Part Five: Future Projects and Initiatives. This is the section of the report that includes our recommendations for what we believe must be done to restore *Crassostrea virginica* to a viable population in the state's subtidal waters.

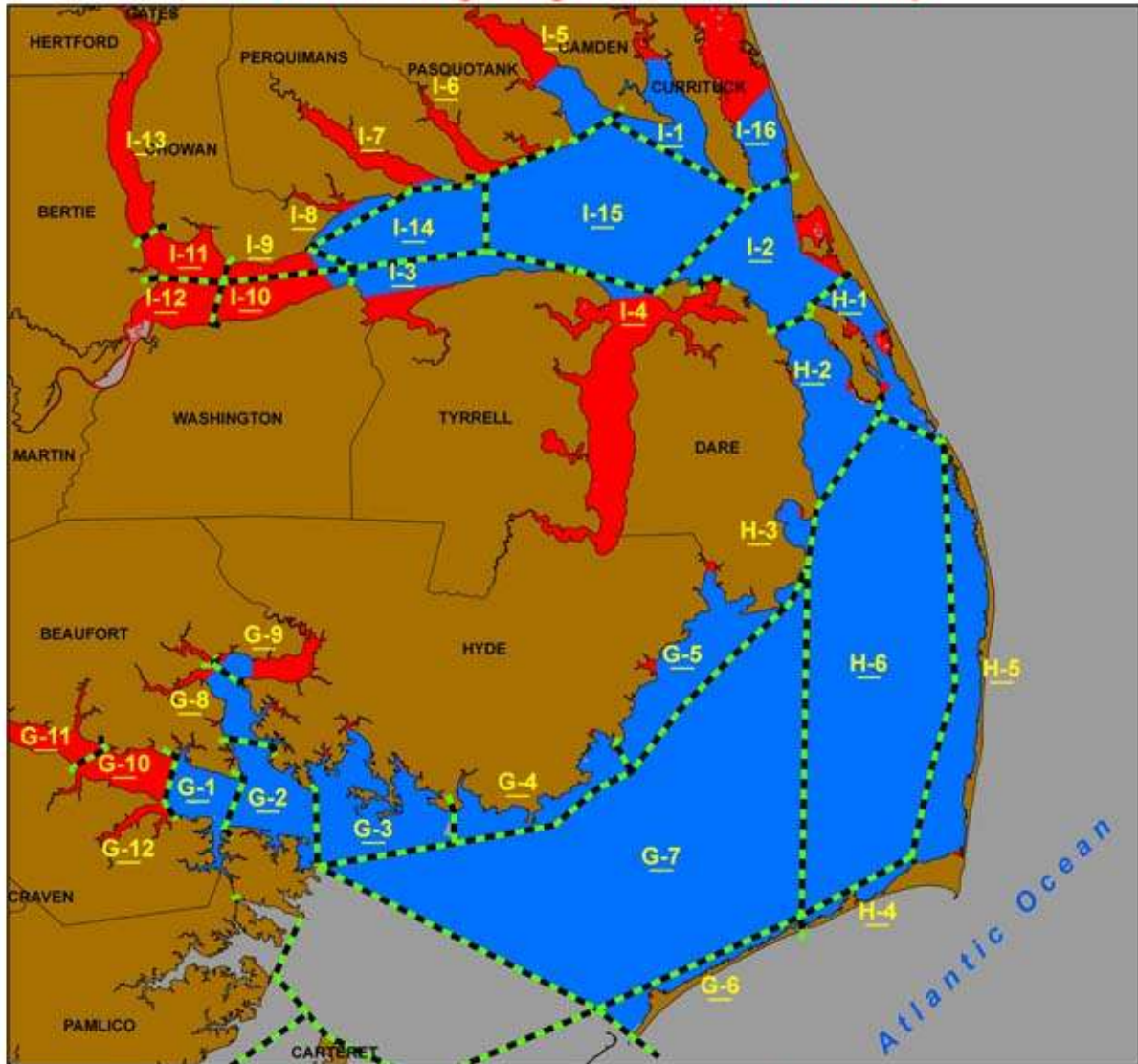
For the foreseeable future most restoration efforts will be concentrated in our high-priority areas. We would like to make a note about the size of these areas. Initially the Oyster Steering Committee designated a much smaller portion of the subtidal region as high priority for oyster conservation. However, in a later review work group members concluded there was little difference between the waters outside the high-priority designation and those within it, especially along the shore of Hyde County. In addition, important areas like the Long Shoal River and portions of Croatan Sound had been left out. Group members agreed that the high-priority designations should be expanded to the size reflected in this report. They also agreed that if possibilities open for good restoration projects in waters designated as middle or low priorities, they should be pursued.

In addition to members of the subcommittee, listed above, the full Northern Oyster Work Group includes Ocracoke fisherman Gene Ballance, NC State University Professor Cynthia Cudaback, Mitch Hall of the US Army Corps of Engineers, Jimmy Johnson of the Albemarle Pamlico National Estuary Program, Professor Charles Peterson from the UNC Institute of Marine Studies, and Alan Saunders of NC Shellfish Sanitation.

Following is a report of our findings and recommendations.

North Carolina Shellfish Growing Areas and Classification Maps

Click on shellfish growing area text to zoom into map



**NOTE: Shellfish Growing Areas temporarily close due to rain.
Please call 252-726-6827 for latest closures.**

Legend

-  Shellfish Growing Areas
-  Shellfish Growing Area Text
- Shellfish Growing Area Classifications**
-  Approved
-  Prohibited



North Carolina Department of
Environment and Natural Resources
Division of Environmental Health
Shellfish Sanitation and Recreational
Water Quality Section

Part One—Threats to Subtidal Oysters

Based on a comprehensive planning effort carried out by The Nature Conservancy over the past two years, the oyster populations of Pamlico Sound and other subtidal areas of the state were determined to be in fair condition. Subtidal oyster populations face many significant threats, ranging from changing estuarine conditions because of sea-level rise to declining water quality to incompatible fishing practices. Concerted management action will be required to improve their condition.

The Conservation Action Plan was developed by The Nature Conservancy in collaboration with NCCF, Environmental Defense, the North Carolina Division of Marine Fisheries, the U.S. Fish and Wildlife Service, and other partners. The plan is based on a multi-step process that entails identifying the key ecological attributes that influence the ability of a species or natural community to persist over time and then analyzing the stresses in the environment that affect those attributes and increase or diminish the long-term viability of the species or community.

Six key ecological attributes were identified for subtidal oyster reef habitat in the Pamlico Sound region. These were:

- Size of the oyster population, i.e., acres of reef and shell bottom.
- Distribution of oyster reef and shell-bottom habitat across the estuary, i.e., the scope and pattern in which oyster reefs are configured.
- Water quality, including appropriate dissolved oxygen levels, temperature, turbidity and sediment loads.
- Water salinity ranges appropriate for recruitment, growth and survival.
- Community structure and composition, i.e., a full range of age classes in the oyster population and the viable presence of all the other species commonly associated with reef and shell bottom habitat.
- Community architecture, i.e., the presence of intact oyster beds and high-relief reefs.

With the exception of salinity (rated good), the key attributes of subtidal oyster reefs and shell-bottom habitat were determined to be in only fair condition. And as noted earlier, the overall condition of oysters and oyster habitat in subtidal areas was rated marginally fair. This signifies that under current conditions subtidal oysters are not viable and will need extensive management and/or threat abatement to return to a viable status.

The major threats affecting oysters in the Pamlico region included a wide range of forces that directly or indirectly cause the key attributes to decline. Based on severity, scope and our potential ability to reverse it, each threat was ranked based on the following classifications:

- Very High – likely to eliminate oysters and oyster reefs over some portion of the area or be pervasive in scope and affect oysters throughout the area.

- High – likely to seriously degrade oysters over some portion of the area or be widespread and affect oysters at many of their locations.
- Medium – likely to moderately degrade oysters or be localized in scope.
- Low – likely to only slightly impair oysters or likely to be very localized in scope.

Threats ranked as Very High for subtidal oysters and oyster habitat were:

- Sea-level rise, which will cause many changes in North Carolina estuaries and result in shifting and altering habitat.
- Increased hurricane activity and intensity. Storm surges and heavy rainfall from tropical storms can destroy reef habitat, introduce huge fluxes of freshwater, release new pollutants into the estuary and increase sedimentation.
- Ditching and draining and the operation of drainage management systems.
- Incompatible fishing practices and overfishing.
- Ocean acidification.
- Diseases.

Threats ranked as High were:

- Housing and urban development, including activities that development brings: increased stormwater runoff, sedimentation from land disturbance and construction, pollution from wastewater treatment, etc.
- Construction of roads, culverts, bridges, shoreline infrastructure, associated dredging and stormwater runoff.
- Agriculture, including concentrated animal operations and nutrient loads from these activities.
- Shoreline hardening and other similar ecosystem modifications.
- Invasive species.

Threats ranked as Medium were:

- Forestry activities, including land management practices that result in hydrologic alteration.
- Boating activities with associated piers, docks and marinas.
- Atmospheric pollution.
- Increasing populations of algae, sea squirts and other problematic native species.

Based on these findings, the CAP recommended some conservation strategies and action steps. These are reflected in the recommendations contained within this report.

Part Two—Ongoing Research and Initiatives

Gene Ballance, a member of the Ocracoke Working Waterman's Association and Hyde County Commissioner, is mapping the location and shape of historic oyster rocks to guide location of future oyster restoration activities along the Outer Banks. He is currently working on two projects, both funded by **NC Sea Grant**. One project, entitled “Winslow in 3D: Tracing Heights of Historic Oyster habitat in NC,” used oyster references on historic USCS hydrographic surveys to extend the information collected and mapped by Francis Winslow in the nineteenth century. By using USGS hydrographic (depth) surveys, he has been able to give the Winslow data a height dimension, as well as calculating the degree of degradation since the time of the surveys. This project extends from the New River north to Roanoke Island, and the majority of the work is done in the subtidal waters of the Neuse and Pamlico Rivers. The work is complete.

Gene’s second project entails gathering side-scan sonar images and using them on a Pocket PC with GPS and color sounder to document the height and position of constructed sanctuary mounds. This work covers subtidal NC oyster sanctuaries around the Pamlico Sound and the report was approved in August 2007. The project was extended to do the same work in 2008 to check on possible mound settlement. It is being done in cooperation with Dr. David Eggleston of NC State University, who is studying six NC oyster sanctuaries.

Dr. Cynthia Cudaback of NC State University, a physical oceanographer, is studying larval dispersal potential through an investigation of current patterns in Pamlico Sound. Preliminary transport studies indicate that drifting oyster larvae can potentially travel significant distances in their first few days of dispersal, and suggest that a series of oyster sanctuaries along the west shore of Pamlico Sound could significantly enhance oyster restoration efforts.

Oyster larval dispersal is predicted by two distinct methods. First, a current meter (an ADCP) is deployed at a single location to measure currents at all depths every five minutes for up to 6 months in summer. The near-surface velocity measurements can be integrated over time to predict the final locations of larvae released near the current meter. As currents are different in different locations, these predictions are only good for an area close to the ADCP, or about a day's travel for a drifting larva.

Data collected in summer 2006 indicate that larvae released near Crab Hole can potentially reach most of northern Pamlico Sound in their first day of drifting. Larvae released near West Bluff experience much slower currents, and their potential dispersal envelope is about 1/4 the size of the envelope at Crab Hole. A current meter deployed near Gibbs Shoal in 2004 completes the picture; this predicted dispersal envelope overlaps with the Crab Hole and West Bluff envelopes. Thus, larvae from Crab Hole can easily reach Gibbs Shoal, and larvae from Gibbs Shoal can easily reach West Bluff.

The second way to predict larval dispersal is to deploy buoys that float on the surface and record their positions via GPS and cellular phone. The drifting buoys respond to all changes in currents and allow us to test the reliability of the ADCP predictions. Buoy deployments in 2006 lasted 4-24 hours, so all locations visited by the buoys are contained within the predicted 1-day dispersal envelopes. Longer buoy were conducted in 2007.

Graduate student Brandon Puckett is conducting a related study of spat settlement at piers around Pamlico Sound. He found that spat settlement was loosely correlated with wind directions, with a three-week lag. Three weeks after a period of southwesterly winds, significant spat settlement was observed in the northeastern part of Pamlico Sound, and three weeks after a period of northeasterly winds, settlement was observed in the southwestern part of the Sound. This result suggests that oyster larvae may travel significant distances during the first week of their lives and maintain position for two weeks before settling. Thus, dispersal predictions based on 1-week drifter deployments may be more accurate than we had anticipated.

