

**Science Serving
Our Coast and Beyond**



2002-2004 Implementation Plan

North Carolina Sea Grant * NC State Box 8605 * Raleigh, NC 27695-8605
Ronald G. Hodson, Director * 919/515-2454 * www.ncsu.edu/seagrant

UNC-SG-01-16-B

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Updated Jan. 30, 2002

INTRODUCTION

North Carolina Sea Grant molds the university functions of research, education and outreach into a program focused on the needs of agencies, people and businesses responsible for coastal and marine resources. Sea Grant serves as the link between academic discoveries and the people of North Carolina. Together we build understanding and appreciation of the coastal ocean, sustainable use of its resources and better conservation. Thus, it is our challenge and privilege to join other coastal and Great Lakes states in a network of Sea Grant universities to meet the needs of our society.

Ronald G. Hodson has been North Carolina Sea Grant director since July 1998, having previously served as associate director for research and as interim director. Hodson is an internationally respected aquaculture researcher. During 2000-2001, Hodson expanded the management team to provide greater input for critical program decisions. The management team now includes:

- Steve Rebach as associate director, with an emphasis on research. Formerly a biology professor at the University of Maryland, Eastern Shore, his focus has been on crabs and their ecology.
- Jack Thigpen as extension director, leading the staff of 10 specialists in three coastal offices and the Raleigh headquarters. He also leads the program's "coastal communities" efforts. He has served as president of the Southern Rural Sociological Association.
- Katie Mosher as assistant director for communications, leading the three writer/editors based in the Raleigh office. A former journalist, she chaired the National Sea Grant Communicators Network in 2001. In 2002, she will serve on the Sea Grant's national media relations committee.
- Tammy Sumner as assistant director for finance and information systems, with budgetary oversight and management of internal databases. She has served as the program's Webmaster and previously worked in the North Carolina State University office of contracts and grants.

The management team meets regularly to address program issues, review master calendar items and provide overall coordination for the program.

STRATEGIC PLANNING

An integral part of the Sea Grant program is a planning process that seeks input from outreach staff members, researchers and scientists at universities across the state, government agencies dealing with fisheries, water quality, coastal management, etc., and community groups with a deep and abiding interest in coastal resources. The result is our strategic plan, which is included as an appendix to this document. While the program's formal strategic plan is updated every two years, the planning process is constant, as Sea Grant staff is in regular communication with coastal communities, government agencies and some of the nation's top universities.

The director and associate director regularly visit various campuses and research facilities to discuss Sea Grant's challenges and opportunities with faculty, administrators and graduate students. These frank and open discussions include researchers who have received Sea Grant funding over the years, as well as new faculty and faculty in new disciplines for our program. Their input is important. For example, many of them — like our Sea Grant staff members — have formal positions on various state and federal review panels or commissions. In other cases, staff and researchers regularly attend — and are often called upon to present crucial, unbiased scientific information at — meetings of

policy-making boards. Thus, staff and researchers are aware of developing issues as well as those sparking heated debate. Such topics are considered as we routinely update our formal strategic plan. Those drafts are sent back to researchers, staff and others for further comment and input.

Every two years, Sea Grant reviews proposals from university researchers seeking funding. The first step is a preproposal submission. In this early stage, Sea Grant convenes an Ad-Hoc Research Advisory Committee, which considers the relevance and need in North Carolina. This panel includes regulators, policy makers, private industry representatives, university administrators and others. This process was crucial for the proposal selection process and we will continue it for future funding cycles.

North Carolina Sea Grant also seeks ongoing input from an Outreach Advisory Board. Members representing various program areas have staggered terms. They provide comment on overall program direction, suggest research priorities and provide input for specific projects for the extension and communications teams. This list includes current advisory board members, with respective program areas.

North Carolina Sea Grant Outreach Advisory Board

Raleigh/Piedmont (3)

Bill Crowell, Ocean Policy Specialist and Policy Analysis Section Coordinator, N.C. Division of Coastal Management (coastal processes)

Jean Spooner, Water Quality Group Director, Biological and Agricultural Engineering, N. C. State University (water quality)

Frank Thomas (Outgoing Chair), Retired Food Science Professor, N. C. State University (seafood technology)

Northeast Coast (3)

Joey Daniels (Co-chair), President, Wanchese Fish Company (fisheries)

Terry Pratt, Commercial Fisherman, Merry Hill, N.C. (fisheries)

Jackie Peoples Woolard (Co-chair), Executive Director, Partnership for the Sounds (sustainable community development)

Central Coast (4)

Bill Hitchcock, Independent Film Producer and Communication Director for N.C. Fisheries Association (communications media)

Penny Hooper, Faculty in Biology Department, Carteret Community College (aquaculture)

Todd Miller, Executive Director, N.C. Coastal Federation (habitat protection and estuarine ecology)

Preston Pate, Director, N.C. Division of Marine Fisheries, (fisheries)

Southeast Coast (3)

Bobby White, President, GoFishNC (fisheries)

Rhett White, Director, N.C. Aquariums (education and human resources)

David Weaver, Assistant County Manager, New Hanover County (coastal processes)

Our discussions with the preproposal review committee and the Outreach Advisory Board provide important insight for our strategic plan updates. For example, in Summer 2001, our advisory spent a day developing a list of areas where North Carolina Sea Grant could have great impact in the next five years. The list included:

- Developing an "Environmental Training Institute" as well as on-site presentations for local public officials and policy makers.

- Establishing greater awareness of Sea Grant programs and results among the public, state legislators, local officials, etc.
- Supporting local community-driven ecotourism initiatives that use, enhance and protect natural resources in low-wealth and natural resource-rich counties.
- Continuing support of water-quality and habitat-protection research, with results providing input for, and compliance, with fishery management plans and other regulatory requirements.
- Disseminating research findings, including Fishery Resource Grant and Blue Crab Research Program results, with an emphasis on applicability to influence the behavior of user groups.
- Exploring and expanding value-added technology to develop seafood products for home and institutional use.
- Developing updated curricula on coastal topics for statewide use K-12.

In addition to identifying broad goals, we also call upon our advisory board to work on specific projects. For example, in 2002, we have asked two board members to serve on a panel that will review North Carolina Sea Grant's presence on the World Wide Web.

With offices in Manteo, Morehead City, Wilmington and Raleigh, the North Carolina Sea Grant staff has regular interaction with coastal residents, policy makers, university researchers and state officials. This interaction enables staff members to see issues developing on the horizon. Regular conference calls and quarterly staff meetings provide cohesion. During a three-day retreat in Fall 2001, the staff began formulating a five-year plan. Crucial goals identified by the staff included:

- Understanding the changing ocean and estuarine shoreline and the impact and management of erosion control alternatives.
- Defining Sea Grant's water quality niche to include watershed-based water quality analysis, management, education and policy.
- Using a variety of Sea Grant expertise to address coastal growth issues in North Carolina, including the impact on the use of natural resources and the balance of economic impacts.
- Resolving conflicts relating to recreational and commercial fisheries issues.
- Helping coastal communities recognize and preserve cultural and environmental heritages.
- Increasing information distribution through Web page development/presentation, while also establishing internal online processes for proposal submission, reviewing, etc.
- Providing up-to-date information on the sustainable use of fisheries resources by providing believable, science-based information about coastal and estuarine fisheries populations.

The priorities suggested by the advisory board and staff show the need for scientific-based information to be provided to residents and policy makers alike. As Sea Grant is recognized as an honest broker of unbiased coastal information, the program is often asked to co-sponsor events that bring a wide spectrum of opinions on a particular topic to the table. In 2001, for example, Sea Grant was a cosponsor of a meeting regarding sea turtle interaction with fishing gear, and another one on the research questions regarding beach nourishment. We anticipate similar requests in 2002-2004.

FUNDING SOURCES

The heart of the North Carolina Sea Grant program is core funding received from the National Sea Grant Program and matched by the N.C. General Assembly through an appropriation to

the University of North Carolina. But our program's capabilities and reputation have resulted in additional funding, which allows Sea Grant to extend its mission.

