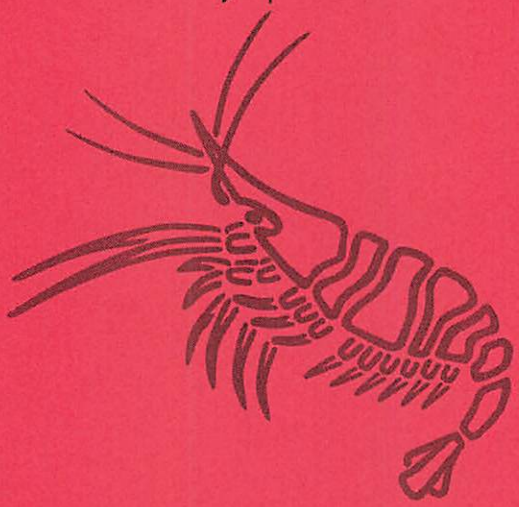
Fishery Resource Grant Program

- Fisheries Equipment & Gear
- Seafood Technology
- Aquaculture & Mariculture
- Environmental Pilot Studies



Selected Impacts

North Carolina Sea Grant
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Fishery Resource Grant Program

Selected Impacts 2006

The word is getting out about the Fishery Resource Grant Program, known across the North Carolina coast as FRG.

"The FRG program provides a unique opportunity for all fishers to be involved in research activities that directly affect their livelihoods," says Ronald G. Hodson, director of North Carolina Sea Grant. The FRG program is funded by the N.C. General Assembly and administered by North Carolina Sea Grant.

The value of the program to fisheries resources grows with time as more information is accumulated, according to Hodson.

"Since the program's inception, FRG projects have expanded seafood businesses, created new seafood markets, improved aquaculture practices, provided more accurate data for fishery management plans, improved coastal habitats, and provided educational opportunities at high school and college levels," he adds.

Data generated from these projects are increasingly sought after by those in the fishing and research communities, according to fisheries specialists working for North Carolina Sea Grant. Although North Carolina Sea Grant has responded to requests from across the United States for FRG final reports, the reports have the biggest impact here in North Carolina. Many go to agencies such as the N.C. Division of Marine Fisheries (DMF) and the N.C. Marine Fisheries Commission, which develop N.C. Fishery Management Plans.

Each year, North Carolina Sea Grant seeks public input on priorities to be addressed within four FRG funding categories: Aquaculture and Mariculture, Environmental Pilot Studies, Fisheries Equipment and Gear, and Seafood Technology.

North Carolina Sea Grant also spreads the news about the FRG program — from the application process to significant results — through news releases, participation at public events, and through various publications, such as Sea Grant's *Coastwatch* magazine and *Marine Extension News*. Many of these items are written by the North Carolina Sea Grant Science Communications Fellow, a position funded in part by FRG.

Public interest in FRG is evident from the media coverage it has received over the last year. Many coastal newspapers routinely feature announcements about the FRG program, and research and results from the program were also featured in many news articles during 2005. This year, FRG studies were featured in several mainstream media outlets across the state, including the *Sun Journal,* the *Jacksonville Daily News,* the *Sunday Star News and* the *News and Observer.*

In March 2006, several successful FRG projects will be featured at the N.C. Fisheries Forum cosponsored by the N.C. Division of Marine Fisheries, N.C. Marine Fisheries Commission and North Carolina Sea Grant.

This booklet describes the impacts to the state and its economy from a selection of FRG projects that have been completed in recent years.

Aquaculture and Mariculture

Aquaculture/Mariculture projects deal with the culture of animals as diverse as oysters, clams, baitfish, food fish and soft-shell crabs. Collectively, these studies contribute to the body of knowledge guiding aquaculture development in North Carolina.

Perhaps of more importance, the FRG program gives aquaculturists a mechanism for trying new techniques and equipment at minimal personal financial risk, and provides the acquired information to others who are interested. In fact, the Aquaculture Development Conference, which is held each winter and cosponsored by North Carolina Sea Grant and the N.C. Cooperative Extension Service, routinely features presentations by FRG recipients. This has proven to be an effective means of communicating results to interested persons.