The studies have been conducted during the summers of 2006 and 2007 and are funded by NC Sea Grant through January 2008. Dr. Cudaback is collaborating with NCSU graduate student Amy Haase, Dr. David Eggleston (PI—ecology), the Coast Guard Auxiliary Fleet, the Hatteras Flotilla, and DMF crews from Wanchese and Morehead City, NC.

Linda D'Anna, graduate student at UNC at Chapel Hill, is examining differences between estuarine vegetation and reefs in providing habitat for oysters. Reefs and other three-dimensional emergent landscape features, like seagrass beds and intertidal salt marshes, provide important complexity and heterogeneity, two features that are limited in the otherwise sedimentary estuarine bottom. In addition to altering local physical conditions, these structures are utilized as habitat by a diversity of organisms for feeding, foraging, nesting, spawning, attaching, and refuge. She hypothesizes that there is low overlap between the species assemblages inhabiting seagrass beds and oyster reefs, suggesting that oyster reefs make a unique and important contribution to overall species diversity in the Pamlico estuary. She anticipates that the study results will support recent efforts to incorporate measures aimed at restoring oysters as habitat for other species into efforts to restore the oyster fishery. Such restoration efforts occur not only in geographical places, but also in places of consciousness and memory, in culturally constructed places. Local perspectives and attitudes can have a measurable effect on the outcome of restoration efforts as they are expressed through practice. Social and political recruitment of local citizens to support restoration efforts over the long-term are vital to project success. This project will demonstrate that documentation of local perspectives, attitudes, and knowledge through ethnographic and oral methods, including cultural models and cultural consensus analysis, is a critical component of restoration work, because those factors affect the physical and biological parameters of restoration success.

Dr. Ed Noga of NC State University College of Veterinary Medicine, professor of aquatic medicine, began working with Dell Newman of Newman Seafood, Swan Quarter, in May of 2006 to develop an improved method to assess the health of oysters. This builds on Dr. Noga's discovery that American oysters have an antibiotic in their tissues that can kill many pathogens. This allows for development of a simple test (ELISA) to measure this antibiotic in oyster blood (hemolymph). An antibiotic test for assessing oyster health would be useful to end-users who wish to improve the efficiency of their oyster broodstock selection program by choosing oysters with the highest potential for disease resistance, and thus overall survival. They hope to use this test to identify

regional strains with high antibiotic levels for optimizing local restoration and enhancement efforts

The Nature Conservancy (TNC)'s project was entitled "community based restoration of subtidal oyster reef habitat in Pamlico Sound." They collaborated with DMF to build high-relief limestone marl reefs in designated sanctuary areas in Pamlico Sound. TNC's goal in this project was to develop pilot projects in several types of oyster reef restoration, including sanctuary-based management, oyster shell recycling, construction of shallow water reef habitat, remote setting of oysters on shell and limestone marl, and the development of monitoring approaches for subtidal reefs.

The first reefs constructed through the project were at a 30-acre site near Clam Shoal in southeastern Pamlico Sound, just north of Frisco. Monitoring of these reefs since 2003 has indicated that high-relief reefs have tremendous potential as a design for restoration. Each year the Clam Shoal reefs had abundant recruitment and high rates of adult survival, and by 2006 there were several age classes of adult oysters present on the reefs. Since then, TNC staff has made no effort to continue monitoring the reefs because oysters were so abundant it was impossible to count them accurately.

This project, which was funded by a series of grants from the TNC-NOAA Community-based Restoration Program supplemented by DMF with state funds, began in 2003 and was completed in 2006. Collaborators included TNC, NCDMF, local businesses, and community members.

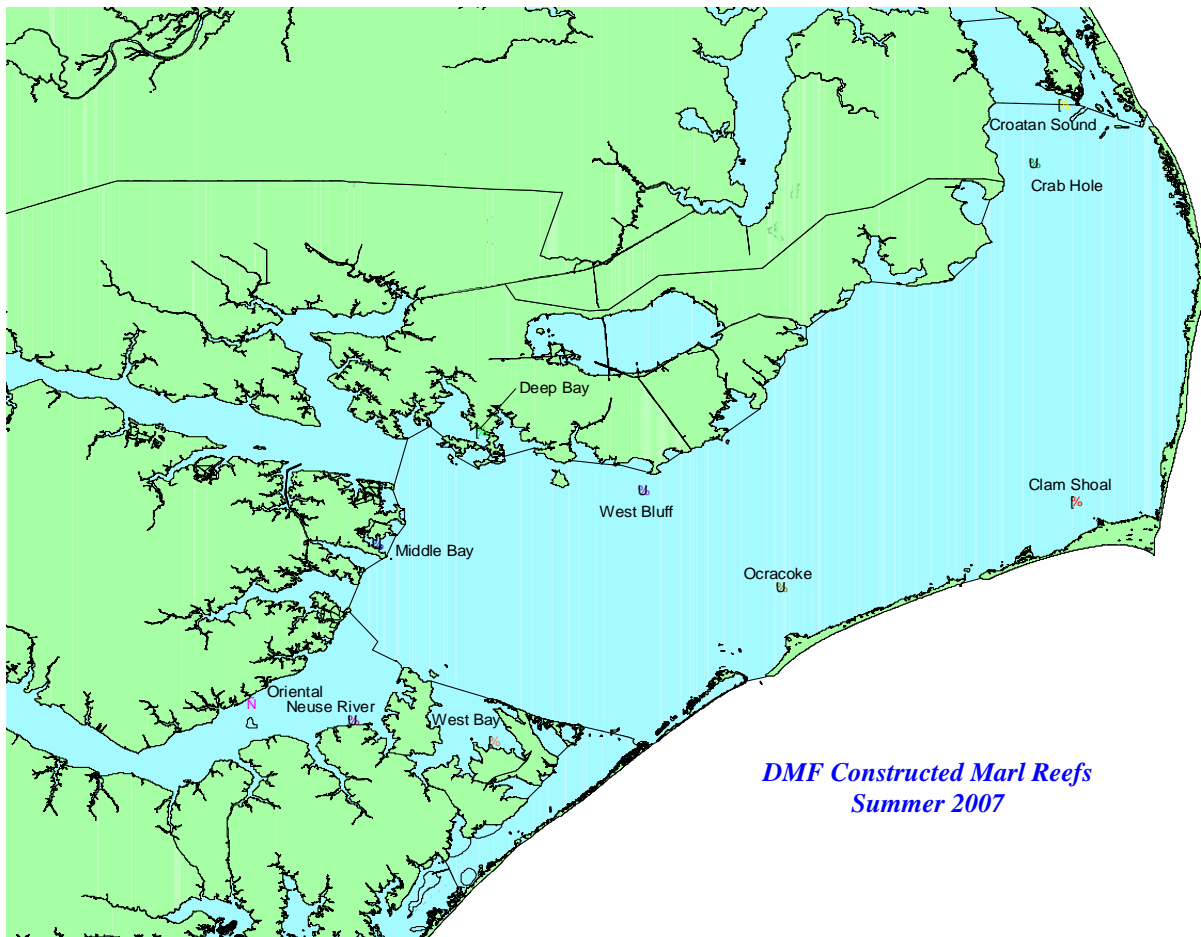
Staff at Jockey's Ridge State Park are constructing shallow reefs made of bagged, recycled shell as part of the park's environmental education programming. These reefs are adjacent to the park in Roanoke Sound in an area designated by the state as a Research Sanctuary for one year. The project began in June 2006 and has been operating under the park's annual budget. Aaron McCall of The Nature Conservancy has collaborated on this project and has donated material as part of TNC's NOAA Community-based Restoration grant. In addition to the three constructed reefs, cultch has been placed in the intertidal *Spartina alterniflora*. The staff plans to continue monitoring the reefs for species diversity, oyster survival and recruitment, and to expand the oyster reef sanctuary area to buffer salt and brackish marsh and submerged aquatic vegetation beds.

North Carolina Sea Grant submits two-year institutional proposals to its parent agency – National Oceanic & Atmospheric Administration (NOAA) – through which several oyster projects have been conducted. It is very important to note that Sea Grant-sponsored research has a specific use and is justified in terms of the ultimate value and utility of results. North Carolina's Fishery Resource Grant (FRG) Program is funded by the General Assembly and administered by Sea Grant. Grants allow fishers and researchers to team up on innovative projects designed to understand the state's aquatic resources, but more importantly, to foster management decisions grounded in scientific, as well as local expertise. The organization decides where to allocate funding and monitors the communications for the projects that it funds, including the Encore for Oysters conferences and projects led by Gene Balance, Dave Eggleston, and Cynthia Cudaback. Sea Grant's Sara Mirabilio is participating in the Northern Oyster Working

Group to ensure that funding corresponds with the Oyster Blueprint for Action. She has also advised the Northern Work Group subcommittee on educational initiatives within the region.

The North Carolina Division of Marine Fisheries (DMF) has nine subtidal oyster sanctuaries in the Pamlico Sound, under the direction of fisheries biologist Craig Hardy. Each sanctuary contains several high profile mounds and class B rip rap (limestone marl). A map of the sanctuaries is shown below. The state of North Carolina allocates \$150,000 annually to this project and other organizations, including The Nature Conservancy, Clean Water Management Trust Fund, and NCDOT, have provided funding in recent years. DMF has also received funding for this project from a National Marine Fisheries Service (NOAA) Hurricane Grant. Other people and institutions involved include:

- NC State's Dr. David Eggleston and his students, Brandon Puckett and Ray McRoch, who are studying larval recruitment and oyster fecundity in the sanctuaries,
- UNC-W's Dr. Ami Wilbur, who is studying genetics with regional differences and differences between wild stock and reared stock, and
- NC State's Cynthia Cudaback and Amy Hasse, who are modeling larval transport and larvae dispersal from sanctuaries.



In 2007 DMF staff began full scale sanctuary monitoring to measure growth, survival, and recruitment of oysters and larvae settlement selectivity on different cultch materials. In the future, DMF seeks to expand the Oyster Sanctuary Program and use the sanctuaries as sources of larvae for existing oyster rocks and for cultch planting sites.

In addition, DMF staff have engaged in an extensive cultch planting program. The purpose is to provide suitable substrate for the attachment of natural oyster spat as well as other filter feeding organisms. Planting sites are selected by biologists on the basis of salinity, bottom type, tidal flow, exposure to wave action, prevailing winds and location of other natural oyster rocks along with input from local fishing interests.

Dare County plantings range from northern Roanoke, Croatan, and Pamlico Sound to Hatteras Island encompassing eastern and western Pamlico Sound. The majority of the sites are located from Jockey's Ridge south to Oregon Inlet, the west side of Pamlico Sound from Point Peter to Long Shoal River, and the Hatteras area from Clam Shoal west to Rollinson Channel. Major sites include Cedar Bush Bay, Wanchese, Walter Slough, Crab Slough, Pea Island, and Buxton Harbor Channel.

Hyde County plantings range from Ocracoke to western Pamlico Sound. Major sites include Howards Reef, Wysocking Bay, East and West Bluff, Juniper Bay, Great Island, Swan Quarter Bay, Rose Bay, Spencer Bay, and Abel Bay.

Pamlico County plantings range from Oyster Creek southward on the west side of the Pamlico Sound to Bay River. Major sites include Clark Creek, Mouse Harbor, Middle Bay, Jones Bay, and Bay River.

Carteret County plantings contain sub-tidal and inter-tidal habitats and include the southern side of the Neuse River, West Bay, Core Sound, and Bogue Sound. Major sites are Adams Creek, South River, Point of Marsh, Raccoon Island, West Bay, Cedar Island, North River and Newport River. (This area spans both the subtidal and tidal regions.)

Since the 1980's the Division of Marine Fisheries have planting approximately 1,700 cultch sites statewide. Planting sites average 5,000 to 30,000 bushels of material each depending on the area. Cultch sites are sampled for recruitment. Samples are collected once a year, during January to April. Samples from the previous three years plantings are analyzed for initial spatset and growth. The data are used to evaluate the success of the plantings, determine the suitability of various areas for oyster culture, and make comparisons between different plantings, areas, or cultch materials and to assist in the selection of future planting sites.

The U.S. Army Corps of Engineers, Wilmington District, and the State of NC are currently conducting the Neuse Study that will identify opportunities for ecosystem restoration. The primary focus areas include: streams and wetlands, anadromous fish passage and estuarine resources. An important aspect of the estuarine component includes the potential restoration of 50 acres of subtidal oyster reef in the Neuse River estuary. Oyster restoration plans will be developed based on geospatial analysis of biological and physical data and water quality data from updates of existing models.