For example, Sea Grant administers the North Carolina Fishery Resource Grant Program (FRG), a \$1 million annual appropriation from the General Assembly to support research proposals from the fishing and seafood industries. Sea Grant developed the proposal selection and ongoing monitoring processes for this program, which encourages the pairing of the fishing community with the academic community in an effort to provide scientifically reliable data on current topics. In light of the success of the FRG program, the General Assembly added a \$500,000 Blue Crab Research Program in FY 2001 and continued the program in FY 2002. Again, proposals are sought from crabbers or processors, with Sea Grant suggesting potential pairing with researchers or graduate students.

Members of the North Carolina Sea Grant staff also partner with a variety of agencies on specific projects. For example, Barbara Doll is the driving force behind the Rocky Branch Restoration Project, a multimillion-dollar initiative to restore the stream that runs through the North Carolina State University campus and drains into a major tributary of the Neuse River Basin. The Rocky Branch project — which is already serving as a national restoration model — is the result of a variety of targeted grants, including funding from the U.S. Environmental Protection Agency, the North Carolina Clean Water Management Trust Fund and the N.C. Department of Transportation.

Other projects also have been supported by outside funding, including sponsorship of the N.C. Coastal Paddling Trails Initiative that included a three-day symposium, printed and online paddling trail maps and several reports. Also, the N.C. Division of Coastal Management has funded the publication of "The Soundfront Series" that focuses on estuarine shoreline topics.

IMPLEMENTATION OF SEA GRANT GOALS

In line with priorities set by the National Sea Grant Program, North Carolina Sea Grant has implemented successful efforts in targeted coastal and marine topics. While much of the Sea Grant funding is focused on major academic research, the program approaches each topic as an opportunity to combine research, extension, communications and education efforts. In addition, mini-grants of up to \$10,000 allow Sea Grant to provide a rapid response to a critical situation arising during the project period. The minigrants also allow researchers an opportunity to lay groundwork or test out a theory before implementing a major project.

While Sea Grant research crosses a spectrum of science, engineering and social sciences, there is a common thread: the results of Sea Grant research should have direct application to the needs of the people. While new academic discoveries are exciting, they must also be spread beyond the scientific community. Our extension and communications teams are conduits for transferring this new understanding and technologies to our coastal communities and beyond. Through workshops, publications, the World Wide Web and personal contact, the scientific results are translated into terms the public can understand, then shared with residents, regulators, elected officials and other business and community leaders. In turn, the Sea Grant outreach staff hears specific concerns from the public, which can then be shared with the academic community.

Sea Grant's projects, both research and outreach, are organized into three broad categories: Economic Leadership, Coastal Ecosystem Health and Public Safety, and Education and Human Resources. The following summaries highlight North Carolina Sea Grant projects for 2002-2004. An executive summary of North Carolina Sea Grant's current strategic plan is included at the end of this

document. Details for specific research and outreach projects are included in the program's omnibus proposal. And additional examples of extension and communications projects are outlined in annual plans of work for the outreach staff.

ECONOMIC LEADERSHIP

During the infancy of the national Sea Grant program in the 1960s, coastal North Carolina was a region dotted by coastal fishing villages and clusters of vacation cottages, with its "cities" focused on the ports in Wilmington and Morehead City. As the North Carolina program received full Sea Grant College Program status in 1976, the coastal region already was undergoing a metamorphosis. Tourists and retirees arrived in greater numbers, and many decided to live at our coast year-round. By the turn of the new century, highways granted easier coastal access for the growing Research Triangle region and other areas of the state and the nation. Traffic jams and pollution concerns at the coast are becoming more frequent. Traditional portions of the economy, such as commercial fishing and shellfishing, face new regulations. Conflicts are rising among various users of the coastal waters that have long been considered part of the state's "public trust."

Amid this sea of change, North Carolina Sea Grant continues to provide stabilization in terms of science-based solutions to a variety of coastal concerns. We have worked with the fishing industries that were once the cornerstone of the coastal economy. In addition to studies of various wild stocks, we also work with the growing aquaculture and seafood technology industries. And we work with recreational anglers — another important economic segment — to consider conservation practices such as catch-and-release techniques. We assist state and local leaders as they look for "sustainable" solutions for coastal management. We help lower-wealth coastal plains communities to see the value of nature-based and heritage-based tourism efforts that value their unique resources.

Fisheries

For centuries, North Carolina's vast fishery stocks served as the leading economic sector of the coastal economy. While commercial fishing was a mainstay for generations of coastal residents, the economic role of recreational fishing has become increasingly apparent. In recent decades, numerous fishery stocks have declined, and state and federal agencies have considered a variety of restoration efforts — efforts that often draw drastically different responses from the commercial and recreational fishing camps. Sea Grant looks at various perspectives on fisheries topics, including:

- Improving the return on investment in the fishing industry, including the application of new technology to improve yields or to protect declining stocks.
- Helping to resolve conflicts over the use of fishery resources.
- Providing a technical basis for developing more effective fishery management programs.
- Demonstrating the linkages between nutrients and related factors and the estuarine fish stocks.

Sea Grant has had a longstanding role in fishery efforts, including projects involving blue crabs, shrimp, flounder, red drum and other important commercial and recreational fisheries.

Research

North Carolina Sea Grant will continue its leadership role with the following research projects:

- **"Hypoxia and Estuarine Nursery Habitat Quality: An Experimental and Modeling Approach Linking Low Dissolved Oxygen with Fish Survival and Growth,"** a continuing collaborative project by Jim Rice of N.C. State University and

Sea Grant researchers from Delaware and Louisiana. The occurrence and perceived effects of hypoxia and anoxia in estuarine and marine environments draw national attention. This collaboration will combine laboratory experiments and simulation modeling to quantitatively link water quality, and hypoxia in particular, with fish survival, growth and behavior in estuarine nursery areas. The data will be incorporated into a simulation model to predict the impact of changes in water quality (i.e.: decreased dissolved oxygen or DO) on fish growth survival and distribution. Comparing responses of fishes from the Mid-Atlantic and South Atlantic bights will help determine the relative importance of low DO to the functional role of estuarine nursery areas and environments with different abiotic regimes. The researchers will determine the degree to which responses differ among species or functional groups, as well as if general relationships may be extended to other estuarine-dependent fish. Juvenile summer flounder, weakfish, spot and Atlantic menhaden will be tested to determine responses — such as feeding, growth and survival rates and avoidance behavior — to hypoxia combined with varying temperatures and salinity rates. Simulation modeling then will predict how changes in these abiotic factors affect fish growth, survival and distribution. The resulting model will then be available for marine resource managers. The model framework may also be applicable to other estuarine systems.

- **“Impact Of Striped Bass Predation On Young-Of-The-Year River Herring In The Albemarle Sound Estuary,”** by Jeffrey A. Buckel, and Joseph E. Hightower, both of N.C. State University. (Hightower also serves as the assistant leader of the N.C. Cooperative Fish and Wildlife Research Unit.) In recent years, the stocks of river herring and American shad have declined along the Chowan River and Albemarle Sound, resulting in new management plans for the fisheries. At the same time, the stocks of striped bass have risen in response to earlier management plans. The researchers seek to confirm a suspected link between the two fisheries. The researchers will quantify diet/selectivity and consumption rates of young striped bass in the region during summer and early fall. They also will estimate total mortality of juvenile river herring (*Alosa* spp.) prior to out-migration. Using that data, they will estimate predatory impact of young striped bass on juvenile river herring in the Chowan River and Albemarle Sound. Results from the proposed study would be directly applicable to resource management agencies charged with decision making for American shad, river herring, and striped bass fisheries. These include the Atlantic States Marine Fisheries Commission, N.C. Division of Marine Fisheries and other state agencies, and industry groups such as the Albemarle Fishermen's Association. Management agencies need better information on predator-prey dynamics along the East Coast as they make crucial management decisions. The North Carolina Sea Grant Strategic Plan recognizes the importance of understanding how species interactions influence population dynamics of resource species.