Black Sea Bass

- **04-AM-03** *Optimizing Hatchery and Nursery Technologies for Production of Black Sea Bass Fingerlings for Pilot Commercial Growout Projects*

- **03-AM-05** *Advancing Black Sea Bass Aquaculture in North Carolina: Developing Growout Technologies for Hatchery-Reared Fingerlings and Intensifying On-Growing of Captive Wild Stock in Recirculating Tank Systems*

- **00-AM-05** *Growth and Feed Utilization of Captive Wild-Caught Black Sea Bass (*Centropristis striata*) Stocked at Four Different Densities in a Recirculating Tank System*

- **98-AM-19** *Growth and Feed Utilization of Wild-Caught Juvenile Black Sea Bass (*Centropristis striata*) Fed Practical Diets in a Recirculating Tank System Under a Semi-Controlled Temperature Regime*

These projects developed proper diet formulations for growing black sea bass as well as techniques for growing these fish in semi-closed recirculating tank systems. Results from these projects are the first steps toward making commercial culture of this species possible in North Carolina.

Careers in Aquaculture

- **01-AM-09** *Apprentice Program and Training for Career Aquaculturists*

Researchers behind project 01-AM-09 developed a training and apprentice program at Carteret Community College (CCC). Students in the program helped produce some 150,000 seed clams, which are distributed to industry partners. Students also worked as apprentices and gained hands-on experience with industry partners. Although the project is complete, the apprentice program has continued and with other funding, now has a dedicated building on the CCC campus.

Clams

- **02-AM-04** *Investigation of the Effect of Sediment Type on the Growth and Survival of Seed Clams Using Soft-Tented Bags and Mesh Covered Bottom Beds*

- **98-AM-02** *More Profits for Clam Farmers by Using an In-Water Nursery System*

- **98-AM-10** *Hard Clam Growth and Survivorship: The Effect of Initial Clam Seed Size in Tented Soft Bags and a Comparison Between Beds and Tented Soft Bags*

These projects developed an alternative to land-based shellfish nurseries. Instead of raceways on land, "nursery bags" are used in the marine environment to produce larger, more predator-resistant seeds for planting on leases.

Clams harvested by these methods relieve some pressure on the wild stock fisheries.

Flounder

- **01-AM-08** *Grow-Out Performance of Hatchery-Reared Summer Flounder (*Paralichthys dentatus*) and Southern Flounder (*P. lethostigma*) Fingerlings in Low- and High-Salinity Recirculating Tank Systems and an Analysis of their Premium Markets*

- **00-AM-04** *Development of a Grow-Out System for Wild-Caught Southern Flounder*

- **97-AM-09** *Development of a Holding and Grow-Out System for Off-Season Sale of Value-Added Flounder*

These projects investigated various aspects of flounder culture, including holding and growing out wild-caught fish, and developing techniques to spawn fish and produce juveniles. Collectively, the projects bring the possibility of commercial flounder culture closer to fruition.

During projects that involved growing out wild fish, control methods for fish louse were developed that help improve the holding of broodstock. This means broodstock fish can be kept in better condition, thus improving spawning. Fishers who provided live fish for the wild fish grow-out project (00-AM-04) received about $1 per pound more than those selling to traditional markets do.

The spawning techniques developed during these projects resulted in the building of a grow-out facility at Lake Wheeler, located near North Carolina State University's main campus in Raleigh, N.C. Approximately 50,000 juveniles are produced annually and experimental grow out of these fish has begun at the Lake Wheeler facility.

Researchers in Wilmington and in South Carolina are also beginning to grow out fish, and many believe commercial culture is probably only a few years away. Southern States Cooperative has augmented these studies with $80,000 and the Golden Leaf Foundation has added $70,000. Sea Grant is beginning to receive inquiries from private individuals interested in the potential for commercial culture of flounder.

In early 2006, FRG researchers will host a series of workshops for people involved in, or interested in becoming involved in flounder culture operations.

Hybrid Striped Bass

- **02-AM-03** *Compensatory Growth: Increasing Production Efficiency of Hybrid Striped Bass Culture*

Results from this study indicate that: 1) hybrid striped bass can undergo compensatory growth (CG) following periods of subsistence feeding; 2) the CG response is accompanied by improved growth rates, hyperphagia and feed efficiency; and 3) IGF-I, a critical regulator of growth in fish, may serve as a valuable instantaneous biomarker of growth in hybrid striped bass needed to optimize feeding parameters.

This can benefit producers by reducing labor and time with minimum impact in the production efficiency of market-sized fish. Cycled feeding may also improve water quality and mitigate some of the risks farmers face with phytoplankton blooms, oxygen depletion and potential fish losses associated with high nutrient loads. These findings about compensatory growth also raise the possibility that farmers may delay the time when fish are marketed, increasing the flexibility of their marketing strategies and overall capacity for year-round production.