Remote sensing of subtidal oyster reefs in the Neuse River estuary using side-scan sonar and reconnaissance multi-beam sonar was completed in July 2006. A detailed multibeam survey of identified reef sites will be completed in July 2007. Updates of the water quality model are ongoing and preliminary model runs and interpretations will be completed in September 2007. Biological sampling of selected reefs is proposed for

2008 and pending a favorable study finding, reef construction could begin as early as 2010.

Initial multi-beam, side-scan and qualitative biological sampling data were used to locate and verify potential reefs in the Neuse River Estuary. These reefs have been characterized and inventoried in GIS based on site descriptors including their size; structural complexity; shape and orientation; and status as an individual site or part of complex. Additional descriptors (location within the estuary relative to the upstream limit of the state designated oyster growing area (OGA); volume, height and roughness) will be determined and inventoried upon completion of the detailed the multi-beam survey.

Water quality in the Neuse Estuary is continually monitored as part of extensive ongoing monitoring programs at cooperating NC universities and a 3-dimensional water quality model is available for the estuary. Combined, these efforts are known as the Neuse River Mod-Mon Project. Water quality and flow data for the Neuse River Estuary OGA (about 185 sq. mi.) will be extrapolated from the aforementioned model for each ~ ¾ sq. mi. grid at four water layers including the bottom, surface and two intermediate layers. Parameters of interest will be collected as available for the period of 1998-2006. Grid data for a given water level will be used to interpret normal water quality conditions at various elevations within each grid. The extent of optimal and suitable oyster growing conditions and the return interval of killing freshets or hypoxia will be determined. Water quality predictions and other physical descriptors as described above will be used to develop a concept model to calculate a Habitat Suitability Index predicting the potential for establishment of sustainable oyster reefs at a given site.

A sub-sample of reefs that represent the range of site conditions in the Neuse Estuary OGA will be selected for detailed biological sampling and analysis. Replicate biological samples will be collected using hydraulic patent tongs to assess oyster condition. The ratio of live oysters to shell, oyster distribution by size class, biomass, disease index and condition will be used to assess the status of the existing oyster population. Appropriate statistical analysis will determine the actual correlation of physical parameters with biological attributes. A verified model, weighted based on the results of field sampling and analysis, or a statistical model will be developed as appropriate for final selection and evaluation of restoration sites.

The North Carolina Coastal Federation's oyster restoration efforts in the subtidal region have been concentrated in mainland Hyde and Dare counties, where staff members are coordinating a wetlands restoration planning project. The goal of the project is to identify potential land-based restoration sites that will lead to water quality improvements in areas where the NC Division of Marine Fisheries plans to build oyster sanctuaries. We are working with a stakeholders group that includes farmers, fishermen, and land managers for state and federal publicly held lands. A wetlands restoration consultant is advising on potential projects.

Funding has been obtained for a project at the Point Peter Canal, which drains to the Croatan Sound from the Alligator River National Wildlife Refuge in Dare County. It is hoped that restoration work will start in 2008. Potential projects on lands that drain to the Long Shoal River, Wysocking Bay, and Rose Bay are also being investigated.

The goal of this planning effort, funded by the Mary Flagler Cary Charitable Trust, is to identify wetlands restoration projects on the Albemarle-Pamlico Peninsula, in essence developing a restoration plan that will take us through the next decade. Some of the projects may be undertaken on lands that do not drain to SA waters. However, we are looking in particular for projects on lands that drain to Middletown Anchorage, Wysocking Bay, East and West Bluff bays, Juniper Bay, Swan Quarter Bay, and Rose Bay, because of DMF's high interest in establishing oyster sanctuaries in those areas.

As the potential land-based restoration projects are identified on the Albemarle-Pamlico Peninsula, we plan to look for additional opportunities in the rich shellfish waters off Pamlico County. Eventually we will also seek projects in the subtidal region's middle priority and low priority areas. The Northern Oyster Work Group has suggested a goal of restoring the hydrology on 10,000 acres in the region by 2020. Much of that will be accomplished through the efforts of NCCF and our partners.

NCCF has also partnered with the US Army Corps of Engineers in the construction of a living shoreline erosion control project at North Carolina's Festival Park on Roanoke Island. This project created oyster habitat behind a rock sill designed to serve as a breakwater.

Part Three: Ongoing Education Efforts

There are now four oyster reefs (via three Research Sanctuary designations) at **Jockey's Ridge State Park** working to cleanse the Roanoke Sound, providing new habitat for fish and serving as a natural way to combat eroding shorelines. The latest reef is courtesy of about 20 volunteers from an environmental science class who canoed, kayaked and carefully positioned 100 bags of recycled shells offshore in April 2007. The Park developed a program around these reefs, "Restoring the Oyster," where participants obtain an up-close look at an oyster restoration project and find out what lives on, and around, oyster reefs by sampling some of the oyster shell bags, which are full of critters. In the inaugural summer of 2007, and merely on Mondays for one hour, rangers conducted 21 programs with a total attendance of 156 persons.

The Nature Conservancy has helped establish nine reef sanctuaries within the region, including the new reefs off Jockey's Ridge State Park. They also help collect brood stock for spawning and production of eyed larvae by Carteret Community College (CCC) to seed NCDMF oyster sanctuary cultch plantings. Tours of reefs and park property are offered by request. Programming aims to promote the recycling of oyster shell to create new oyster reefs and to educate the general public about the importance of restoring, preserving and enhancing oyster reefs along the North Carolina coast. Preserve staff assist other local conservation organizations with public shell bagging days. The Nature Conservancy also provided recycled shells and larvae that was seeded in habitat created by the living shoreline at Roanoke Island Festival Park. That project was completed in partnership with the US Army Corps of Engineers (Wilmington District Office) and NCCF.

The **Roanoke Island Festival Park** Aquatic Habitat Restoration & Protection Project restored and/or protected five acres of maritime forest and shallow estuarine habitat, including marsh, sea grass and oysters. It includes a rock sill that increases diversity by providing attachment substrate and protects the habitat and adjacent public facilities from future erosion. The sill stabilized 1,500 feet of coastal marsh and maritime forest. Leading from the main park entrance to the restoration site is an "educational boardwalk" with traditional graphic (or signage) panels explaining oyster biology and restoration efforts.

Oyster gardening is another novel way for citizens to learn about oyster biology and habitat function by growing oysters as an educational or recreational activity. In 2002, **NC Sea Grant** published a how-to guide (Shellfish 4 Us: Backyard Shellfish Gardening, Publication #UNC-SG-BP-02-01) for waterfront residents who want to grow clams and oysters along their shorelines. Extension personnel will visit private sites and provide an evaluation of the restoration potential and assist homeowners with the permitting and reef construction process.

The **UNC Coastal Studies Institute** is currently in the planning stages for the upcoming coastal studies curricular redesign of the Cape Hatteras Secondary School. Student stewardship projects focusing on water quality and oyster restoration will provide a

hands-on approach to learning. Middle school students and teachers from the school have taken part in a pilot program in which students raised oysters from fertilized eggs given to them by the North Carolina Oyster Hatchery Program (NCOHP). Juvenile oysters (spat) will then be used by the NC Division of Marine Fisheries (NCDMF) for placement on oyster sanctuaries located off Hatteras and Ocracoke islands.

Beginning in 2005, the Department of Environment & Natural Resources (**Aquariums Division**) received recurring monies to plan for the development of oyster hatcheries at each of the three aquariums and to develop public education programs regarding those oyster hatcheries. A virtual oyster classroom at www.ncoysters.net provides standards-based, grade-related interdisciplinary curriculum on a variety of oyster and estuarine topics. Many activities are hands-on and easy to use in classrooms.

Part Four: Future Restoration Projects

Dare County—On land

1. Reduce flow of Point Peter canal, Alligator River National Wildlife Refuge. Project funding obtained; work planned for 2008. Water will be spread into lateral canals to slow flow and reduce freshwater intrusion into the sound. This project will reduce drainage from 16 square miles of refuge lands, decrease freshwater intrusion into Croatan Sound, and help buffer the refuge from sea level rise. Water quality monitoring will be conducted to measure results.
2. Durants Point, Hatteras Village—Place conservation easements on property and purchase key parcels to protect shellfish waters and important village green space. The Dare County Commissioners have agreed to hold conservation easements, and terms have been reached with a land owner to place an easement on 65 acres, including the tip of the point. Steps are being taken to transfer another piece from ownership by NC State University to the Division of Marine Fisheries for conservation. In addition, NCCF is investigating the possibility of building a living shoreline to protect the point from erosion and create more shallow water oyster habitat. This project is being tied into a Working Waterfront project that the county hopes to complete in the village.

Hyde County—On land

1. Reduce flow from Fifth Avenue Canal on private land—This project will involve numerous land owners and funding sources over several years. It will be done in two phases. In the first phase, NCCF will work with local farmers to reduce flow into the canal by pumping water onto lands preserved through conservation easements, land sales, the USDA Wetlands Restoration Program, and possibly other strategies. Water will be directed away from the Long Shoal River and Pamlico Sound. This project has the potential to restore the hydrology to thousands of acres. It will benefit water quality along a shore that is seen as a prime candidate for oyster reef restoration. Negotiations with property owners and managers and funding agencies are ongoing.
2. Divert water from the Fifth Avenue Canal on to state lands—In the second part of the project, remaining water from the Fifth Avenue canal would be run through spreader swales across the Wildlife Resources Commission game lands on the east side of Highway 264. The decrease in freshwater output to the Long Shoal River will enhance local water quality and increase the success of planned oyster reef restoration projects in the river.
3. Purchase/place conservation easement on a large parcel off Rose Bay and restore hydrology. Discussions with the land owner are continuing.

4. Work with farmers in Hyde and Pamlico counties to employ BMPs in drainage ditches and canals.

Additional projects are being identified through the Albemarle Pamlico Wetlands Restoration Project being administered by NCCF. We are looking in particular for projects that will improve the quality of water flowing into the Long Shoal River, Middleton Anchorage, Wysocking Bay, East and West Bluff bays, Juniper Bay, Swan Quarter Bay, and Rose Bay in Hyde County. More work will be done to identify potential restoration sites in the Middle Bay and Jones Bay areas south of the Pamlico River.

Reef Building Projects

The Division of Marine Fisheries has reef construction projects identified for 2007 and 2008:

2007 Sanctuary deployments: 4,200 tons class B rip rap (~28 mounds)

- * 2,000 tons (~13 mounds) Neuse River site
- * 1,200 tons (~8 mounds) Ocracoke site
- * 1,000 tons (~7 mounds) West Bluff site

2008 Sanctuary deployments: 1,800 tons class B rip rap (~12 mounds)

- * 900 tons at Ocracoke
- * 900 tons at West Bluff
- * Possible CRFL Funding for initiation of new site (Funding level, material amount, and location to be determined)

In 2009 and 2010 DMF will continue to use appropriated funds to expand existing sites and construct new sanctuaries, with modifications to procedures and protocols based on research findings. DMF will continue to monitor sites for structural integrity and biological/ecological function. The division will also continue to cooperate with researchers to improve the body of knowledge about oyster recruitment, survival, and restoration in North Carolina waters.

In addition, the ongoing shellfish mapping efforts will be expanded to include mapping of deep water areas. Deep water rocks will be mapped to document their size, shape, profile, and biological status. A pilot project will be undertaken to monitor dissolved oxygen, along with other parameters. Data from deep water rock and adjacent areas will be included in the monitoring.

The Shellfish Mapping Program is designed to identify shellfish resources by delineating substrate types (shell bottom, sand, mud, firm, and soft bottoms and SAV presence) and calculating shellfish densities by sampling in the various substrates. For about 15 years the program has focused on near shore areas less than 12 feet deep, due to manual mapping methods—sounding poles, tongs and rakes. The acquisition of an advanced sonar unit will allow the program to expand into the deeper areas of the Pamlico Sound and major tributaries. This dedicated equipment should provide a clearer picture of deep

water shellfish resources and historic oyster rocks, providing the Division with the opportunity to sample, monitor, and perhaps enhance these naturally occurring oyster rocks. Accurate locations of these resources will allow for data acquisition both on the structures and adjacent to them, so we can better understand the stresses affecting the health of the oysters. The shellfish Mapping Program is under the direction of Brian Conrad.

Existing oyster sanctuaries will be mapped with this equipment. Stopher Slade, oyster sanctuary biologist, will assist with the deep water mapping and assimilate information gathered on the sanctuaries into current and future projects. Data collected will be used as part of site selection criteria for new sanctuaries.

During the first three years following the placement of marl in the water, Stopher collected 30 pieces of cultch from each site, counted and measured the attached oysters, and completed a statistical comparison. The first year of sampling found significant recruitment. In the second and third years, sampling showed secondary recruitment and good survival and growth rates.