- **“Broken Rungs At The Bottom Of The Ladder: Effects Of Stratification-Induced Hypoxia On Trophic Transfer Between Plankton And Grazers In A Shallow Eutrophyng Estuary,”** by Peter S. Rand of N.C. State University. Rand will expand upon his current Sea Grant research utilizing mobile sonar surveys as well as traditional trawl sampling methods. The new project looks to increase the understanding of trophic transfer to secondary consumers (specifically zooplankton and planktivorous fishes) and how that energy transfer might be modified by adverse water quality. In particular, he will determine if water column stratification leading to bottom water hypoxia influences *in situ* feeding and growth dynamics of dominant pelagic fishes (Atlantic menhaden *Brevoortia tyrannus* and bay anchovy *Anchoa mitchilli*). Initial field research suggests these events result in a spatial separation of these fishes from their prey — which may have important implications for pelagic fish growth and performance in this ecosystem. The lagoonal nature of the Neuse River Estuary and Pamlico Sound increases residence time of water masses and

increases the importance of biological interactions. In the field, Rand will sample environmental and biological parameters on a monthly basis along transects in the Neuse River Estuary to understand macro-scale distribution of fishes in the estuary. He also will conduct intensive fixed site meso-scale sampling during summer stratification period to quantify prey and predatory overlap and trophic efficiency. Using those data sets, they will develop models to explain patterns of distribution and abundance of planktivorous fish at macro- and meso-scales in the estuary. Understanding habitat selection and movement patterns of key members of the plankton grazing community — and focusing on trophic linkages in the estuarine food web — may provide insight into how various nutrient management strategies will influence the magnitude of ecological change in this ecosystem.

In addition, the annual report provides details on several projects that will be completed in 2002, including:

- **“Field Tests of an Ecophysiological Model of Habitat Value to Predict Performance and Recruitment of Juvenile Marine Fishes,”** by John Miller of N.C. State University and collaborators in Texas and Florida.
- **“Linking Water Quality and Trophic Interactions in a Eutrophic Coastal River: Movement Patterns, Foraging and Mortality of Blue Crabs,”** by David Eggleston and Thomas G. Wolcott, both of N.C. State University.
- **“Linking Water Quality in Pelagic Fish Distribution and Behavior: A Multi-Scale Approach,”** by Peter Rand of N.C. State University.

Also, the minigrant program provides seed funding for smaller projects that will set the stage for future research efforts.

Outreach

The largest component of the North Carolina Sea Grant extension staff focuses on fisheries, with specialists located in each of three coastal offices. These veteran Sea Grant staff members have longstanding ties with the coastal communities and can often draw upon “highliners” to demonstrate new gear or participate in sampling studies. For example, those efforts have included demonstrations of a skimmer trawl for shrimp. In 2002, the staff plans to continue expand demonstrations of the trawl, which has already proven to be popular in the central coastal region.

The Fishery Resource Grant Program and the Blue Crab Research Program, both funded by the North Carolina General Assembly and administered by North Carolina Sea Grant, will continue to enhance the link between the fishing communities and the state’s university researchers. Coordinator of the FRG program, fisheries specialist Bob Hines is again organizing seminars at the N. C. Commercial Fishing Show. Many of the sessions will present results of FRG projects. Based on the success of the seminar series at the 2001 show, the 2002 series will be expanded to a second day. An annual report on the Fishery Resource Grant Program, including successful transfer of project results, is presented to the Joint Legislative Commission on Seafood and Aquaculture.

Blue crabs are North Carolina’s leading commercial fishery. Over the years, Sea Grant has introduced new technology for the soft/peeler crab industry, which grew from about 1.5 million pounds worth \$4.2 million in 1999 to nearly 1.75 million pounds worth nearly \$5.4 million in 2000. In early 2002, fisheries specialist Wayne Wescott and aquaculture specialist Marc Turano will offer a series of workshops on closed-circulation systems, thus giving the crabbers a chance to update their system before the 2002 season opens in the spring. Turano coordinates the state-funded Blue Crab Research Program.

Coastal waters draw thousands of recreational fishers each year — and North Carolina Sea Grant is ready with educational materials on ethical angling and catch-and-release techniques. Earlier efforts have included a pocket-size information card on red drum, the state saltwater fish. In Fall 2001, as state regulators were noticing a high mortality of red drum due to improper tackle, fisheries specialist Jim Bahen provided not only the information cards, but also gave samples of the preferred circle hooks to anglers along the central coast. In 2002, Sea Grant will continue this outreach with a brochure on ethical angling other efforts with the N.C. Division of Marine Fisheries to ensure the fisheries continue for generations.

Staff members routinely attend the N.C. Marine Fisheries Commission meetings and are often called upon to provide the commission with background information. Bahen currently chairs the commission's Southeast Regional Advisory Committee. He and other specialists also attend a wide range of meetings called by state and federal agencies, including sessions on controversial topics, such as efforts to protect endangered sea turtles and marine mammals.

Aquaculture

Consumers worldwide are increasing the amount of seafood in their diets, yet many wild stocks are on the decline. Thus the role of aquaculture, also known as fish farming, is gaining attention. But aquaculture operators and community leaders have many questions, including costs and environmental impact. Thus the goals of the Sea Grant aquaculture program include:

- Increasing return on investment in rapidly growing aquaculture industries, especially hybrid striped bass.
- Assisting in production of high quality seafood products by developing new culture species and systems.
- Improving the efficiencies of a variety of shellfish aquaculture and shellfish mariculture operations.

North Carolina Sea Grant is recognized as a leader in hybrid striped bass aquaculture, which is now a multimillion-dollar industry. Much of that research is being transferred to other species, including flounder. In addition, Sea Grant researchers are developing new feed formulas to meet the nutritional demands for proper growth.

Research

In the new funding cycle, several of the projects build upon previous or current research efforts that have proven successful. The new projects include:

- **“Reproduction of Domesticated Striped Bass: Coldbanking to Arrest Maturation and Atresia,”** by Craig V. Sullivan, N.C. State University. (This project continues from the previous funding cycle.) Continued growth of the hybrid striped bass aquaculture industry will require full domestication of striped bass and white bass as parental lines. In addition, the industry will need to program reproduction at any time during the year. Earlier efforts have provided domesticated white bass and allowed triple cropping of fingerlings. This project is taking the domestication of striped bass to the same level, including attention to both husbandry and diet. The results of Sea Grant efforts are already seen in that many hybrid striped bass fingerlings produced in North Carolina came from domesticated broodstock. Additional work includes the refinement of methods to allow multiple fingerling crops per year per pond. In addition, techniques are being developed to put broodfish into a temporary maturation arrest so that spawning can time to avoid adverse weather. Finally, cold-banking methods will allow fish to be induced to mature out of season, thus offering continuous year-round production. This project involves a direct interaction with the aquaculture industry. It has included a graduate student and has resulted in a number of presentations to professional meetings.

- **“Accelerated Genetic Improvement of Striped Bass: Molecular Biomarkers of Growth Performance,”** by Russell J. Borski and Craig V. Sullivan, both of N.C. State University. (This project will start in 2003.) North Carolina Sea Grant anticipates a "fast-track" program of selective breeding based on this novel breeding biotechnology. This project is an outgrowth of Sea Grant’s aquaculture research, particularly in hybrid striped bass. These researchers anticipate developing a breeding system that will improve fish performance traits several times faster than would be possible in a traditional breeding program — at less than 10 percent of the cost. Growth in the hybrid striped bass industry has slowed in recent years, and many point to competition from foreign products and high production costs. Production costs for hybrid striped bass could be reduced by 12 percent if selective breeding can yield 20 percent faster growth rates. This project aims to develop genetically enhanced broodstock for the hybrid striped bass (HSB, genus *Morone*) industry via selective breeding based on modern molecular genetics and cutting-edge growth physiology. The proposed research will combine pedigree tracking using microsatellite DNA markers (MDMs), common garden performance trials of genetically tagged progeny from multiple families, and quantitative trait loci (QTL) that predict fish growth performance. The researchers will take a "candidate gene" approach to identify QTL, targeting critical growth-regulating factors and the genes encoding them. These anabolic factors will include growth hormone, insulin-like growth factor I (IGF-I) and its receptor, IGF-binding peptides, and myostatin. The breeding system will employ "walk-back" selection, in which broodstock generating performance-tested progeny with elevated growth or growth biomarkers will found each successive generation.