- **02-AM-11** *Development of a Novel Test to Monitor the Health of Hybrid Bass*

This study developed a method to test the concentration of histone-like protein-1 (HLP-1), a naturally produced antibiotic, in the tissue of hybrid striped bass. Repeated measurements indicate that chronic stresses, such as cool temperatures and poor nutrition, lead to a decrease in HLP-1 levels.

Periodic testing of HLP-1 levels will allow hybrid striped bass farmers to monitor the health level of the stock.

Proper use of the test is still being developed, however the test has already generated much interest within the aquaculture community.

Marine Finfish

- **98-AM-25** Codifying Marine Finfish Aquaculture in North Carolina

This project was used in developing the current regulations for aquaculture operations in North Carolina.

Oysters

- **99-AM-14** *Demonstrated On-Bottom Oyster Grow-Out Method Using Remotely Set Seeded Cultch*

- **98-AM-03** *Remote Setting to Produce Single 30-mm Seed Oysters for Off-Bottom Culture*

These projects developed and implemented techniques for remote setting of oyster larvae. The methods proved so successful that North Carolina extension staff now recommends remote

setting as a preferred way to produce seed. Using these techniques, shellfish growers Jim and Bonnie Swartzenberg (98-AM-03) continue to successfully produce oyster seed for their own shellfish lease and to sell to others. In addition, several private operations in North Carolina have started using these methods commercially.

The results from these projects also have helped the N.C. Division of Marine Fisheries (DMF) streamline and improve permitting procedures for importing seed — especially eyed larvae — from other states for planting on North Carolina leases. The DMF is also considering testing remote setting in their oyster reef/shell planting program.

As a result of project 98-AM-03, an interactive CD and a print manual were produced. The video and manual describe: how to set a site and nursery area; how to build and set up equipment; and how to order, handle and evaluate larvae. The manual also includes checklists for inventory selection and oyster setting, as well as a list of sources for supplies. Several manuals and videos have been distributed to two area community colleges, Dixon High School, DMF and North Carolina Sea Grant. These products were also featured at the 2005 Aquaculture Conference in Atlantic Beach, N.C., and at the 2005 Oyster Summit in Raleigh, N.C.

A second video featuring several successful FRG-funded oyster projects has been produced by North Carolina Sea Grant.

Yellow Perch

- **03-AM-02** *Accelerated Growth and Domestication of Yellow Perch*

The success of the yellow perch *Perca flavescens* aquaculture industry will likely depend on increasing growth efficiency to reduce production costs and increasing fingerling availability for year-round production. Through this study, researchers developed recommendations for achieving uniform growth between the sexes, increasing the proportion of market-size fish, and proper cold-banking methods to prolong out-of-season finglerling availability and stagger harvest times for market-size fish.

Fisheries Equipment and Gear

Projects in this category include: studies of gear selectivity for various species; methods of reducing bycatch in certain fisheries; development of new and improved types of gear; and the compilation of information for use in fishery management decision-making. In studies producing data for fishery management, fishers are given an avenue through which they become actual participants in the decision-making process.

The N.C. Commercial Fishing Show was discontinued after 2004. North Carolina Sea Grant organized seminars at the show in cooperation with the show sponsors for several years. FRG researchers often used this show as an outlet for presenting results of their projects.

North Carolina Sea Grant is working with the Division of Marine Fisheries to develop a Fisheries Forum that will provide an alternate venue for researchers to present their findings. The first Fisheries Forum will be held on March 14, 2006 in New Bern, N.C. Several FRG researchers are expected to participate in both oral and poster presentations.

North Carolina Sea Grant routinely provides final reports from projects to the N.C. Division of Marine Fisheries, federal fisheries advisory panels, and individuals who request copies. Many final reports are now posted in .pdf format online at *www.ncseagrant.org*. Follow the research links to the FRG pages.

Bycatch Reduction

- **04-FEG-08** *Bycatch, Discard Composition and Fate in the Snapper/Grouper Commercial Fishery, North Carolina*

The snapper/grouper complex is a heavily-exploited fishery in the South Atlantic. There is concern that minimum size limits do not adequately protect undersized fish from trauma sustained from being angled in the South Atlantic Bight deep waters; and that many small fish do not survive catch-and-release practices.