Part Five—Recommendations for Future Actions

Water-based Projects

Biologists are seeing good recruitment and survival on the new reefs that have been created in the last five years through DMF’s sanctuary program. However, the Albemarle-Pamlico estuary covers a million acres. If you look at the map of where oyster reef restoration has been done to date (page 7), the largest new reef, Crab Hole, appears as a tiny blip. It was agreed that for restoration efforts to be effective, they must go forward faster and on a larger scale.

How much in-the-water restoration is enough to assure the recovery of the native oyster? This question was the subject of much discussion during a year-long collaborative effort to write a Conservation Action Plan (CAP) for the Outer Banks and Sounds. The CAP was written with input from conservation groups, scientists, and state agencies. Based on the CAP’s conclusions, it was agreed that efforts to restore oysters must be ambitious and aggressive, in the water and on land. After much discussion, it was decided to adopt the following goals for the Subtidal Region’s water-based restoration program:

- 500 acres of new marl reef constructed and designated as sanctuaries by 2018
- 500 acres of new cultch planted in managed fisheries areas by 2018

This is ambitious, but it will go far toward beginning the recovery of *Crassostrea virginica*.

To reach this goal, NCDMF and its partners will need more resources than are currently available. To that end, we urge the state to make additional staff and equipment available to NC DMF. Specific recommendations for new resources can be found beginning on page 24. The cost of these added resources will be high. But Northern Work Group members believe such expenditures are necessary if the Eastern oyster is to be returned to healthy numbers in this region.

In addition, we believe that wherever possible, the development of new sanctuaries and oyster management areas should be coupled with hydrologic and wetlands restoration and storm water outfall removal projects.

The work group talked about also setting goals for in-the-water restoration for a shorter period, such as three to five years. However, the reef-building projects already planned by DMF will take that long to complete. A list of those projects appears on page 14.

Land-based Projects

When considering on-land restoration projects, at first we thought about matching the water-based program and setting a goal of 1,000 acres of restored wetlands in the next ten years. However, recent work by members of the Albemarle Pamlico Wetlands Restoration Group in mainland Dare and Hyde counties has shown that work in this

region will proceed slowly. Land owners and managers with holdings upstream from restored properties must be assured that their lands will continue to drain.

The Albemarle-Pamlico Peninsula is so flat that water flow is heavily influenced by wind direction. It is so far from an ocean inlet that it is not influenced by lunar tides. The same is true of Pamlico County. These two factors make for unusual hydrology in a coastal region and may complicate the design of restoration projects.

NCCF's wetland restoration experience at North River Farms has shown that restoration can cost between \$340 and \$2,100 per acre. In one part of the project that involved more extensive grading, the cost was \$12,000 per acre. These costs are in addition to any land purchase that would be required. A proposal to create a 45-acre wildlife impoundment in Hyde County carried a price tag of between \$250,000 and \$520,000, in part because of the pumping equipment that would be required. It was not clear how much of the cost would be absorbed by the farmer.

In the next five years, the Albemarle-Pamlico wetlands restoration project hopes to design and fund several small (45 to 100 acre) projects and to set things in place for one or two much larger scale projects somewhere in the subtidal oyster region. Even with all this, we would likely fall far short of restoring 1,000 acres of wetlands over the next decade.

Instead of setting a goal for restoring a certain number of wetland acres, it was decided to set a goal of eliminating outfalls and restoring the hydrology to 2,000 acres of land within the next three to five years and to 10,000 acres over the next decade. These goals are achievable and may even prove to be modest. The project at Point Peter in Dare County, which NCCF hopes to begin next year, would eliminate runoff from 16 square miles of land. A project the size of North River Farms could eliminate drainage from many thousands of acres.

It is important to note that while large restoration projects are important, our goal is to restore water quality to the many bays where oysters were able to thrive 200 years ago. Small, scattered projects will be just as vital as large efforts. The pilot project with the 45-acre wildlife impoundment described above would have eliminated runoff from 300 acres of farmland. This would yield measurable improvements to water quality in Wysocking Bay, an important habitat for oysters. It is our hope that once a few projects are successfully completed, we will find many more willing partners.

Areas of Interest

Unlike the rest of the NC coast, the subtidal region is characterized by large areas of relatively deep, open water. Historically, many areas of Pamlico Sound have been highly productive for oysters, and a map of our high-priority areas reflects that. The high-priority areas for the central and southern work groups are much smaller.

Subcommittee members agreed that we should target certain sections of the high-priority areas for water- and land-based restoration. In consultation with DMF staff, the following areas were considered to be of special interest for restoration:

(Moving North to South)

Long Shoal River

Middletown Anchorage

Wysocking Bay

Juniper Bay

East Bluff and West Bluff bays

Rose Bay and the Swan Quarter area

Bombing range area south of Tar-Pamlico—Jones Bay and surrounding creeks

Middle Bay

Artificial reefs on the Neuse River north shore, east of Oriental

Additionally, the USACE is planning a reef restoration project in the Neuse as part of an ongoing, multi-year study of the river and water quality. A full description of that project is included in Part Two of this report.

Any water-based restoration projects that can be pegged to land-based projects will be considered of the highest priority. Conversely, we will be especially looking for restoration opportunities on lands that drain to these waters.

Research Needs

Because of the size of the subtidal region, there is a pressing need for research on larval dispersal and the hydrodynamics affecting transport during the first two to three weeks after spawn. A study by Cynthia Cudaback and David Eggleston is tracking where currents may carry larvae during the first eight to ten hours. This work is described in detail in Part Two—Ongoing Research and Initiatives. More research is critically needed to help determine more precisely where to build reefs and plant cultch so that they will receive the highest spat set. Dr. Cudaback is expanding her investigation into subsurface currents. However, extensive work involving numerous investigators will be needed to yield a thorough understanding of the complex currents of northern Pamlico Sound.

Questions persist about the dispersal of larvae into different areas. Dr. Ami Wilbur of the University of North Carolina at Wilmington has investigated larval dispersal in the southern estuaries and the Neuse region by using genetic markers. Work group members agreed that a similar study is needed for the subtidal region. Investigations into timing of oyster spatfall also would be beneficial to timing of cultch placement activities.

There is a great need for research on constructing oyster reefs to help with shoreline stabilization and in adding resilience to estuarine systems as sea level rises. The Roanoke Island Festival Park Habitat Restoration & Protection Project demonstrated successful protection of habitat and adjacent public facilities from future erosion while simultaneously providing an attachment substrate for oysters on a rock sill. Research is

needed into the most beneficial designs, feasibility and costs for sills. A project that was to be conducted by The Nature Conservancy on the Albemarle Pamlico Peninsula has been put on hold because of funding and staffing issues.

As reefs are constructed, they should be monitored for oyster recruitment and survival, as well as the presence of diseases. This work is beginning now but will need to be expanded to help with the choice of sites for reef construction in the future. This would be further enhanced by a better understanding of settlement success on different cultch materials and the chemical cues that initiate settlement behavior in larvae. Last, an assessment of survival and productivity of relayed oysters versus natural recruitment on planted cultch is needed.

A suggestion was made to study placing sandy dredged material in areas where it might aid reef building and cultch planting. This would dovetail with current research to determine optimum sanctuary size, profile and amount of material needed. Specifically, high quality sand could be placed in carefully chosen areas where good oyster growing conditions are in the vicinity of Corps navigation channels and no existing SAV or other significant resources exist that would be impacted by the sand disposal. Submerged sand islands or bars would be topped with rock and cultch, reducing the amount of costly rock needed to raise bottom elevations so that they would be suitable for oyster growth. Similar work has been done in the Chesapeake Bay. The subcommittee has not fully investigated this proposal; however, the Corps has suggested that areas in the vicinity of Old House Channel, where maintenance dredging has historically produced large quantities of sand, would be worthy of investigation. This area is scheduled for dredging in 2008, which might provide a potential first opportunity to implement such a plan.

Water-based restoration off the Outer Banks was seen as problematic because of sand settlement on reefs. However, the suggestion was made to experiment with modifying reef design in such shallow subtidal areas. Potential models might include a combination of cultch and marl placement that would discourage dredging for oysters. Because the Outer Banks waters were once rich in oysters, and because so much of the land is in public ownership, free of development or agriculture, they should not be abandoned.

Finally, work group members believe there is a need to determine the most cost efficient way of funding marl reef construction and cultch planting. Is it more economical for the state to continue its current program, using marl donated for mitigation, for example, or for NGOs and the federal government to undertake this kind of restoration project? The answer to this question is important to determining how to accomplish the most restoration projects in the coming decade.

Public Education

Restoration of a complex ecosystem requires a multi-pronged approach. The Northern Work Group has divided its restoration efforts into restoring habitats, protecting watersheds, and coordinating research. A critical fourth element is fostering stewardship through education – formal and informal.

Education efforts include a broad range of actions, from expanding opportunities for residents to experience and protect North Carolina's coastal sounds, to formal outdoor environmental education experiences for school-age children, to engaging communities and helping move them to action.

K-12 program efforts will work to directly link to the state Standard Course of Study. In merely examining Competency Goals for grades 9-12, there are many avenues where oyster-related information could be worked into existing curriculum needs. The Northern Work Group has set goals of:

- By 2013, outreach programs will have provided training opportunities for more than 10% of area teachers.
- By 2013, all Dare County school students will have participated in an oyster restoration field experience during their K-12 education.

In regards to specific programming, the Georgia Marine Extension Service offers a class called, "Oyster Restoration in Georgia," which introduces the history of the Georgia oyster industry, followed by a discussion on why our populations are declining. Students visit a restored oyster reef and get an overview of oyster restoration processes currently being conducted in the area. Each stage of the process involved is discussed, from the collection and bagging of shell, to the planting and monitoring of reefs. Students have the opportunity to participate in the restoration program by visiting the shell-recycling center to assist in the bagging of shell. Similar programming for area students should be considered.

Festival Park operates several week-long "Voyager" camps for children 6-8 and 9-11 years old. They have dabbled with campers visiting restored oyster habitat, getting an overview of oyster restoration processes currently being conducted in the area and the processes involved in restoration, from the collection and bagging of shell, to the planting and monitoring of reefs. Children even participated in the restoration program by visiting the Wanchese NCDMF shell-recycling pile and assisting in the bagging of shell for placement at the site. This hands-on interaction and experiential learning could become a permanent curricular component of their "Living by the Sea" camp.

One of the most important things that everyone can do to ensure that they can continue to enjoy oysters is to recycle empty shells. In 2007, the NCDMF will deploy 300,000 bushels of oyster reef material in sanctuaries and harvest areas. This represents an increase from 239,000 bushels in 2005 and 277,000 in 2006. But unfortunately, the NCDMF has received, in total, only 24,000 bushels of recycled oyster shells since the program's inception in 2003. The Northern Work Group feels increases in this metric will be a good indicator of behavioral change brought about by our education programs and sets a goal of:

- By 2013, 5,000 bushels of oyster shells per year will be collected from Dare and Hyde County individuals and businesses, with 90 percent placed back overboard on NCDMF sanctuaries and the remainder set aside for community shell-bagging educational opportunities.

Jockey's Ridge State Park is now a recycling center for oyster shells, adding to the Nags Head Woods and Carawan Seafood public drop-off locations. Three new oyster shell drop-off locations have been established on Hatteras Island - Village Grocery in Avon, Rodanthe-Waves-Salvo Recycling Center at the Rodanthe Harbor, and in Hatteras, at the Burrus Red & White. Students could also create shell-recycling centers at their schools, such as at Cape Hatteras Secondary School.

A Master Oyster Gardener Program is anticipated in the near future, where individuals are taught how to measure water quality and are given information on oyster gardening techniques. Course "graduates" are given the tools and materials to introduce oysters into estuaries and creeks in their areas and are encouraged to promote awareness of the importance of oysters to our estuaries. Supporting this effort is the Shellfish Gardeners of North Carolina (SGNC), established by a group of citizens whom are interested in growing oysters as a recreational and environmental activity. The SGNC is organized into localized chapters to enhance networking and information transfer for various water bodies and geographical areas of the state. Our Work Group has set a goal of:

- By 2013, Manteo and Hatteras Chapters of the SGNC will be fully established.

Chapter workshops geared to novice oyster gardeners could then be expanded to the northern coast. The SGNC Web page also serves as a source of up-to-date information.

The work group also believes it essential to leverage oyster gardener efforts to produce a continuing regional Public Oyster Forums to raise awareness about the need for oyster restoration and to learn about a variety of projects focused on water quality and oysters, including wetland restoration projects, storm water control initiatives, oyster reef restoration projects, and updates on shell recycling and oyster gardening. As with the 2006 forum, the event could feature poster displays, informative presentations from regional oyster experts, and field trips celebrating the values of the oyster. Thus, the goal is:

- By 2013, develop the capacity to host biennial Public Oyster Forums, with attendance surpassing the 2006 total attendance of 80 persons.