- **“Characterization of Novel Peptide Antibiotics From Hybrid Striped Bass,”** by Edward J. Noga of N.C. State University. This project is an outgrowth of an earlier cutting-edge project, “Improved Methods for Managing Water Mold Infections of Fish,” that resulted in the discovery of novel antibiotic factors in fish. The results, as reported in the journal *Nature*, could prove crucial for aquaculture operations, where control of infectious disease is a constant struggle. Traditionally, controlling many of these pathogens has relied heavily on drugs or other chemicals. But drugs can be expensive and must meet strict regulations before they are approved for use in food fish. Also, there are concerns for drug residues and a possible public health threat. Clearly, there is a need for innovative approaches to controlling infectious diseases that have broad application to many fish species and which may be implemented at a relatively low cost. Noga’s team recently isolated potent peptide antibiotics from the gill tissue of hybrid striped bass (*Morone saxatilis* male x *M. chrysops* female). This peptide was determined to constitute a new type of peptide antibiotic. The overall goal of the new project is to characterize what may be a critically important defense in protecting hybrid striped bass, one of the most rapidly growing segments of U.S. aquaculture. Noga will purify these novel defenses, determine their structure (via amino acid sequencing), and explore their possible role in defending against important diseases. He also will determine the tissue distribution of these peptides and if other commercially important fish express these peptides.

- **“Aquaculture of Southern Flounder: Improved Fingerling Production and Development of Growout Technology”** by Harry V. Daniels, N.C. State University and Wade. O. Watanabe, UNC-Wilmington. Southern flounder has tremendous potential for aquaculture because of its wide salinity tolerance and rapid growth rate in fresh water. The development of southern flounder culture would be a significant contribution to the U.S. mariculture industry through the introduction of a high-value product that can be readily marketed worldwide. Such research could have an economic impact along the southern flounder’s wide distribution range, from North Carolina along the South

Atlantic and Gulf of Mexico. However, advances in fingerling production have been hampered by variable results in larval rearing that are related to unsuccessful first feeding. A novel approach using different live feeds is needed to significantly increase survival through first feeding, thereby improving the economic prospects of fingerling production. Additional information on larval nutrition is needed to optimize growth and development. Fundamental information on commercial-scale growout is needed to further the development of reliable, practical, commercial-scale culture technology and to firmly establish flounder farming as a viable aquaculture activity in the U.S. These researchers expect to significantly improve larval survival through first feeding by using cultured copepods. They plan to further define the role of fatty acids in larval flounder growth and development, and to establish practical production protocols for southern flounder growout in freshwater and seawater recirculating systems. This project builds upon the results of "Aquaculture of Southern Flounder: Improved Production Through Environmental and Nutritional Optimization," by Daniels, Watanabe and Margie Gallagher of East Carolina University.

Outreach

Finfish aquaculture outreach efforts include participation in the state's annual conference and by direct interaction with state officials and industry leaders in aquaculture. In addition, North Carolina Sea Grant Director Ronald Hodson remains active in the research and outreach efforts, including serving as a session moderator at World Aquaculture Society meetings. The Sea Grant communications team anticipates working with researcher Harry V. Daniels of N.C. State University to develop a flounder hatchery manual.

Outreach efforts in shellfish mariculture are expanding with new facilities at the Center for Marine Science and Technology in Morehead City. Mariculture specialist Philip "Skip" Kemp teams with Carteret Community College faculty to teach classes in shellfish aquaculture. He also provides workshops, such as at the annual Aquaculture Development Conference, works with the statewide growers association and monitors aquaculture/mariculture projects for the FRG program. New publications and Web products on shellfish mariculture are expected in 2002-2004.

Seafood Technology

One of the earliest Sea Grant projects in North Carolina was the funding of seafood laboratory projects for N.C. State University. That tradition of leadership continues today through research, extension and communications efforts, as well as extensive education programs for the seafood processing industry. Overall goals for this category include:

- Expanding the seafood industry by improving product quality and handling, and increasing the development of value-added products.
- Improving the safety of seafood for consumers.
- Developing new technology to increase the use of byproducts, thus reducing waste and improving use and value of traditional products.

With the new funding cycle, North Carolina Sea Grant not only will expand upon past success, but also will move into new arenas of this cutting-edge industry.

Research

Two new research projects focus on shellfish food safety while a third expands ongoing research on surimi processing. The seafood technology projects beginning in 2002 are:

- **"Alkaline-Aided Processing to Upgrade Value of Southeastern Pelagic and Demersal Species: Croaker (*Micropogon undulatus*) and Menhaden (*Brevoortia tyrannus*,"**

patronus)” by Tyre C. Lanier of N.C. State University. This project continues extensive research regarding surimi processes, but in this case new species will be considered in efforts to increase yield of recovered protein. Alkaline solubilization will likely minimize catheptic and other protease activity and modify myofibrillar proteins to enhance their gelling ability. Furthermore, higher protein yield with less waste occurs. Yet we presently do not understand how the control parameters of this process affect the protein changes which influence gelling ability and process yield. In general, this project will determine the underlying biochemical responses to processing. Lanier will investigate conditions of protein solubilization, reprecipitation, and stabilization which develop the optimal functional properties, including gelling ability, appearance, flavor/odor and protein stability). In addition, the project will determine the retention, if any, of desirable transglutaminase (TGase) protein-crosslinking activity and modifications to the process that would maximize this, or enhance response of proteins to added TGase. Frozen stability of the product is still uncertain, and the response of recovered proteins to the further processing steps commonly used for surimi-based foods must be ascertained before the new recovery process can be confidently commercialized.

- **“Characterizing the Stress Response of *Vibrio Vulnificus* to Sublethal Stresses During Oyster Handling and Processing”** by MaryAnne Drake, David P. Green and Lee-Ann Jaykus, all of N.C. State University. The shellfish industry has been a traditional component of North Carolina’s coastal heritage and economy. In recent years, consumer demand for raw oysters continues despite public health concerns associated with *Vibrio vulnificus*, which can be isolated from oysters. Sporadic cases associated with consumption of raw oysters supplied in the summer months have been reported in North Carolina and the Southeast. Due to the high mortality rate and its ubiquity in shellfish, *V. vulnificus* is a critical organism of concern in raw or minimally cooked or handled oysters. Ensuring safety of this important food commodity through a better understanding of this organism is critical for maintaining market share, increasing consumer consumption and identifying methods to minimize consumer risk. Previous research indicates that sublethal stress of *V. vulnificus* can impact subsequent survival and resistance of the organism. The current work proposes to study the effects of cold, starvation, and acid stress on subsequent heat and acid tolerance and cold storage survival and freeze/thaw resistance of *V. vulnificus*. Knowledge of the response of *V. vulnificus* to sublethal stresses encountered during oyster processing or storage will enable design of appropriate processes/regimes to eliminate this organism and to minimize food safety risk. In particular, the researchers will determine the effects of starvation, cold stress, acid stress, and cold adaptation on heat tolerance, cold storage survival, and freeze/thaw tolerance of *V. vulnificus*. They also will determine the effects of starvation, cold stress, acid stress, and cold adaptation on acid tolerance of *V. vulnificus*. Finally, they will characterize the effects of starvation, cold stress, acid stress, and cold adaptation of *V. vulnificus* in a model food system.

- **“The Viable but Nonculturable State in Human Bacterial Pathogens in Eastern North Carolina Waters”** by James D. Oliver of UNC-Charlotte. This study is designed to understand the entry into, and resuscitation from, the “viable but nonculturable” or VBNC state of *V. vulnificus*, *V. cholerae*, and *V. parahaemolyticus* in North Carolina estuaries. In addition the project will provide methods to both detect and cultivate these pathogenic bacteria when in this otherwise undetectable state. Oliver will examine the role of temperature and nutrients on entrance of three human bacterial pathogens, *V. vulnificus*, *V. cholerae*, and *V. parahaemolyticus*, into the VBNC state at sites on the Neuse and Pamlico rivers, and the Intracoastal Waterway. Then, he will develop and optimize PCR technology to detect these pathogens when in the VBNC state. In addition, the project should determine the conditions required for resuscitating these species back to the actively metabolizing and virulent state. Finally, the project will yield new media to allow the direct culture of cells when present in the VBNC state.

In addition, a pair of projects will be completed in 2002. Lanier will complete “Acid-Aided Processing to Upgrade Value of Atlantic Pelagic Fish Species.” Also, Brian Farkas of N.C. State University has worked with Lanier on “Infusion of Active Proteins to Improve Quality of Intact Seafood Meats.” Details on both projects are in our annual report.

Outreach

North Carolina Sea Grant’s leadership in seafood technology is evidenced in the role of Director Ronald G. Hodson as co-chair of the Seafood Technology Theme Team for the national Sea Grant network. Hodson is coordinating the development of a “white paper” to evaluate the existing Sea Grant efforts in the seafood technology arena as well as the research and outreach needs on national and regional levels.