This study examined discard percentages documented hooking location, barotraumas, and presence of bleeding and post-release indices to evaluate the effectiveness of minimum size limits in protecting the stock.

While released reef fishes may experience delayed post-release mortality from predation of barotraumas, the mostly favorable release outcomes found in this study suggest that minimum size limits do help to reduce fishing mortality for some species over depths common in the North Carolina reef fishery. Researchers believe this information will be useful to the South Atlantic Fishery Management Council to defend current and proposed minimum sizes in the snapper/grouper fishery in North Carolina and other southeastern states.

- **03-FEG-10** *Reducing Mortality of Undersize Groupers (Gag and Reds) and Bycatch of Non-Targeted Species by Varying Hook Size and Style*

This project demonstrated that both the commercial and recreational grouper fishery can use "circle" type hooks instead of larger than traditional "J" style hooks to reduce the take of undersized fish without significantly reducing the targeted catch. The finding may have

management implications — hook sizes could be regulated in order to reduce bycatch and undersized fish mortality in the state's grouper fishery.

Information from this project was also used in a North Carolina Sea Grant "Blueprint" publication that has been offered at recreational boat and fishing shows.

- **02-FEG-05** *Habitat Use of Sea Turtles in Relation to Fisheries Interactions*

This project attached satellite tags to sea turtles and monitored their movements within an area of Pamlico Sound currently closed to gillnetting. The results help shed light on the movements of turtles into, within, and out of Pamlico Sound. This information can help fisheries managers better define areas that should remain closed to gillnet fishing and those that might be reopened.

In addition, data presented in this report both corroborate and dispel various hypotheses regarding sea turtle life history and behavior. One particularly interesting finding involves migration routes for juvenile turtles. Researchers expected tagged juvenile turtles to migrate south to warmer waters after leaving North Carolina, but instead they exhibited three different migratory strategies: some migrated south to the Georgia or Florida coast, some headed to North Carolina coastal waters, and still others moved long distances into the North Atlantic by way of the Gulf Stream. Until now, transport in the Gulf Stream and residency in the North Atlantic has been documented for hatchlings and small juveniles, but large juveniles were believed to undergo an ontogenetic habitat shift into coastal waters.

This project received international attention when it was included in a presentation at the 2004 American Association for the Advancement of Science (AAAS) meeting. The study was cited as an example of research that will be used in a Global Census of Marine Life.

Results were also presented at the 2005 Sea Turtle Symposium by the PhD. student working on the project. The student received the Archie Carr award for best student presentation at the symposium, which is the most important global meeting of sea turtle biologists and managers.

- **02-FEG-01** *Evaluation of Large-Mesh Recreational/Commercial Gear License (RCGL) Use in Southeastern North Carolina*

- **02-FEG-13** *Large Mesh Gillnet Bycatch Potential, Discard, and Mortality of Red Drum*

- **02-FEG-18** *What Effect Does Setting a Flounder Net Close to the Marsh Have on the Incidental Bycatch of Red Drum*

- **00-FEG-14** *Gillnet Bycatch Potential, Discard Mortality and Condition of Red Drum (*Sciaenops ocellatus*) in Southeastern North Carolina*

These projects examined different aspects of using large-mesh gillnets to catch flounder in North Carolina. One project in particular, 02-FEG-13, addressed the practice on the Newport River where there was a conflict between the flounder gillnet fishery and recreational drum fishery. The recreational anglers contended that netters catch an excessive amount of red drum as bycatch in flounder nets. Results from the project period indicate that the bycatch of red drum in the Newport River is not excessive. Thus, the results helped the N.C. Division of Marine Fisheries (DMF) manage this conflict.

- **02-FEG-21** *Use of TEDs in Crab Trawl Fishery*

This project determined the impact of trawl nets equipped with turtle excluder devices (TEDs) on crab catch. There has been some discussion among fishery managers about requiring TEDs in crab trawls, and the project results are relevant to making this decision. Data indicated that such a requirement would devastate the crab trawl fishery. To date, the National Marine Fisheries Service (NOAA Fisheries) has not required use of TEDs in crab trawls.