Finally, state hatcheries will provide the opportunity to develop a cohesive oyster stewardship program. Trained citizens could be utilized as volunteers for the hatchery outreach staff in a similar fashion to the NC Cooperative Extension's Master Gardener Program. Workshops and training will build upon, and expand, existing stewardship efforts, such as the backyard shellfish gardening programs.

Fostering Partnerships

Jockey's Ridge is on the edge of natural oyster populations locally, with water salinity in the correct range for larvae and adult survival. Subtidal waters just north of the park are too fresh to foster growth of oyster larvae, and this is why there are not any reefs off of Nags Head Woods Ecological Preserve or the Kitty Hawk Woods Coastal Reserve.

The North Carolina National Estuarine Research Reserve (NCNERR) is an educational partner in other regions of coastal NC, such as working with the Citizens' Oyster Gardening Program to teach gardeners about the quality of water in estuaries and what affects that water quality. The challenge is how to fold in the locally based Kitty Hawk Woods Coastal Reserve into oyster education and outreach efforts when oysters do not occur within managed resources.

The Coastal Reserve does maintain “Estuary-Net,” a water quality-monitoring curriculum that helps students understand water quality measurements and allows them to sample water quality and post it to a Web page for future use by scientists and the like. A similar program, but for waterfront property owners, is the Albemarle-Pamlico National Estuary Program's (APNEP) Citizens' Monitoring Network (CMN). The network is comprised of private citizens whom monitor ambient, surface water quality in the Albemarle-Pamlico watershed basin and its tributaries. This area encompasses not only five major river basins, but beaches and marshes as well – primary habitat for oyster reefs – and expansion of volunteer monitoring sites, currently at 22, to include waters that support oyster growth would be a natural progression. All data collected are forwarded to the program office (East Carolina University, Greenville) where staff compile the information and enter the data into report form for citizen and government agency use. The group hosts a Web site and newsletter – The Monitor – which could serve as a vehicle for oyster-related information transfer.

The APNEP also partners with the Kitty Hawk Woods Coastal Reserve for a segment on EstuaryLive –real-time, interactive Internet field trips at scheduled times twice a year. The primary educational concept could be expanded to show how students from western NC mountain communities have a stake in how the cleanliness of their inland rivers affects the oyster beds, as they flow to the sea.

Other local water-quality initiatives include efforts by the NC Coastal Land Trust (Kill Devil Hills Office) to preserve natural areas and raise public awareness about the important role regional land trusts play in land conservation. Though the NCCLT primarily acquires open spaces and natural areas to preserve landscape function and water quality, they do conduct some conservation education and promotion of good land stewardship. Land-use patterns, impervious surface coverage and water quality in coastal waters greatly influences biological resources, like oysters.

As for Pamlico County and points south, the North Carolina Estuarium (Partnership for the Sounds) is an educational center that spotlights the importance of the state's coastal rivers and sounds. Visitors can see, hear and touch some of the features that make the region unique. For example, one display has three tubes that drip water with different concentrations of salt to represent water from the ocean, brackish water from estuaries and fresh water. Another display shows how the wide, shallow estuary is more influenced by wind than tide. Oyster tongs compliment a display on the regions' fishing heritage, and visitors can view an introductory film on the Pamlico region that includes interviews with long-time fishermen. Programs, classes and other regularly scheduled

activities, and program topics include subjects like wetlands and blue crabs and could easily fold in more on oyster biology and reef ecology.

Part Six—Resources Needed

The Northern Work Group has strived to shape this report so it will be a true Blueprint For Action for bringing the native oyster back to subtidal waters. In closing we would like to highlight the resources that are needed to carry out this plan:

For in-the-water restoration, which we view as one of the most promising components of the plan, the state Division of Marine Fisheries will need:

- Four to five new staff positions dedicated to reef building and cultch planting—A boat captain, a mate/engineer, a vessel engineer, and one or two heavy equipment operators.
- A new, purpose-built, shallow-draft barge and
- Money to contract out reef construction until a new boat can be designed and built

It should also be noted that the state will need to preserve waterfront staging areas for this work, just as it will need to preserve working waterfront space for commercial fishermen.

For on-land hydrologic and vegetative restoration, we will need continuing partnerships between NCCF, TNC, public and private land owners and managers, the Natural Resource and Conservation Service, state programs like the Ecosystem Enhancement Program, and funding organizations like the Clean Water Management Trust Fund and private foundations. In looking ahead to what we hope to accomplish over the next decade, it is not possible to name a dollar figure, except to say that it will likely run into the millions. We urge the funding agencies to allocate resources in a way that will enable the partners to rebuild the oyster ecosystem of the subtidal waters in a cohesive fashion, linking on-land and in-the-water projects. We believe this approach will benefit not just our natural resources, but the rural communities that traditionally have depended on commercial fishing.

Crucial for successful education and outreach efforts is a devoted, regional shellfish education specialist. The current number of research and restoration sanctuaries within the region provide the best opportunities for K-12 education; thus, this position's main focus would be promoting oyster restoration through schools. The specialist would design and offer teacher workshops, curriculum materials, and experiential learning opportunities via a community-based restoration project and sanctuary site tours. This person would work with public schools and other formal education institutions to promote oyster and water quality education. A secondary focus area would be to facilitate growth of an Oyster Stewardship Program, though we hope that K-12 programming will also be cultivating students' conservation ethic. A captain certified to carry 15 or more paying passengers and a boat that is coast guard approved to carry more than six paying passengers transporting and monies for sufficient liability insurance are needed to carry students and the public to reefs.

Further, shallow-water reef sites provide for hands-on learning in comparison to subtidal reefs that only provide for learning from afar. Unfortunately, construction of the few

shallow water reefs within the region has been regulated through Research Sanctuary permits that must be renewed annually and at the pleasure of the Director of the Division of Marine Fisheries. Long-term programming would benefit from a new classification of permit – an Education Sanctuary – which would continue *ad infinitum* as long as the Point of Contact remained consistent and no public petitions were filed for intrusion against state Public Trust doctrine.

To take the Oyster Shell Recycling Partnership to the next level, more manpower is needed to collect shells from public drop-offs. The key would be to build a sizable volunteer base. This presents a further challenge, however, as a suitable vehicle that can be driven by volunteers will be needed.

In addition, we would like to mention a resource need that will benefit all of North Carolina's coastal waters. It is imperative that a clearinghouse of some sort be established to track the data that is collected as this collaborative effort moves forward. The drafting of the Blueprint for Action has enabled collaborators to share information in an unprecedented spirit of cooperation. As new research is conducted, a mechanism is needed that will enable the collaborators to stay in touch.

Restoring a healthy population of oysters to our estuaries is proving to be a Herculean task. However, with the collaboration that has begun through this project, we are optimistic that we will succeed.

Oyster Plan Priority Shellfish Growing Areas (SGAs) and Watersheds Overall Summary

Region: Northern

Priority: High

SGA: F-1: Neuse River Area (NC DEH SS Survey Report – January 2007)

Physical Description

Subbasin:	Neuse; # 03-04-10, 03-04-13
Extent:	the portion of the Neuse River bounded by a line from Cherry Point to Wilkinson Point on the west end and on the east by a line from Daniels Point to Great Neck Point
Watershed/Drainage area:	---
Water Acreage:	13,700 acres
Closed Acreage:	1,200 acres
Major Waterbodies:	Clubfoot Creek, Harlowe Canal, Mitchell Creek, Gulden Creek, Long Creek, Dawson Creek and Gatlin Creek
Populated Areas:	Janeiro, Temple, Bachelor
Peak Population:	3,200 people (approximately 5,000 during the summer)
Land cover:	---

Ecosystem Health

Production Rating:	Poor (oysters); <i>Rangia</i> only (clams)
Commercial Value:	Poor
Salinity Range:	0 ppt -16 ppt (2002)
Significant Closures?:	No
Water Quality Rating:	3
Habitat Health Rating:	3
Avg. Monthly Rainfall:	---

Water Quality

Overall, there has been a decline in bacteriological water quality in the Dawson Creek area of F-1. During this most recent survey of the Dawson Creek area, one area of concern was identified where a dog pen was located directly along a ditch that drained into Dawson Creek near a prohibited shellfishing water area. Some water quality improvements have been seen for parts of Clubfoot Creek, including Mitchell Creek. Of 16 stations studied in this survey, only 2 stations exceeded standards for growing area criteria and both stations were located in closed shellfishing waters. The first station was located at the mouth of Dawson Creek and while it had met approved standards according to the 2002 survey, this station has exhibited significant decline since then. The second station was located at the confluence of Golden and Clubfoot Creeks in an area already closed to shellfishing because of previously exhibited declines in water quality from the 2002 survey report. (DEH SS 2007)

Stormwater runoff from farms, forests, and residential areas pose the greatest threat to water quality throughout Pamlico County side of Area F-1. Row crop agriculture—of corn, soybeans, and cotton—is widespread. Drainage from many ditched fields empties into the Neuse River and contributes sediment and fecal loading. This area is experiencing fast-paced development. A total of 15 subdivisions were located on the Pamlico County side of F-1. Two of the largest newest subdivisions, Shine Landing and Dawson Creek, are located near the mouth of Dawson Creek. Shine Landing includes a 40-slip marina and a 10-slip

docking facility. Land for Phase 1 of the Dawson Creek subdivision was underway and will consist of 260 lots. Other subdivisions currently under construction include Janiero Crossing, Nature's Run, and Cribbs Cove. Another 15 subdivisions are located on the Craven County side of Area F-1 and span the border between shellfish growing areas F-9 and F-1 along the Neuse River. Cherry Branch subdivision has experienced the highest growth and is now almost completely developed. Many undeveloped lots and open farmland exist within the Clubfoot Creek watershed and while growth in this area is not imminent, these areas would provide ample room for more population growth. This survey identified other pollution threats for the Clubfoot Creek watershed. Homeowners have reported illegal baiting that brings large numbers of waterfowl to creeks each winter. Also, throughout this watershed—especially along Blades Road, Fisher Town Road and within the Salter Harris farm—many of the ditches are littered with garbage solid waste, and old abandoned vehicles that may pollute the creek with chemicals and toxins. A property at the confluence of Mitchell and Clubfoot creeks drains into prohibited shellfishing waters and was found heavily littered with garbage as well as populated with a number of stray cats.(DEH SS 2007)

Plantation Harbor subdivision has septic tanks installed from which effluent is pumped to a central treatment plant that uses a small lagoon system WWTP. At the time of this survey only 30 homes were connected to this system and the flow was well below the permitted level. As this subdivision develops, DWQ will monitor this system closely to ensure that the sprayfield lands are sufficient. With the exception of Camp Don Lee and Camp Seagull, most of F-1 is serviced by individual septic systems. All septic systems were functioning by the time the DEH Shellfish Sanitation completed their 2006 triennial survey. Camp Don Lee and Camp Seagull operate their own wastewater treatment plants. Although Camp Don Lee has had some fecal coliform limit violations over the past few years, since the discharge never reaches shellfishing waters, this WWTP does not pose significant threat to shellfishing waters. (DEH SS 2007)

In 2006 the Neuse River (30,330.9 acres) was considered impaired from Streets Ferry to Minnesott Beach. Thirteen ambient monitoring stations were established in this segment of the Neuse River as part of MODMON. The Neuse Rapid Response Team, based in New Bern, had been established to quickly investigate algal blooms and fish kills. Four phytoplankton monitoring stations were established in this segment as well. Algal biovolumes were in excess of 5,000 mm³/m³. Bottom dissolved oxygen had regularly been below 5 mg/L, although it was not known to what extent this was driven by nutrient loading from point and nonpoint sources. (NCDWQ 2002)

Point source wastewater discharges in the Lower Neuse Basin Association reported a 48% reduction in total nitrogen in discharges over the past four years. While this reduction of nutrient loading to the Neuse River is significant, nonpoint source management strategies were just getting underway. There have not been significant changes in nitrogen and phosphorous levels in this segment of the Neuse River. Because of the chronic overloading of nutrients into this segment of the Neuse River, there is much recycling of nutrients in the estuary, and it may be some time before current reductions in nutrient loading will be realized in terms of improved water quality.