Our program also has been deeply involved with the development of materials for a federal seafood safety program known as Hazard Analysis and Critical Control Points, or HACCP. Seafood technology specialist Barry Nash will continue to present HACCP training and other safety training programs in 2002-2004. Nash works closely with state and federal agencies as well as the seafood industry to provide HACCP and other seafood safety training for the industry, state inspectors, and retail and restaurant operations.

Located at N.C. State University’s Seafood Laboratory, Nash also will continue to help individual processors to develop and update the required HACCP plans, as well as encouraging the processors to develop “value-added products” that make it easier for seafood to be cooked at home and in restaurant or institutional settings. These efforts will include his regular “Seafood Enterpriser” column in the Marine Extension News and his work with participants in the FRG program. In fact, one of those participants hopes to announce a restaurant chain that will add a new seafood menu item resulting from an FRG project. In addition, Nash has worked with the “True Blue Crab” program and other efforts to identify and market North Carolina seafood.

Coastal Policy and Sustainable Development

The dramatic increase in the population of many coastal communities places new demands on traditional coastal businesses and creates the need for new ones. Many rural coastal communities are generally unprepared for such changes and, as a result, must adjust to a variety of economic and social changes. Many coastal economies are based on natural resources that can be jeopardized during rapid change. Thus, our priorities in this area include:

- Modeling the coastal economy and its links to the geological and ecological sustainability of coastal communities.
- Defining existing land- and water-use patterns and exploring techniques — such as zoning, land- and water-use planning — to meet challenges posed by an increasing population.
- Defining parameters needed to support nature- and heritage-based tourism and quantifying the economic impact of such activities.
- Understanding the policy and economic implications of public-trust resource allocation and use — with particular attention to the range of issues associated with beach nourishment, beach access and surface-water activity conflicts.

Once again, Sea Grant’s reputation as an “honest broker” is crucial as researchers and staff members tackle the often controversial topics that fall under this category.

Research

Two new research projects look at coastal demographics and efforts to establish coastal policies. They are:

- **“Stakeholder Perceptions of Water Quality: New Approaches to Assessing and Responding to Public Involvement”** by David Griffith and Jeffrey C. Johnson of East Carolina University. As resource managers struggle to design regulations regarding water quality and marine ecosystem health, several problems are evident. Stakeholder perceptions of water quality and threats to water quality vary by one’s social and economic position in relation to coastal waters. Also, recent growth in coastal population calls for changes in the methods of soliciting input from the public on these critical topics. Many of those who interact with the coastal environment already engage in practices that reduce threats to water quality or, in some cases, improve water quality and general ecosystem health. Finally, perceptions, practices, and venues for public input vary within as well as between stakeholder groups that regulators often treat as homogeneous. Thus Griffith and Johnson will determine how different perceptions of environmental processes and human activities fuel public responses and reactions among individuals living, visiting, and working in the coastal zone, and how these perceptions impact tourism and related industries. The researchers will compare perceptions of water quality problems, including causes, across the following six groups: commercial fishers, recreational fishers, farmers, environmentalists, city/county officials, and tourists. And they will identify “best practices” that fishers, farmers, and city/county governments already perform to reduce their contributions to deteriorating water quality. The final research objective is to determine how perceptions of water quality influence coastal tourism. This project includes specific outreach efforts, including workshops to inform current and prospective coastal managers and representatives of the six target groups of the findings of the project, with a focus on areas where consensus building between various groups is possible. The researchers also will work with Sea Grant communicators to develop a publication to inform fishers, farmers, and city/county governments about practices that others use to reduce threats to water quality. This project recognizes that protecting water quality and general marine ecosystem health is directly related to the general health of the coast and the continued viability of coastal tourism.

- **“Demographic Change in North Carolina's Coastal Counties and Related Policy Implications”** by Lauriston R. King of East Carolina University. The influx of new, culturally and economically diverse groups continues to transform coastal communities. Thus, King seeks to outline economic transition and displacement issues in the wake of demographic transition. These issues have especially significant implications for those engaging in traditional coastal primary economic activities and often mean the disruption of long practiced ways of life. The North Carolina coast has already seen a major transition from fishing villages to vacation and retirement havens. Across the country, census data in similar coastal areas has shown increased stratification of socioeconomic groups in coastal populations, indicating a widening gap between rich and poor. Meanwhile, the coastal population is seeing a surge of Hispanic residents, but little is known as to how cultural aspects and societal preferences of this group will affect coastal communities and economies. Finally, as the percentage of individuals over 65 years of age increases, the medical needs and recreational preferences of this group could become a challenge for coastal planners. King expects to provide a more complete characterization of the changes taking place demographically and economically in coastal counties. Reports of the demographic and survey findings will be significantly enhanced through display and analytical capabilities now available through East Carolina University’s Geographic Information Sciences Center. A combination of narrative analysis and graphic display promises to enhance the usefulness of these project results

for area planners and managers. This data also will allow industry and managers to direct their efforts to areas where they will be most effective. North Carolina's coastal counties can then better prepare for their economic and sociological future.

In addition, Griffith and Johnson are completing a project from the previous funding cycle. Details on "Local Knowledge and Scientific Resource Management in Changing Coastal Communities" are included in the annual report. Also, minigrants provide opportunity for rapid response to policy and development-related issues during the course of the funding cycle. Past efforts have included studies of community response to and the economic impact of coastal storms, as well as efforts to bring consensus on controversial subjects including beach nourishment proposals.

Outreach

Coastal policy and sustainable development outreach effort are led by Jack Thigpen, extension director, and Walter Clark, coastal law and policy specialist. Thigpen will continue his emphasis on coastal communities, building upon his training in the state's natural resources leadership program. He also is working with NOAA's Coastal Services Center to study demographic changes in coastal counties. That work will be coordinated with King's research project. Thigpen will also continue sustainable development projects, such as the successful coastal paddling trails initiative. In 2002, Thigpen will work with communicator Ann Green to complete a series of policy reports, including community perspectives on oil drilling proposals and the economic impact of coastal tourism activities.

As president of The Coastal Society, Clark plays a national leadership role in the discussion of crucial policy and development issues facing communities along all U.S. coastlines. He also continues to follow-up on earlier research on sea-level rise that was done in conjunction with the U.S. Environmental Protection Agency. Clark also works with communicators to include regular "Legal Tides" feature stories in *Coastwatch* magazine.

Several staff members are involved in the development of "The Soundfront Series" of estuarine guidebooks. Funded by the N.C. Division of Coastal Management, the series will look at a number of factors, including policy and management decisions to protect the estuarine shoreline and waters, as well as landscape design to protect water quality.

COASTAL ECOSYSTEM HEALTH AND PUBLIC SAFETY

In the category of Coastal Ecosystem Health and Public Safety, our strategic plan includes a number of topics, including coastal processes and natural hazards, water quality and habitat protection and restoration. In fact, some of the first Sea Grant projects in North Carolina involved evaluations of estuarine ecosystems and habitats. (These efforts were featured in a special issue of *Coastwatch* magazine in the summer of 2001.) In 2002-2004, we will continue to build upon the strong base we have built in this area, as well as look to new challenges as we address the ongoing needs of the coast while also responding to immediate needs resulting from storms and other events.

Coastal Processes and Natural Hazards

The coast is a dynamic place, where the land meets the sea. This sets the stage for beautiful vistas, constant change and the potential for danger. North Carolina Sea Grant has several goals in this category, such as:

- Reducing the loss of property and other capital investments in the coastal zone.
- Improving the ability of man to live and recreate in the *coastal hazard zone*.

- Enhancing the socioeconomic status and environmental quality for coastal residents.

Thus, our strategic plan to implement these goals includes both research and outreach activities.