- **01-FEG-15** *Catch Comparison of Three Gillnet Designs in the North Carolina Flounder Gillnet Fishery*

This study compared flounder catch rates to bycatch using three types of gillnet, one of which uses no corkline. In terms of reducing bycatch and maintaining acceptable flounder catch, the nets without corkline worked better than the other two types. The N.C. Division of Marine Fisheries (DMF) is planning to conduct further tests on a variation of this net in an area of Pamlico Sound that has been closed to flounder gillnets because of sea turtle bycatch. This gear could provide a means of reducing or eliminating turtle takes, thus keeping the fishery open.

- **01-FEG-11** *Alternative Flounder Nets*

Because of several sea turtle strandings that occurred during the flounder gillnet fishery season (September through November), the National Marine Fisheries Service (NOAA Fisheries) closed an area adjacent to Hatteras and Ocracoke in Pamlico Sound to large mesh flounder gillnets. This project sought to develop fyke nets as alternative gear that would catch flounder but eliminate turtle mortality.

Results indicated that the fyke nets did not catch flounder successfully, but a concurrent collaborative study with principal investigators and staff from the N.C. Division of Marine Fisheries examined alternative configuration of gillnets. The work resulted in a reconfigured gillnet that may allow the flounder gillnet fishery to resume operation in the area.

- **99-FEG-36** *Bycatch Comparison of Flounder Gillnets Utilizing Different Denier Webbing*

This project compared catch rates of flounder gillnets using different diameters of monofilament webbing. The results showed little difference in catch rate of flounder for the different sizes. This means that fishers can use the larger diameter, heavier webbing (which holds up much better than lighter webbing) with no reduction in catch.

- **98-FEG-23** *Bycatch Reduction Device Certification Program*

- **97-FEG-40** *Certification of BRDs for North Carolina Waters*

The N.C. Division of Marine Fisheries (DMF) and the National Marine Fisheries Service (NOAA Fisheries) have required the use of bycatch reduction devices (BRDs) in shrimp trawls

for many years. When the requirement was initiated, many devices were developed that claimed to effectively reduce bycatch. At the time, the DMF lacked resources to test these products.

In the above projects, students in the Marine Vocations Class at Pamlico High School tested many of these devices using a protocol developed by the DMF. All students were under supervision of their instructor. Besides being a cost-effective solution for the DMF, the projects provided students — many who came from fishing families — with the opportunity to help shape fisheries regulations they will likely face in the future.

Conch

- **02-FEG-17** *Viability of a Conch Fishery in Southeast North Carolina*

Along the East Coast of the United States, conch pot fishing has emerged as an alternative to traditional target fisheries. The conch pot fisheries predominately capture channeled whelk (*Busycotypus canaliculatus*) using wooden pots.

Recently in southeast North Carolina, there has been interest in initiating a conch pot fishery, especially during the winter months when other fisheries are less active. Blue crab, the most common bycatch species captured in the pots, is marketable resources. A winter conch fishery could provide income for fishermen during their slowest months.

Reducing Marine Mammal Entanglements and Bycatch

- **04-FEG-04** *Will acoustic deterrents reduce depredation by bottlenose dolphins in the Spanish mackerel Gillnet Fishery?*

- **03-FEG-13** *Interactions Between Bottlenose Dolphins and the Spanish mackerel Gillnet Fishery in North Carolina*

These projects made several important conclusions regarding the behavior of dolphins around commercial gillnets. From observations aboard commercial vessels, it was determined that dolphins encountered nets frequently and interacted with commercial fishing gear in a variety of ways, including diverting around the net to avoid it, patrolling along the length of the net, engaging in depredation, and occasionally begging for fish from the commercial vessels. Researchers observed a significant reduction in the catch of Spanish mackerel and other commercially valuable species when dolphins interacted with the nets. These interactions may have important economic costs for fishers.

Given these findings, researchers proposed a potentially effective tool for mitigation and management: the use of sound makers, or acoustic alarms, that produce sounds within the hearing range of dolphins but above the upper auditory threshold of Spanish mackerel. These devices did not impact the catch per unit effort of Spanish mackerel. The effect on dolphin behavior is still be analyzed.

- **00-FEG-24** *Will Pingers Reduce By-catch of Bottlenose Dolphin in N.C. Gillnet Fisheries?*

Results from this study indicate that pingers are not likely to help reduce bottlenose dolphin bycatch in North Carolina's gillnet fisheries. Pingers have been shown effective in reducing bycatch of harbor porpoises in the Gulf of Maine, but the devices do not appear to deter bottlenose dolphins from approaching gillnets. In fact, pingers may actually have the reverse effect — they may alert the dolphins to the fishers' catch, a potential source of food. With this information, fisheries managers in North Carolina can focus their future efforts on developing new techniques and gear to reduce bottlenose dolphin bycatch.