2001 Status: Bacteriological analysis indicated little change in water quality throughout the area. There was a slight decline in water quality at Station #1 at the mouth of Mitchell Creek and at Station #3 at the mouth of Clubfoot Creek, possibly due to agriculture and new development in the area. Slight improvement was noted at Station #12 at the mouth of Dawson Creek. Generally, rainfall normally has little effect on the approved waters in the area. Since the 1998-1999 sanitary survey report, the approved waters of area F-1 were temporarily closed four times for a total of 82 days. Three of these closures, totaling 51 days, were due to extremely heavy rainfall associated with Hurricane Bonnie in August 1998 and Hurricanes Dennis and Floyd in August and September 1999.

Changes (from 1998 survey to 2002 DEH report): Classification of the area appeared adequate and no changes were recommended.

2002 Subbasin Summaries

Subbasin 03-04-10 With a total water area of 183 square miles and a total land area of 519 square miles, Subbasin 03-04-10, includes parts of Carteret, Craven and Pamlico Counties. Land use is dominated

by forest and agriculture and this subbasin was reported to have 48,378 acres of managed public lands in this 2002 report. A total of 99,059 estuarine acres (86% of all estuarine waters) was monitored during this assessment period. Of these, 31,480.2 (32 %) were impaired in the aquatic life/secondary recreation use support category. Further, 3,2668 acres (4%) estuarine waters were impaired in the shellfish harvest use support category. South River and its tributaries were reported to have 784.6 acres impaired for shellfish harvest., whereas the Neuse River had 165.6 impaired acres. From this 2002 report, shellfishing water status classifications consisted of 73,101 acres that were classified as approved, 2, 499 acres were conditionally approved-open, 373 acres were conditionally approved-closed with a total of 3,422 acres prohibited. Monitoring and the implementation of the Neuse River NSW strategy was recommended as well as the implementation of the Neuse total nitrogen TMDL study to refine water quality goals.

Subbasin 03-04-13 Population growth was minimal for Subbasin 03-04-13 as lands are largely agricultural and includes parts of Carteret and Pamlico Counties. There are 933 acres of managed public lands, mostly associated with Goose Creek Game Lands. The total water area of this subbasin is 132 square miles. In Subbasin 03-04-13, of 62,244 estuarine acres(77%) monitored in 1998 for the 2001 subbasin report, approximately 386 acres (< 1%) were impaired for shellfish harvest use. Also, 198 acres were classified as prohibited /restricted and 81,257 acres were approved for shellfish harvest.

EEP Targeted Local Watersheds:

There are no Targeted Local Watersheds within area F-1. (2006)
2002 DWQ report: portions of the Trent River and Brice Creek near New Bern are NCWRP targeted local watersheds. South River and Adams Creek are also NCWRP targeted local watersheds.

Impaired Waters (SA):

Neuse River Estuary - 30,331 acres, Rated Impaired, Status Partially Supporting - Source Nutrient Loading from Point and Nonpoint Pollution
Clubfoot Creek, Dawson Creek, and Tributaries - 170 acres, Rated Impaired, Classified Prohibited or Conditionally Approved-Closed - Sources Nutrient Loading from Nonpoint Pollution and Clear-cutting

Impaired Waters (SA):

Adams Creek and Tributaries - 841.5 acres, Rated Impaired, Status Partially Supporting, Classified Prohibited or Conditionally Approved-Closed
South River and tributaries - 784.6 acres, Rated Impaired, Status Partially Supporting, Classified Prohibited or Conditionally Approved-Closed - Source Agricultural Runoff

Shellfish Habitat

Threats and Trends

Stormwater Runoff: rainfall normally has little effect on the approved waters of the area, but runoff from farming poses the most significant threat to water quality in area F-1

Marinas and Ferry Terminals: Matthews Point Marina has 106 slips, a ramp, a pump out facility, and bathroom facilities with subsurface disposal; As of 2002, a new ten-slip dock had been constructed adjacent to this marina; NC DOT maintains Ferry Terminals at Cherry Branch and Minnesott Beach, are both located in closed waters. In the Pamlico County side of F-1, in the Prohibited waters in Dawson Creek, a new marina was built to serve the Shine Landing community and has 40 slips that are > 3,000ft from nearby Open Shellfishing Waters. Shine Landing also includes a small 10-slip dock facility but is well away from open shellfish waters. At the end of China Grove Rd, an area was dredged to fit 10 slips and serves as a small boat basin; A local developer presented a proposal to dig out much of the surrounding farmland to build a 634-slip upland marina basin. Planning for this project was only at the initial scope meeting with no imminent construction as of the 2007 DWQ SS report.

Development: 20 subdivisions, 3 of which have been developed since the 1998 survey; 2 subdivisions have docking facilities in closed waters; subdivision development is increasing rapidly in this area.

Septic Tanks: not a major problem in this area; the few failing systems do not pose a serious threat; One area of concern was found along River Road for open shellfishing waters in Neuse River. Severe erosion from hurricanes caused seasonal houses along the river to relocate their septic systems and use a pump and haul company. Small spills, due to tank overflows have been reported during summer months when homes are in use.

NPDES and/or WWTP(s): one activated sludge package plant at Camp Don Lee (15,000 gpd) and one WWTP at Camp Sea Gull (70,000 gpd)

Industry/Commercial: none

Agriculture: farm runoff is the most significant threat to water quality in this area; row crop agriculture is widespread, consisting of corn, soybeans, and cotton; drainage from many fields empties into the Neuse, contributing sediment and fecal loading; small horse farms are common in area F-1; an ostrich farm near the head of Temple Creek probably contributes to degradation

Forestry: Clear-cutting in the Clubfoot Creek watershed was noted in 2002

Restaurants: none

Ports: none

Hydrologic Modifications: Most ditches in this area drain into swamp or marsh areas prior to discharge into shellfishing waters; but much of this area is poorly drained because the topography is flat and water flow depends almost entirely on wind direction.

Fecal coliform: From 2007 report, of 16 sampling stations, only 2 exceeded NSSP criteria for approved shellfishing waters. From the 2002 the report, of 16 sampling stations, three exceeded NSSP criteria for approved shellfishing waters

Recreational: several very large summer camps operate in this area

Golfing: Plantation Harbor subdivision has been developed around a golf course that drains to Clubfoot Creek, but waterfront properties are limited and stormwater runoff areas are well vegetated

Other Stressors: none

Previous Oyster Habitat and Water Quality Protection and Restoration Initiatives

UNC Institute for Marine Science (2002)

With CWMTF funding, UNC IMS initiated a restoration project on Open Grounds Farm.

EPA 319 project on Open Grounds Farm—South River Watershed (2000)

-mentioned in DWQ 2002 report

Gum Thicket

NCCF partnered with Neuse River Foundation and Weyerhaeuser to acquire an area around Gum Thicket as a conservation easement that would protect primary nursery habitat and further protect an open shellfishing area in Neuse River.

Ongoing Oyster Habitat and Water Quality Protection and Restoration Initiatives

See Part Two in Report

SGA: F-2: Merrimon-South River Area (NC DEH SS Survey Report –April 2007)

Physical Description

Subbasin:	Neuse; # 03-04-10, 03-04-14
Extent:	all waters of Adams Creek and its tributaries from the Neuse River to the Hwy. 101 Bridge, all of South River and its tributaries, Turnagain Bay, Rattan Bay and that portion of the Neuse River in Carteret County between Point of Marsh and Great Neck Point
Watershed/Drainage area:	100 square miles
Water Acreage:	39,000 acres
Closed Acreage:	1,425 acres
Major Waterbodies:	all waterbodies mentioned above
Populated Areas:	Adams Creek and South River-Merrimon
Peak Population:	1,350 people
Land cover:	---

Ecosystem Health

Production Rating:	Fair
Commercial Value:	Fair
Salinity Range:	0ppt -29ppt (2006); 0 ppt -21 ppt (2002)
Significant Closures?:	No
Water Quality Rating:	3
Habitat Health Rating:	3
Avg. Monthly Rainfall:	4.7 inches

Water Quality

Portions of the South River area have show slight declines in bacteriological water quality since the 2002 Sanitary Survey Report. Of 20 stations four stations exceeded NSSP criteria for shellfish waters and all stations were located in waters that are closed to shellfish harvest. These stations were located at the mouth of Hardy, Southwest, Eastman Creeks and 1000 yards upstream in Back Creek. Approximately 130 acres of closed waters in Adams Creek had met standards and were slated to be reclassified as Approved for shellfishing. A station at the mouth of Dumpling Creek had shown slight improvement in water quality and met standards. Sampling stations were added to Adams Creek, and to the confluence of Jonaquin and Cedar Creeks to better monitor Area F-2. The southern portion of Adams Creek that was Conditionally approved closed was reclassified as Prohibited. No other changes were recommended. (DEH SS 2007)

The northern portion of Adams Creek is well inhabited with a total population of 700 people; but much of the rest of the watershed is used for large-scale silviculture. For South River, silviculture areas, owned by Weyerhaeuser, also exist on the eastern shore of the river banks. The South River and tributaries (2,288 acres) was conditionally approved-open to shellfish harvesting because bacteria levels did not always meet approved area criteria. This area was temporarily closed 4.2 percent of the five-year assessment period prior to the 2002 report and was classified as supporting for the shellfish harvesting use. Open Grounds Farm, adjacent to South River, recently removed cattle operations and installed flashboard risers on many ditches on the property. Both of these BMPs helped reduce sources and delivery of bacterial contaminants to shellfish harvesting waters.

Open Grounds Farm (OGF) currently has 36,000 acres under cultivation for crops and another 5,000 acres in timber harvest. Ditch networks drain about 22,000 acres of the farm into the headwaters of South River. This drainage potentially adds, sediments, fertilizers, pesticides, and fecal coliform to adjacent waters. Managers of OGF have proactively introduced new and high quality Best Management Practices (BMPs) to

their farm operations, including: no-till production, precision fertilizer management, integrated pest management, flashboard riser installation, buffer maintenance, and the installation of flapper gate devices to prevent saltwater infiltration into farm ditches. Two experimental wetlands filter runoff from a total of 3,400 acres of farmland. Studies by university researchers on the wetland located at the head of Southwest Creek have shown a significant decrease in the output of nutrients and bacteria into the Creek from 1,000 acres of farmland. The second wetland, at the head of South River, treats 2,400 farm acres through a series of wetlands and settling pools which help reduce BOD, suspended solids, nutrients and bacteria. These management practices have reduced the farm's impact on South River's water quality and impacts are not as wide-spread as in the past. (DEH SS 2007)

Merrimon-South river is primarily affected by wind tides though salinities remain low. (DEH SS 2007)

June 2002 Status: Bacteriological analysis indicates a marked improvement in water quality in the area since the last survey report in February, 1999, possibly due in part to unusually dry weather in 2000 and 2001. Many stations now meet approved area criteria that did not during the previous evaluation period.

Rainfall normally has little effect on the approved waters of the area. Since the last sanitary survey report, the approved waters of area F-2 have been temporarily closed five times for a total of 55 days. Three of these closures, totaling 41 days, were preemptive closures due to Hurricanes Dennis, Floyd and Irene in August, September and October 1999, respectively.

The conditionally approved waters of the area are normally closed to shellfish harvesting, but are opened temporarily when weather conditions are favorable and when water and shellfish samples are bacteriologically acceptable. During the time frame of this report, there were no temporary openings of the conditionally approved-closed waters in the area.

Changes (from 1999 survey to 2002 DEH report): Classification of the area is adequate at this time, and no changes are recommended.

2002 Subbasin Summaries

Subbasin 03-04-10 With a total water area of 183 square miles and a total land area of 519 square miles, Subbasin 03-04-10, includes parts of Carteret, Craven and Pamlico Counties. Land use is dominated by forest and agriculture and this subbasin was reported to have 48,378 acres of managed public lands in this 2002 report. A total of 99,059 estuarine acres (86% of all estuarine waters) was monitored during this assessment period. Of these, 31,480.2 (32 %) were impaired in the aquatic life/secondary recreation use support category. Further, 3,2668 acres (4%) estuarine waters were impaired in the shellfish harvest use support category. South River and its tributaries were reported to have 784.6 acres impaired for shellfish harvest., whereas the Neuse River had 165.6 impaired acres. From this 2002 report, shellfishing water status classifications consisted of 73,101 acres that were classified as approved, 2, 499 acres were conditionally approved-open, 373 acres were conditionally approved-closed with a total of 3,422 acres prohibited. Monitoring and the implementation of the Neuse River NSW strategy was recommended as well as the implementation of the Neuse total nitrogen TMDL study to refine water quality goals.

Subbasin 03-04-13 Population growth was minimal for Subbasin 03-04-13 as lands are largely agricultural and includes parts of Carteret and Pamlico Counties. There are 933 acres of managed public lands, mostly associated with Goose Creek Game Lands. The total water area of this subbasin is 132 square miles. In Subbasin 03-04-13, of 62,244 estuarine acres(77%) monitored in 1998 for the 2001 subbasin report, approximately 386 acres (< 1%) were impaired for shellfish harvest use. Also, 198 acres were classified as prohibited /restricted and 81,257 acres were approved for shellfish harvest.