Research

Charles H. Peterson of the UNC-Chapel Hill Institute of Marine Sciences continues his interest in the effects of beach nourishment projects. **“Enhancing the Scientific Basis for Predicting Fish Habitat Impacts of Beach Nourishment”** recognizes the unprecedented demand for beach nourishment projects in North Carolina and along the East Coast in light of erosion during recent hurricanes and other storms. As illustrated in a May 2001 workshop on beach nourishment, the biggest technical uncertainty surrounding beach nourishment involves the biological impacts on habitat and to the prey of fishes, shorebirds, and other predators. As sea level continues to rise — and many predict at increasing rates with global warming — development of a rational policy to protect critical or essential fish habitat depends on resolving the controversies over biological impacts of beach nourishment and over the constraints required to minimize the impacts. Peterson intends to evaluate the rigor and adequacy of the monitoring designs for beach nourishment projects conducted in North Carolina, South Carolina and Florida — and then to suggest improved monitoring techniques. He will also use wave-tank beach mesocosm and field experiments to determine how sediment grade (such as sand, mud or shell) and turbidity affect burrowing and feeding of key benthic invertebrates and the feeding ability of surf fishes. In particular, this project will monitor the Bogue Banks beach nourishment project, assess the importance of seasonal timing of sand deposition on benthic invertebrates, test the hypothesis that enhancement of shell materials persists on nourished beaches, and provide one test of potential cumulative impacts on feeding by surf fish.

Spencer Rogers not only is a Sea Grant extension specialist, but also is on the faculty of N.C. State University’s College of Engineering and UNC-Wilmington’s Center for Marine Science. He is actively involved in N.C. State University research projects on hurricane damage and breakaway walls, and is working with Sea Grant researchers from Clemson University to study wind damage and hurricanes in order to develop retrofitting techniques for existing homes.

In 2002, results also will be expected from **“Relationship of Hazard Zones, Shoreline Erosion and Post-storm Recovery to the Geologic Framework of Selected Southeastern North Carolina Shoreline Segments,”** by William J. Ciery of UNC-Wilmington. Details on this project are in our annual report.

In addition, minigrants are an ideal way to provide rapid response to research needs in the natural hazards arena. In the past, minigrants have supported the seminar on research needs regarding beach nourishment, as well as research targeted to the wind and water damage from coastal storms. We anticipate similar minigrant requests in the new funding cycle.

Outreach

Rogers is considered a national expert on coastal processes and is often called upon to assist with projects developed by the Federal Emergency Management Agency and the U.S. Army Corps of Engineers. He also serves on the state’s Coastal Resources Advisory Council and on the state’s scientific panel on natural hazards. Rogers, who has studied every major East Coast hurricane since 1978, will continue his mentoring role for many of the new coastal hazards specialists in Sea Grant’s national network.

In 2002-2004, he will translate research findings into useful information for residents and policymakers. His topics will include innovative storm shutters for coastal homes and other retrofitting efforts. These options are crucial for the coastal homeowners and thus Rogers has a leadership role in the annual Hurricane Preparedness Expo in New Hanover County. Each year he presents a series workshops that have included Tim Reinhold and other South Carolina Sea Grant researchers at Clemson University.

In addition, Rogers will continue his extensive work with oceanfront communities dealing with the effects of erosion, and in particular erosion near the state's 22 inlets. The media often calls upon Rogers to explain complicated erosion topics in terms the public can understand. Rogers is also a co-author of a book on estuarine shoreline stabilization, part of the "The Soundfront Series" which will come out in 2002. In addition, Rogers has worked closely with the National Weather Service and Sea Grant communicators to expand a public education program on the dangers of rip currents. This project will be explained in more detail in the education section of this report.

Water Quality

The water quality topic includes a broad range of issues, from restoration of urban streams in the piedmont to studies of the chemical mix found in estuarine and coastal waters. In particular, we look to:

- Apply the latest technology to improve environmental quality and reduce the impacts of pollution.
- Reduce the eutrophication of coastal waters by recognizing the variety inputs from throughout the river basins.
- Enhance the environmental quality and resulting socioeconomic status of coastal communities.

Land uses — exacerbated by increasing intensity of development, agriculture and water use — in the estuarine watersheds and the subsequent effects on coastal water quality jeopardize ecosystem productivity. Citizens increasingly demand state, local and federal officials to "turn the tide." They need more and better information on the various interactions of land activities, nutrient run-off, atmospheric sources, and fates of contaminants for the development of nutrient-sensitive watershed criteria, outstanding resource water designations and implementation of best management practices. This issue has become a priority concern.

Again, the Sea Grant approach includes a mixture of research and outreach activities. Recent research has resulted in information on the role of nutrients in phytoplankton production, causes of fish kills, impact of toxic dinoflagellates, submerged aquatic vegetation survival, onset of hypoxia and interactive effects of eutrophication on food webs. Over the years, Sea Grant has brought together scientists, managers and interested citizens to design better estuarine water quality management plans. Much of the state's current coastal water quality management scheme is based on information generated and disseminated by Sea Grant research.

Research

In 2002, two research projects related to water quality will begin:

- **"Increasing Ammonium Concentrations in the Cape Fear River Estuary: Where Is It Coming From?"** by Robert Kieber, Joan Willey and Stephen Skrabal, all of UNC-Wilmington. Concentrations of ammonium (NH_4^+) in the Cape Fear River Estuary (CFRE) have almost doubled in the last four years. The rates continue to increase, while the exact sources of this NH_4^+ increase are unknown. The three rivers (Cape Fear, Black and Northeast Cape Fear) that feed into the CFRE are all lower in NH_4^+ concentrations than the estuarine waters (Mallin et al., 2000), so there must be an

NH_4^+ source in addition to river input. Ammonium is of particular interest because such reduced forms of nitrogen are well known to be preferred by phytoplankton. In addition, NH_4^+ plays an important role in maintaining bacterial productivity by processes such as nitrification. Such bacterial processes may be particularly important in the Cape Fear estuary, which contains very high levels of dissolved organic carbon, a substrate for bacterial growth, yet relatively low phytoplankton productivity due to light limitation imposed by its deeply colored waters. These researchers anticipate quantifying the input rates of critical nutrients (NH_4^+ , $\text{NO}_3^- + \text{NO}_2^-$, and DON) into the estuary. Because NH_4^+ , $\text{NO}_3^- + \text{NO}_2^-$, and probably DON rapidly interconvert, it is necessary to study various nitrogen species in order to understand NH_4^+ . They hypothesize that the rivers, sediments, and atmosphere are important nutrient sources for the estuary. This innovative project uses a system-wide approach to understanding nutrient sources and transport in the estuary whereby the relative importance of fluxes from sediments and atmosphere will be evaluated along with river inputs. Laboratory experiments will complement field data to identify processes and quantify fluxes. The resulting data will be of considerable interest to several agencies investigating water quality issues, including the U.S. Army Corps of Engineers, the Lower Cape Fear River Program and the N.C. Division of Water Quality.

- **“Linking Changes in Human N Input to Eutrophication, Harmful Algal Blooms and Trophic Alteration in the Neuse River Estuary and Pamlico Sound, N.C.”** by Hans W. Paerl and Luke J. Twomey of the UNC-CH Institute of Marine Sciences. Since the early 1980s, the Neuse River Estuary (NRE), a key tributary of the Pamlico Sound (PS) and the nation’s second largest estuarine complex, has experienced nuisance cyanobacterial blooms in the freshwater reaches and extensive winter-spring dinoflagellate and cryptomonad blooms in the oligo-meso-haline segments downstream. In recent years the downstream blooms have become commonplace and have been shown to play a central role in the supply of organic matter fueling summer bottom water hypoxia and anoxia. These blooms have been attributed to persistent and extensive nutrient loading associated with expansion of agricultural and urban development in the NRE-PS watershed. Recent changes in land use, agricultural practices, and urbanization have led to changes in the *forms* and *amounts* of nitrogen (N) being discharged, either overland, by groundwater or via atmospheric deposition, to estuarine and coastal waters. The researchers hypothesize that human-induced changes in N discharge in coastal watersheds are an integral causative agent of eutrophication, phytoplankton community compositional change and disrupted trophic transfer. Changes to the relative supply rates of specific forms of N will lead to an alteration of the phytoplankton and zooplankton community structure and function, which may have serious consequences at higher trophic levels. Thus, this project will determine whether the relative abundance of biologically available forms of N influences phytoplankton community structure and biomass in the NRE-PS. Specifically, the proposed research will determine whether reduced N (NH_4^+ & urea) is favored by harmful phytoplankton that are less likely to be grazed, and/or whether oxidized N ($\text{NO}_2^- + \text{NO}_3^-$) is taken up more readily by desirable species. The project also will determine the relationship between nitrogen inputs and trophodynamic response in the estuary and sound. Specifically, it will examine how changes in the phytoplankton community composition — induced by variable forms and amounts of N — affect the micro- and meso-zooplankton community structure and function due to differences in the palatability and/or food quality of the phytoplankton community.

Also, a number of water-quality focused Sea Grant research projects will be completed in 2002, but will continue to provide important results for a number of years. Details of these projects can be found in our annual report. They include:

- **“Sediment-Water Exchange in the Lower Cape Fear Estuary: Effects of Metal Speciation on Water Quality and Benthic Biota”** by Stephen A. Skrabal of UNC-Wilmington.
- **“Interactions Between Nutrient Additions and Trophic Controls: Scaling Effects and System Variability”** by Martin Posey, Lawrence Cahoon and Troy Alphin, all of UNC-Wilmington.
- **“Phytoplankton and Zooplankton Community Response to External Nitrogen Loading in the Pamlico Sound, N.C.: Mechanisms and Links to Management of Coastal Eutrophication”** by Hans W. Paerl and Tammi L. Richardson of the UNC-Chapel Hill, Institute for Marine Science.

Again, minigrants are another opportunity to provide a rapid response to water quality issues. For example, when the floodwaters of Hurricane Floyd brought massive amounts of fresh water into the Neuse/Pamlico and Cape Fear estuaries, Sea Grant provided funding for special research cruises to gather immediate data to show the impact.

Outreach

Transfer of information from research findings to ultimate use will require communication activities and extension programs in workshops, technology transfer and interactions with agencies and users. These activities are in tremendous demand as the state and region struggle to balance economic return and quality of the environment that serves as the attractant for economic development. Increasing pressure on the use of public trust resources and how the agencies and interest groups deal with them will require the best information possible.

Our outreach efforts in the water quality arena are driven by the efforts of Barbara Doll, water quality specialist. She also works closely with the communications office on a number of projects, from the well-respected *WaterWise* newsletter to collaborations with state agencies to provide citizens science-based yet understandable information on water quality. For instance, her work with community leaders to restore a stream within a Wilmington area golf course has served as a demonstration project and has earned media attention.

In addition to Doll's varied presentations at state and national conferences, the Sea Grant team works with water quality education for the general public. Her stream restoration work is detailed in the education section of this plan. Other outreach efforts include participation in community events, such as the RiverRevival festival in Wake County, home to portions of both the Neuse River Basin and the Cape Fear River Basin. Also, the *Coastal Water Quality Handbook*, written by Doll and Lundie Spence, marine education specialist, continues to be popular for teachers and coastal residents alike. An updated edition is expected for the handbook.

Habitat Protection and Restoration

This category is tied closely to the water quality efforts listed above. North Carolina has taken steps in recent years to reduce nutrient runoff and thus protect the delicate balance in coastal ecosystems. The goals include:

- Assisting in better management of estuarine ecosystems.
- Reclaiming estuarine habitat that has been destroyed or damaged by development.
- Contributing to state and federal management plans to more effectively manage estuarine waters.

Earlier research by Sea Grant scientists provided crucial background for management and policy decisions regarding coastal habitats. Sea Grant was a leader in bringing together scientists,

managers and coastal residents to consider management options, and Sea Grant will continue this “honest broker” role during 2002-2004.

Research

Oysters have long been valued as a seafood delicacy and thus declining oyster stocks have earned attention. In “**Oyster Reefs as Fisheries Habitat: The Influence of Edge Characteristics and Vertical Complexity**,” Martin Posey and Troy Alphin of UNC-Wilmington will consider how oyster reefs also provide a refuge and forage area for certain decapods and fish. These reefs are associated with enhanced benthic and epibenthic faunal abundances, and have broad ecosystem effects through their filtration of the overlying water. A major gap in our understanding of oyster reef function lies in understanding how morphological and/or landscape characteristics of a reef may affect its habitat function. Yet, understanding how these factors affect oyster reef utilization is critical to understanding how changes in natural oyster reefs affect the broader estuarine communities — and it is critical to designing created oyster reefs to maximize habitat functions. This study focuses on two aspects of oyster reef morphology in order to determine how they affect infaunal and epibenthic utilization of intertidal reefs: 1) variations in vertical complexity on the surface of the reef, and 2) amount of edge area relative to reef surface area. Recent declines in seagrass beds from southeastern North Carolina to northern Florida means that oysters represent the dominant structural habitat in the mid intertidal to shallow subtidal along those coasts. Thus, the results of this study could influence management of coastal ecosystems in the region. Management decisions will require an understanding of the factors that affect the quality of oyster reefs as habitat for other fauna. Mitigation or coastal monitoring efforts must be able to assess whether changes in oyster reef habitat, including structural and morphological changes, may affect available nursery areas for fish and decapods. Similarly, restoration efforts should consider designs that maximize habitat potential, especially considering reef shape, morphology and location. This research will delineate important morphological characteristics of oyster reefs that may affect their quality as habitat for other organisms. Such findings likely will directly impact future restoration plans for oyster reefs and selected fisheries in North Carolina as well as potentially influence how managers view different types of oyster reefs. If the landscape relationships are confirmed, then habitat restoration attempts will need to target key reef features and managers will be able to consider environmental factors that may affect these features, such as disease, disturbance, water quality, and effects of harvesting in some areas.

In addition, Sea Grant research slated for completion in 2002 will continue to yield results. For example, “Fine Scale Spatial and Temporal Variation in Abundance of *Pfisteria piscicida* and *Pfisteria*-like Species in North Carolina Waters,” by Parke Rublee of UNC-Greensboro and JoAnn M. Burkholder of N.C. State University, has provided DNA-probe groundwork that can be used in a variety of research efforts to improve early detection of water quality problems. These researchers are continuing to collaborate with colleagues in several states. Details on the project are included in our annual report.

Outreach

North Carolina Sea Grant’s water quality specialist, Barbara Doll, chaired a 2001 stream restoration workshop that drew more than 300 persons from a number of states. In 2002, she will continue to work with the state’s stream institute to improve the curriculum that covers crucial topics for engineers and community leaders.

Doll’s work with the Rocky Branch restoration project, as outlined in the funding section earlier, provides not only demonstrates water quality improvements, it also provides examples of habitat protection and restoration. In addition, Doll continues to partner with a variety of agencies on restoration projects — including Jumping Run in Carteret County, which includes shellfish habitat in

tidal creeks. This collaboration with the N.C. State University design faculty and community leaders continues. Doll's restoration efforts also include a project at Yates Mill in Wake County. In 2002-2004, Doll's work with a national committee will result in a guide to aquatic nuisance plants that is being edited by Pam Smith of the North Carolina Sea Grant communications team.

EDUCATION AND HUMAN RESOURCES

North Carolina Sea Grant's education efforts provide a broad spectrum. We teach classroom teachers to utilize coastal and marine topics in many areas, from science and math to reading, social studies and art. We partner with nontraditional educators who provide "lessons" in parks, museums and aquariums. We provide educational materials for coastal residents and other to continue in their lifelong journey of learning about the world around them. We provide important safety and consumer information, from identifying rip tides to purchasing safe seafood or understanding the lingo and regulations of coastal development. In addition, we work directly with university and graduate students, who are critical factors in the Sea Grant mission of transferring new technology and academic findings to "real world" applications.

Developing an Informed Citizenry

North Carolina Sea Grant seeks to increase coastal knowledge across a variety of audiences. This requires a delivery system that provides relevant information — through personal contact, printed or electronic products — to the public in a timely manner. In particular, we present the following goals:

- Increase marine literacy among people of all ages.
- Organize and design a delivery system to get relevant information to the public.
- Deploy an effective extension program to respond to state and regional priorities.

These goals are reflected in a variety of activities across the Sea Grant spectrum.

Research

Karen Dawkins of N.C. State University will focus on development of new coastal curricula for classroom teachers. "**Sea-View: Introducing Coastal Processes and Conflicts to North Carolina Students**" will provide unique course materials that will mesh with state educational requirements for courses in earth/environmental science, biology and physical science. The project will include classroom teachers and students, along with university faculty and the final products will include printed materials, a CD-ROM and online activities. There are no existing materials that fill this particular niche for high school science, and there are probably few issues more critical than those related to our marine and coastal resources. The future of those resources rests at least in part on wise decision-making by North Carolina's citizenry. The ultimate goal of this project is to develop informed citizens, beginning with high school students and teachers.