Many streams in subbasins 03-04-10 and 03-04-14 have noted impacts from recent hurricanes. The biological community in the streams can recover rapidly if instream habitat is maintained. De-snagging

operations should carefully remove debris from stream channels to restore natural flow and leave enough instream habitats so the biological community can recover.

Impaired Waters (SA):

Neuse River Estuary - 30,331 acres, Rated Impaired, Status Partially Supporting - Source Nutrient Loading from Point and Nonpoint Pollution

Clubfoot Creek, Dawson Creek, and Tributaries - 170 acres, Rated Impaired, Classified Prohibited or Conditionally Approved-Closed - Sources Nutrient Loading from Nonpoint Pollution and Clear-cutting

EEP Targeted Local Watersheds:

EEP has listed Adams Creek Watershed 3020204050050 as a Targeted Local Watershed due to the following existing criteria - SA waters, Presence of Aquatic Natural Heritage Element

EEP has listed South River Watershed 3020204070010 as a Targeted Local Watershed due to the following existing criteria - SA waters, Presence of Aquatic Natural Heritage Element

Impaired Waters (SA):

Adams Creek and Tributaries - 841.5 acres, Rated Impaired, Status Partially Supporting, Classified Prohibited or Conditionally Approved-Closed

South River and tributaries - 784.6 acres, Rated Impaired, Status Partially Supporting, Classified Prohibited or Conditionally Approved-Closed - Source Agricultural Runoff

Threats and Trends

Stormwater Runoff: agricultural runoff is the most significant threat to area F-2

Marinas and Ferry Terminals: private docks are abundant, particularly along Adams Creek; Two 10-slip boat docking facilities associated with residences; 2 commercial boat dockages. Ellinwood Pointe subdivision's docking area had violated its 10-slip permit by 1 boat slip and so warranted a shellfish closure if that slip remains.

Development: Merrimon Bay subdivision on Neuse river has stormwater drainage, a boat ramp, and a boardwalk. The area still has potential for significant future growth. Fulshire Plantation (66 lots) is under construction and has plans for a 44-slip marina on Adams Creek; but no permits have been issued. Duffy's point is a new subdivision on Cedar's Creek in permitting process for 18-24 lots

Septic Tanks: two water discharge pipes exist at Hardy Creek; failures near Hardy Creek and Silver Dollar Rd. are probably common during wet conditions

NPDES and/or WWTP(s): none

Industry/Commercial: Pittman's Seafood provides fuel and dockage for commercial trawlers along Cedar Creek, a tributary of Adams Creek; approximately six commercial trawlers dock at the end of Silver Dollar Rd. in Adams Creek

Agriculture: small row crop farms are common; some small horse farms exist; Open Grounds Farm affects area F-2

Forestry: The eastern shore of South River is owned and managed by Weyerhaeuser and other forestry companies for silviculture. These areas are drained by a network of ditches. Clear-cutting and thinning logging operations exist in several areas of F-2.

Restaurants: none

Ports: none

Hydrologic Modifications: massive ditch system at Open Grounds Farm and in Weyerhaeuser properties

Fecal coliform: In previous survey, of 20 sampling stations, two exceeded NSSP criteria for approved shellfishing waters.

Recreational: none

Golfing: none

Other Stressors: none; wildlife are abundant, especially waterfowl

Previous Oyster Habitat and Water Quality Protection and Restoration Initiatives*South River Oyster Cultch Stockpile*

The Division of Marine Fisheries maintains an oyster cultch stockpile and dockage for a 115-foot landing craft and a 50-foot barge at South River.

South River Bacterial Source Tracking

North Carolina State University has obtained funding to study bacterial source tracking in the South River area. This study would help identify sources of fecal coliform bacteria in the watershed.

South River Oyster Cultch Stockpile

The Division of Marine Fisheries maintains an oyster cultch stockpile and dockage for a 115-foot landing craft and a 50-foot barge at South River.

South River Bacterial Source Tracking

North Carolina State University has obtained funding to study bacterial source tracking in the South River area. This study would help identify sources of fecal coliform bacteria in the watershed.

Ongoing Oyster Habitat and Water Quality Protection and Restoration Initiatives*Shellfish Sanitation Shoreline Survey Methodology Project*

As part of an EPA Wetlands Program Grant, a new shoreline survey methodology was developed by DEH Shellfish Sanitation in conjunction with NCCF. This new methodology is now being used on all shellfish growing areas throughout the state. Based on guidelines set forth in the National Shellfish Sanitation Program Model Ordinance, the shoreline survey is a comprehensive triennial review of all potential and actual pollution sources that may impact a given shellfish growing area (SGA). Pollution sources that are tracked include marinas, stormwater discharges, development, animal farms, agricultural areas, failing septic systems, wastewater treatment plants, and other areas of concern.

In addition to fulfilling these basic requirements, the new methodology utilizes GIS and GPS technologies to provide more accurate pollution source mapping, and to make the information collected during the survey more useful and accessible to other land-use and water-quality agencies. Interagency cooperation and information sharing are key components of the new methodology, and should enhance the ability of federal, state, and local governments to protect and restore water quality in shellfish growing areas throughout North Carolina.

Currently, 14 out of 50 growing areas have been completed using the new methodology, including areas A-3, C-1, D-2, D-3, D-4, E-1, E-3, E-4, E-6, F-1, F-2, F-3, F-4, and H-2. The remaining growing areas should be completed by the end of 2009.

Planned and/or Recommended Restoration and Protection Efforts:

See Part Four in Report

SGA: F-5: Oriental Area (NC DEH SS Survey Report – April 2004)

Physical Description

Subbasin:	Neuse; # 03-04-10,13,14
Extent:	the waters of Swan Creek, Broad Creek, Gum Thicket Creek, Orchard Creek, Pierce Creek, Whittaker Creek, Smith Creek, Kershaw Creek, Greens Creek, and that portion of the Neuse River between Daniels Point and Maw Point within the boundaries of Pamlico County
Watershed/Drainage area:	80 square miles
Water Acreage:	---
Closed Acreage:	---
Major Waterbodies:	all waterbodies mentioned above
Populated Areas:	Oriental
Peak Population:	3,670 people
Land cover:	---

Ecosystem Health

Production Rating:	Poor (oysters); None (clams)
Commercial Value:	Poor
Salinity Range:	mean of 10.4 ppt (rarely exceeding 18 ppt)
Significant Closures?:	No
Water Quality Rating:	3
Habitat Health Rating:	3
Avg. Monthly Rainfall:	---

Water Quality

Shellfish resource is patchy and sparse, and consists of oyster almost exclusively; fresh water input from the Neuse River inhibits the growth of hard clams. There are no conditionally managed waters in this growing area. Bacteriological analysis indicates that the waters of F-5 have generally improved during the 2004 report survey period.

There was a statewide preemptive closure of all shellfishing waters within the state on the morning of September 18, 2003, as precaution against the effects of Hurricane Isabel. The closure was lifted after 15 days in area F-5 when bacteriological analysis indicated normal water quality. This was the only closure to approved shellfishing waters that occurred during the time frame of the 2004 report.

Changes (from 1998 to 2004): Approximately 50 acres of open shellfishing waters downstream of the current closure line at Orchard Creek was closed as a result of this survey.

2002 Subbasin Summaries

Subbasin 03-04-10 With a total water area of 183 square miles and a total land area of 519 square miles, Subbasin 03-04-10, includes parts of Carteret, Craven and Pamlico Counties. Land use is dominated by forest and agriculture and this subbasin was reported to have 48,378 acres of managed public lands in this 2002 report. A total of 99,059 estuarine acres (86% of all estuarine waters) was monitored during this assessment period. Of these, 31,480.2 (32 %) were impaired in the aquatic life/secondary recreation use support category. Further, 3,2668 acres (4%) estuarine waters were impaired in the shellfish harvest use support category. South River and its tributaries were reported to have 784.6 acres impaired for shellfish harvest., whereas the Neuse River had 165.6 impaired acres. From this 2002 report, shellfishing water status classifications consisted of 73,101 acres that were classified as approved, 2, 499 acres were conditionally approved-open, 373 acres were conditionally approved-closed with a total of 3,422 acres

prohibited. Monitoring and the implementation of the Neuse River NSW strategy was recommended as well as the implementation of the Neuse total nitrogen TMDL study to refine water quality goals.

Subbasin 03-04-13 Population growth was minimal for Subbasin 03-04-13 as lands are largely agricultural and includes parts of Carteret and Pamlico Counties. There are 933 acres of managed public lands, mostly associated with Goose Creek Game Lands. The total water area of this subbasin is 132 square miles. In Subbasin 03-04-13, of 62,244 estuarine acres (77%) monitored in 1998 for the 2001 subbasin report, approximately 386 acres (< 1%) were impaired for shellfish harvest use. Also, 198 acres were classified as prohibited /restricted and 81,257 acres were approved for shellfish harvest.

Many streams in subbasins 03-04-10, 03-04-13, and 03-04-14 have noted impacts from recent hurricanes. The biological community in the streams can recover rapidly if instream habitat is maintained. De-snagging operations should carefully remove debris from stream channels to restore natural flow and leave enough instream habitats so the biological community can recover.

EEP Targeted Local Watersheds:

There are no Targeted Local Watersheds within area F-5.

Impaired Waters (SA):

Whittaker Creek - 96.1 acres, Rated Impaired, Classified Prohibited

Pierce Creek - 50.7 acres, Rated Impaired, Classified Prohibited

Orchard Creek - 37.1 acres, Rated Impaired, Classified Prohibited

Threats and Trends

NPDES: none

Stormwater Runoff: rainfall and stormwater runoff have not been shown to influence bacterial levels in approved waters

Marinas and Ferry Terminals: 18 established marinas, most in closed shellfishing waters; 3 new marinas, all within prohibited shellfishing waters; many neighborhoods have 10-slip docking facilities that are not considered marinas but whose proliferation combined with hundreds of individual docks will contribute to the degradation of open shellfishing waters

Development: home building is slow, but roads and parking areas have increased dramatically; a large amount of land-clearing for homes has reduced the vegetative buffer; few homes have been built in subdivisions, but many have been planned that will probably contribute to water quality degradation

Septic Tanks: Styronton, north of Wiggins Point, is a low lying area with small homes and trailers that was under a foot of water during this shoreline survey

WWTP: Bay River Metropolitan Sewer District

Industry/Commercial: Fulchers Point Pride, Garland Fulcher Seafood, and Select Seafood

Agriculture: most of the land in area F-5 is agricultural

Forestry: loblolly pine forests dominate the undisturbed areas in F-5

Restaurants: none

Ports: none

Hydrologic Modifications: ditching near horse pastures is common

Fecal coliform: of 18 sampling stations, 8 exceeded NSSP criteria for approved shellfishing waters

Recreational: none

Golfing: none

Other Stressors: Granite Investments has purchased the Gum Thicket area and has plans for 397 single-family homes, 83 patio homes, 120 condominium units, and a 400-slip upland basin marina with fuel and pump out facility to be constructed on the 1,400 acre tract. The area includes roughly 23,000 linear feet of wetlands.

Ongoing Oyster Habitat and Water Quality Protection and Restoration Initiatives

Shellfish Sanitation Shoreline Survey Methodology Project

As part of an EPA Wetlands Program Grant, a new shoreline survey methodology was developed by DEH Shellfish Sanitation in conjunction with NCCF. This new methodology is now being used on all shellfish growing areas throughout the state. Based on guidelines set forth in the National Shellfish Sanitation Program Model Ordinance, the shoreline survey is a comprehensive triennial review of all potential and actual pollution sources that may impact a given shellfish growing area (SGA). Pollution sources that are tracked include marinas, stormwater discharges, development, animal farms, agricultural areas, failing septic systems, wastewater treatment plants, and other areas of concern.

In addition to fulfilling these basic requirements, the new methodology utilizes GIS and GPS technologies to provide more accurate pollution source mapping, and to make the information collected during the survey more useful and accessible to other land-use and water-quality agencies. Interagency cooperation and information sharing are key components of the new methodology, and should enhance the ability of federal, state, and local governments to protect and restore water quality in shellfish growing areas throughout North Carolina.

Currently, 14 out of 50 growing areas have been completed using the new methodology, including areas A-3, C-1, D-2, D-3, D-4, E-1, E-3, E-4, E-6, F-1, F-2, F-3, F-4, and H-2. The remaining growing areas should be completed by the end of 2009.