Outreach

In the simplest terms, our extension and communication efforts are "public education" projects. Throughout this plan, we have cited these efforts in a variety of fields, from fisheries and water quality to erosion control and coastal policy, from marine education to aquaculture and seafood technology. This coordinated effort — linking university researchers, our extension and communications staffs and the people of North Carolina — will continue in 2002-04. Our staff will also continue to work on regional and national efforts, such as presentations at the Mid-Atlantic

Watermen's Show in Maryland and participation in collaborative efforts involving the Intracoastal Waterway.

Over the years, Sea Grant extension specialists have reached countless residents through workshops, personal contact, publications and interviews in the mass media. By providing accurate, relevant information to businesses, interest groups, agencies and consumers, Sea Grant has helped the state and nation to realize gains in both economic and environmental terms. New aquaculture businesses were initiated. Better and more profitable seafood processing operations were set in place. Lives have been saved by our rip current education efforts. Damage from coastal hazards has been reduced by our coastal construction research. Coastal resources were conserved as people learned more about their environment. Community needs and issues were presented to researchers.

Our extensive communications program pulls the public into ongoing extension efforts and shares the results of scientific research. The program's hallmark publication is *Coastwatch* magazine, which continues to win national awards for its writing style that brings cutting-edge marine science and complicated coastal policy debates into understandable terms. *Coastwatch*, which draws praise from researchers, legislators and the general public, reaches thousands with each of six issues published annually.

Communicators and extension specialists work together to produce newsletters for targeted audiences. Each has subscription list of more than 2,200. *WaterWise*, published quarterly, provides the latest information on coastal water quality issues. *Marine Extension News*, published quarterly, provides updates on a variety of Sea Grant extension projects. *Conch Shell*, published three times a year, provides classroom teachers and other educators with a variety of resources on coastal and marine topics. These newsletters will continue through 2004.

In recent years, the Internet has become increasingly important as an avenue to present important information to classroom students and teachers, community leaders and the general public. We already have general information on our program, including our strategic plan, available online. And we have provided listings of the FRG and blue crab research projects. In 2002, we will take time to review our presence on the World Wide Web. Our committee will include two members of the management team, two members of the extension staff and two members of our Outreach Advisory Board. Communicators will also participate in Web-related sessions at a national meeting of Sea Grant communicators.

Other communications projects include a variety of special products, from guidebooks or brochures to videos and media relations. Again, these products are the result of a team effort of communicators, extension specialists and partner agencies. For example, in 2002, the special projects will include:

- As coastal development interests move increasingly to estuarine areas, Sea Grant is leading an education effort regarding estuarine shorelines. With a grant from the N.C. Division of Coastal Management, Sea Grant has worked with NC State University College of Design to develop a guidebook series that focuses on shoreline erosion, shoreline stabilization options, landscape design and policy/planning issues. The guidebooks will be available in printed form and on the Web. Coordinated by marine educator Lundie Spence, the guidebook authors include Spencer Rogers and Walter Clark.
- North Carolina Sea Grant is considered an East Coast leader in rip current safety information, with its poster, video and brochure series. That effort has expanded through a partnership between Rogers and the National Weather Service, which resulted in daily rip current forecasts for North Carolina that are updated on the Web. In 2002, Sea

Grant and NWS will begin distribution of aluminum rip current signs that provide safety tips and the Web link.

Communicators respond to countless requests for information each year — and the demand continues to grow. Communicators also work extensively with the general media to spread news of Sea Grant efforts. For example, in Fall 2001, Sea Grant researcher Ed Noga's groundbreaking research on naturally occurring antibiotics found in fish was published in the highly respected journal *Nature*. Sea Grant communicator Ann Green worked with a variety of general media, including *The (Raleigh) News & Observer*, The North Carolina News Network and other state media. Green worked with Ben Sherman, Sea Grant's national media relations officer, to send the news to national and international publications, including Reuters health news service, *The Scientist* and *DVM* magazines. The news release appeared or was linked from more than 45 Web sites, including *noaa.gov* and *nationalgeographic.com*.

Education

Teaching teachers is a national priority for Sea Grant, and the North Carolina program continues to offer outstanding examples in this arena. Training programs include both those seeking education degrees and those now teaching in both formal classroom settings and more informal locations such as museums and parks.

Sea Grant marine education specialist Lundie Spence is chair-elect of the national network of Sea Grant educators and is active in the National Marine Educators Association. In recent years, Spence has developed Operation Pathfinder workshops for teachers. She also developed the first environmental education course in the UNC system. The course is taught through an innovative teleconferencing format that includes students at four campuses. And she is working with The Science House at N.C. State University to develop pilot curricula using NOAA/NESDIS satellite data.

Spence and Walter Clark, coastal law and policy specialist, also teach seminars on ocean policy and ocean frontiers for upperclassmen and graduate students at N.C. State University. The classes, offered through the university's Multidisciplinary Studies division, draw a mix of students, including future teachers, engineers, journalists and others who know and love the coast.

Training of Scientists, Engineers and Resource Managers

North Carolina Sea Grant uses a variety of avenues to reach this goal, including:

- Developing a means of technology transfer via the availability of well-trained graduate students and extension personnel.
- Providing opportunities to train the best graduate students, thus producing future researchers, problem-solvers and teachers.

In each funding cycle, Sea Grant funds research by some of the best and brightest university faculty members in the state. In turn, those faculty members incorporate outstanding graduate students — and in some cases undergraduates — in this high quality, cutting-edge research. These students are then well prepared and trained to take the latest technology and theories into practice in the private and public sectors of the U.S. economy. North Carolina Sea Grant takes several avenues toward this goal:

- Each year we provide stipends for graduate students working on Sea Grant research projects. In the 2002-2004 funding cycle, we expect to provide stipends for 16 students each year. Most of those students also receive tuition and health insurance.
- Sea Grant also suggests promising graduate students as partners with members of the fishing communities who propose projects in the Fishery Resource Grant

Program and the Blue Crab Research Program. The programs give the students contact with the “real world” fisheries issues, while also ensuring the scientific validity of the research projects.

- Since 1985, North Carolina Sea Grant has sent 32 outstanding graduate students to Washington, D.C., as part of the Knauss Marine Policy Fellowship Program. These students put their scientific background to work in various areas of the legislative and executive branches of the U. S. government. Our Knauss alumni continue to provide critical input as science and policy are brought together at the local, state and federal levels. North Carolina Sea Grant plans to develop a directory of these former fellows. In 2002, our fellows are both from Duke University. Angela Corridore will serve on the staff of the U.S. Commission on Ocean Policy and Jeremy Potter will spend his year in NOAA’s Office of Ocean Exploration. Walter Clark will continue to coordinate our support of the Knauss program.

- North Carolina Sea Grant encourages applications for other national fellowship opportunities, such as the Coastal Services Center program, an industrial fellows program and a national fisheries fellowship. In 2002, North Carolina fellows included Charlene Couch, who is doing aquaculture research with Craig Sullivan of N.C. State University, and Maria Ruilova-Duval, who is continuing seafood technology research with Tyre Lanier of N.C. State University.

- In addition, North Carolina Sea Grant initiated its own fellowship program in coastal community development. Working with the N.C. Division of Coastal Management (DCM) and using the Knauss program as a model, the new fellowship developed using discretionary funds targeted for coastal communities. In Fall 2001, Audra Lescher, a graduate student at UNC-Wilmington, started her fellowship that will include a project to evaluate the impact of rising sea level on estuarine shorelines. In the partnership, Sea Grant will provide the stipend and DCM will provide housing and other resources necessary for the fellow to complete the selected project. A committee consisting of Sea Grant and DCM personnel will select a project each year prior to advertising for and selecting the fellow. This fellowship will be on a trial basis for three years.

- A similar fellowship opportunity, jointly funded by the N.C. Division of Marine Fisheries (DMF) and Sea Grant, will debut in 2002. The fellow will work on marine fisheries projects selected by Sea Grant and DMF personnel. Each agency will provide half the stipend support. Jeffrey Buckel, an N.C. State University faculty member located at the Center for Marine Science and Technology in Morehead City, will coordinate this new fellowship. The DMF office is located in the same coastal office complex.