For additional projects, see Part Two of Report

Planned and/or Recommended Restoration and Protection Efforts:

See Part Four of Report

SGA: G-3, G-4: Swan Quarter, Wysocking Bay Area (NC DEH SS Survey Report – November 2005)

Physical Description

Subbasin:	Tar-Pamlico; # 03-03-07, 03-03-08
Extent:	G-3 consists of the waters bounded within an imaginary line beginning on the north shore of the Swanquarter Narrows, thence to the southern tip of Great Island, thence to Little Porpoise Point near Mouse Harbor, thence across Pamlico River to Roos Point. G-4 consists of those waters beginning at Long Point near Wysocking Bay, thence in a southerly direction to Flashing Beacon #4 in Pamlico Sound, thence in a westerly direction to the Flashing Beacon near Hog Island, thence in a southwesterly direction to the Flashing Beacon at Bluff Point Shoal south of East Bluff Bay, thence in a westerly direction to the southern tip of Great Island, thence across Swanquarter Narrows to a point on the north shore to include the waters of Juniper Bay, West Bluff Bay, East Bluff Bay, Mt. Pleasant Bay, Douglas Bay, Wysocking Bay and all tributaries
Watershed/Drainage area:	---
Water Acreage:	68,000 acres
Closed Acreage:	1,300 acres
Major Waterbodies:	Swanquarter Bay, Deep Bay, Deep Cove, Rose Bay, Spencer Bay, all their tributaries, and all waterbodies mentioned above
Populated Areas:	Swan Quarter
Peak Population:	1,700 people
Land cover:	---

Ecosystem Health

Production Rating:	Fair
Commercial Value:	---
Salinity Range:	3 ppt -23 ppt
Significant Closures?:	No
Water Quality Rating:	3
Habitat Health Rating:	4
Avg. Monthly Rainfall:	---

Water Quality

Bacteriological analysis indicates slight improvement in many of the area sampling stations since the last triennial survey.

During the sampling time frame of this 2005 report, portions of the approved waters of areas G-3 and G-4 were temporarily closed three times for a total of 45 days. All of these closures were due to severe rain events. Each of these closures were due to extremely heavy rainfall associated with Hurricane Isabel in September 2003, Hurricane Ophelia in September 2005, and Tropical Storm Tammy in October 2005.

2002 Subbasin Summaries

Subbasin 03-03-08 Summary

Many streams in subbasin 03-03-08 have noted impacts from recent hurricanes. The biological community in the streams can recover rapidly if in-stream habitat is maintained. De-snagging operations should

carefully remove debris from stream channels to restore natural flow and leave enough instream habitats so the biological community can recover.

EEP Targeted Local Watersheds:

EEP has listed Germantown Bay Watershed 3020105030010 as a Targeted Local Watershed due to the following existing criteria - Closed SA Waters, ORW or HQW

Impaired Waters (SA):

Rose Bay [AU#29-44a] and Rose Bay Creek [AU# 29-44-1] - 472.3 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Germantown Bay and Tributaries [AU# 29-42-1a] - 241.6 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Swanquarter Bay [AU# 29-49a] - 171.5 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Juniper Bay [AU# 29-52a] - 86 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Wysocking Bay [AU# 29-60a] - 126.3 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Many streams in subbasins 03-03-07 and 03-03-08 have noted impacts from recent hurricanes. The biological community in the streams can recover rapidly if instream habitat is maintained. De-snagging operations should carefully remove debris from stream channels to restore natural flow and leave enough instream habitats so the biological community can recover.

Changes: Review for the current period has confirmed that all areas of the G-3 and G-4 growing areas are classified properly. No changes in classification are recommended at this time.

Threats and Trends

NPDES: none

Stormwater Runoff: stormwater runoff in area G-3 can be a problem, particularly in the Swanquarter Bay area, due to the numerous canals and drainage ditches; however, only rainfall of 3 inches or more normally causes additional water quality problems; rainfall does not normally cause problems in the G-4 areas since much of the runoff can be controlled by flood gates constructed in the canals

Marinas and Ferry Terminals: 2 or 3 ferries that run from Swan Quarter to Ocracoke use the Swan Quarter Ferry Terminal; 8 marinas in the area

Development: one housing project and no subdivisions; this is an area of very little growth

Septic Tanks: most risky systems are seldom used

WWTP: Swan Quarter WWTP (125,000 GPD), Hyde County Correction (67,500 GPD), Mid-east WWTP (40,000 GPD)

Industry/Commercial: Gullrock Seafood is located adjacent to a canal that flows directly into the sound; Germantown Crab and Oyster is a crab/fish buying station; Rose Bay Oyster Company is located on a creek that flows into Rose Bay

Agriculture: the 3 hog farm operations within this area have all closed; there are significant populations of waterfowl within these areas, possibly as many as 250,000 birds; in the daytime during winter months, waterfowl feed in fields within these areas where ditching makes runoff likely

Forestry: there has been some logging, especially around New Holland on Hwy. 264

Restaurants: none

Ports: none

Hydrologic Modifications: extensive canals and drainage ditches; the extensive network is serviced by tide gates to control flooding from the sound and lift pumps to remove water from farm ditches; discharge from these gates and pumps is likely to contribute to water quality degradation

Fecal coliform: of 27 sampling stations, three exceeded NSSP criteria for approved shellfishing waters

Recreational: 3 camping areas are connected to low-pressure pipe systems, but these systems are seldom used; 3 hunting cabins and one residence are connected to similar systems

Golfing: none

Other Stressors: waterfowl impoundments may affect water quality when they are drained annually into nearby canals and ditches that run into adjacent bays; there is a large waste collection center located on S.R. 1127 near Oyster Creek Landing and runoff to adjacent canals is possible

Ongoing Oyster Habitat and Water Quality Protection and Restoration Initiatives

Shellfish Sanitation Shoreline Survey Methodology Project

As part of an EPA Wetlands Program Grant, a new shoreline survey methodology was developed by DEH Shellfish Sanitation in conjunction with NCCF. This new methodology is now being used on all shellfish growing areas throughout the state. Based on guidelines set forth in the National Shellfish Sanitation Program Model Ordinance, the shoreline survey is a comprehensive triennial review of all potential and actual pollution sources that may impact a given shellfish growing area (SGA). Pollution sources that are tracked include marinas, stormwater discharges, development, animal farms, agricultural areas, failing septic systems, wastewater treatment plants, and other areas of concern.

In addition to fulfilling these basic requirements, the new methodology utilizes GIS and GPS technologies to provide more accurate pollution source mapping, and to make the information collected during the survey more useful and accessible to other land-use and water-quality agencies. Interagency cooperation and information sharing are key components of the new methodology, and should enhance the ability of federal, state, and local governments to protect and restore water quality in shellfish growing areas throughout North Carolina.

Currently, 14 out of 50 growing areas have been completed using the new methodology, including areas A-3, C-1, D-2, D-3, D-4, E-1, E-3, E-4, E-6, F-1, F-2, F-3, F-4, and H-2. The remaining growing areas should be completed by the end of 2009.

For additional projects, see Part Two of Report

Planned and/or Recommended Restoration and Protection Efforts:

See Part Four of Report

SGA: G-5: Long Shoal Area (NC DEH SS Survey Report – March 2006)

Physical Description

Subbasin:	Tar-Pamlico; # 03-03-08
Extent:	the waters in Pamlico Sound within the boundary of a straight line beginning at a point on Sandy Point and proceeding WSW through Parched Corn Point and Long Shoal Point to a Flashing Beacon SSE of Long Point, thence NNW to Long Point on the mainland
Watershed/Drainage area:	---
Water Acreage:	46,000 acres
Closed Acreage:	1,954 acres
Major Waterbodies:	Sandy Bay, Parched Corn Bay, Pains Bay, Long Shoal River, Otter Creek, Berrys Bay, Far Creek, Middletown Creek, all waterbodies mentioned above, and all other tributaries within said border
Populated Areas:	Engelhard, White Plains
Peak Population:	1,100 people
Land cover:	---

Ecosystem Health

Production Rating:	Fair
Commercial Value:	---
Salinity Range:	2 ppt -26 ppt
Significant Closures?:	No
Water Quality Rating:	3
Habitat Health Rating:	3
Avg. Monthly Rainfall:	---

Water Quality

Bacteriological analysis indicates some changes in water quality throughout the area. In Far Creek, a station (#7) has shown a significant decline in water quality since the last triennial survey. Also, in Middletown Creek, a station (#19A) now exceeds NSSP criteria for approved shellfishing waters. Stations #6, (in Far Creek), and #30, (at Pump Canal), have shown significant improvement since the last survey. Since station sampling results were mixed in Far Creek, monitoring will continue for a possible future opening.

Rainfall normally has little effect on water quality in the area. Since the last survey, portions of the approved waters in area G-5 were closed temporarily twice, for a total of 33 days. These two closures were statewide preemptive closures as a result of Hurricane Isabel in 2003, and Hurricane Ophelia in 2005.

Changes (from 2002 survey to 2006 DEH report): Classification of the area appears adequate at this time, and no changes are recommended.

2002 Subbasin 03-03-08 Summary

Subbasin 03-03-08 Summary

Many streams in subbasin 03-03-08 have noted impacts from recent hurricanes. The biological community in the streams can recover rapidly if in-stream habitat is maintained. De-snagging operations should carefully remove debris from stream channels to restore natural flow and leave enough instream habitats so the biological community can recover.

EEP Targeted Local Watersheds:

There are no Targeted Local Watersheds within the G-5 area.

Impaired Waters (SA):

Middle Town Creek [AU# 29-66] - 71.5 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Far Creek and Tributaries [AU# 29-70-(4)] - 545.8 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Berrys Bay [AU# 29-71a] - 1.8 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Long Shoal River [AU#29-73-(2) a and c] - 455 acres, Rated Impaired, Classified Prohibited or Permanently Closed

Threats and Trends

NPDES: none

Stormwater Runoff: rainfall normally has little effect on water quality in the area

Marinas and Ferry Terminals: 1 marina with 32 slips and fuel

Development: very little

Septic Tanks: little threat

WWTP: one 120,000 GPD facility services Engelhard and will soon serve Middletown and Amity; Mattamuskeet Village utilizes a 2,640 GPD low-pressure pipe system

Industry/Commercial: several seafood businesses in Engelhard adjacent to Far Creek with large trawlers and commercial fishing vessels

Agriculture: 6 hog farms, none in operation, but lagoons still exist; one farm with 30 cattle

Forestry: none

Restaurants: none

Ports: none

Hydrologic Modifications: extensive farmland ditching

Fecal coliform: of 25 sampling stations, four exceeded NSSP criteria for approved shellfishing waters

Recreational: none

Golfing: none

Other Stressors: the Dare County Bombing Range has a 10,000 gallon storage tank, pump and haul system, and several fuel tanks; the facility drains to Long Shoal River

Ongoing Oyster Habitat and Water Quality Protection and Restoration Initiatives

See Part Two of Report

Planned and/or Recommended Restoration and Protection Efforts

See Part Four of Report

References***F1 through F5:***

Basinwide Planning Program :: 2002 Neuse River Basinwide Water Quality Plan. 2002.

Neuse River Basin Watershed Restoration Plan. November 2002. North Carolina Ecosystem Enhancement Program.

Report of Sanitary Survey- Neuse River Area: Area F-1. December 2001. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.
Report of Sanitary Survey- Neuse River Area: Area F-1. January 2007. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.

Report of Sanitary Survey- Merrimon-South River Area: Area F-2. June 2002. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.

Report of Sanitary Survey- Merrimon-South River Area: Area F-2. April 2007. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.

Report of Sanitary Survey- Oriental Area: Area F-5. April 2004. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.

G1 through G5

Basinwide Planning Program :: 2004 Tar-Pamlico River Basinwide Water Quality Plan. 2004. Section B - Chapter 7 Tar-Pamlico River Subbasin 03-03-07. North Carolina Division of Water Quality. pp 141-152.

Basinwide Planning Program :: 2004 Tar-Pamlico River Basinwide Water Quality Plan. 2004. Section B - Chapter 8 Tar-Pamlico River Subbasin 03-03-08. North Carolina Division of Water Quality. pp 153-160.

Report of Sanitary Survey- Swanquarter, Wysocking Bay Area: Area G-3, G-4. November 2005. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.

Tar-Pamlico River Basin Watershed Restoration Plan. April 2004. North Carolina Ecosystem Enhancement Program.

Report of Sanitary Survey- Long Shoal Area: Area G-5. March 2006. Shellfish Sanitation Section, North Carolina Department of Environment and Natural Resources Division of Environmental Health.

Tar-Pamlico River Basin Watershed Restoration Plan. April 2004. North Carolina Ecosystem Enhancement Program.