- **98-FEG-54** *Whale Disentanglement Program for the Cape Hatteras Region*

FRG funding for this project provided training for volunteers regarding the proper and safe techniques for disentangling marine mammals that become caught in fishing nets. It also provided an equipment cache (housed at the Oregon Inlet Coast Guard Station) and a portable first response kit (housed at the Duke University Marine Lab in Beaufort) for use in freeing trapped whales.

Soon after the start of the project, a juvenile humpback whale became entangled in a net in the Cape Lookout Area and project personnel were able to free it. In numerous other cases, the North Carolina team has been on alert when fishers or other boaters have spotted entangled marine mammals. If team members are able to locate the animal, they make every attempt to free it after assessing the safety and feasibility of the current situation. In some cases, they are able to attach satellite buoys to the nets so that the animal can be tracked until a more appropriate time for the disentanglement process.

The project not only allows a means to save whales caught in nets, but also has lessened the need for more federal restrictions in North Carolina.

This was the first such response center to be located outside Massachusetts — the first state to develop this capability. Disentanglement is now an integral part of the Large Whale Take Reduction Plan. The disentanglement capability in North Carolina allows fishers to keep fishing while gear modifications and changes in fishing practices are being developed to reduce entanglements.

Spiny Dogfish

- **99-FEG-47** *Determination of Gillnet Bycatch Potential for the Spiny Dogfish (*Squalus acanthias*) in Southeastern North Carolina*

- **98-FEG-28** *Characterization of the Spiny Dogfish Population South of Cape Hatteras for Potential Commercial Harvest and Management Plan Development*

- **98-FEG-29** *Biological Information on the Northern District Spiny Dogfish Fishery Needed for a Fishery Management Plan*

- **97-FEG-28** *Biological and Social Characterization of the North Carolina Spiny Dogfish Fishery*

The Atlantic States Marine Fisheries Commission (ASMFC) is using findings from these projects to develop management plans for the dogfish fishery. North Carolina fishers have traditionally operated in this fishery during the winter, but several years ago ASMFC issued an emergency closure because of concerns the fishery was depleting dogfish stocks from New England to North Carolina. The ASMFC developed a quota landing system for East Coast dogfish stocks that limited annual landings of dogfish.

This presents a significant obstacle for North Carolina: by the time dogfish season begins in our state the quota has already been reached by states to our north. Data from the studies listed above are intended to help managers develop a plan for dogfish and develop equitable regulations by the ASMFC.

Snapper/Grouper Complex

- **03-FEG-21** *Release Mortality of Undersized Red and Vermillion Snapper and Red Porgy Caught in the North Carolina Hook and Line Fishery.*

The snapper/grouper complex in North Carolina consists of approximately 75 species of commercially and recreationally important fish. Each fishery is regulated by minimum size limits. Regulations that increase the minimum size would likely increase the probability of catching undersized fish which may lead to increased release mortality. This project examined the effect of hooking on undersized gag grouper, red porgy and scamp.

Results of the study suggest that hook-and-release mortality should be considered in future stock assessments of reef fish. Estimates of short- and long-term, post-release mortality are necessary to improve fishing mortality estimates used in stock assessment models, assisting fisheries managers in developing appropriate daily catch and size limit regulations, and to develop an awareness of the role of anglers in the conservation of fish stocks.

- **04-FEG-08** *Bycatch, Discard Composition and Fate in the Snapper/Grouper Commercial Fishery, North Carolina*

- **03-FEG-10** *Reducing Mortality of Undersize Groupers (Gag and Reds) and Bycatch of Non-Targeted Species by Varying Hook Size and Style*

These studies deal with bycatch in the snapper/grouper fishery and are summarized in the earlier section on Bycatch Reduction. (See p. 8.)

Blue Crabs

Since 2001, additional research on blue crabs has been funded through the N.C. Blue Crab Research Program.

- **98-FEG-08** *Development of Two Simple Devices to Increase the Accuracy of Catch-Per-Unit-Effort Data*

- **98-FEG-10** *Crab Trawl Tailbag Testing*

- **97-FEG-33** *North Carolina Blue Crab Harvest Data Collection*

These projects have provided fishery-dependent data to the N.C. Division of Marine Fisheries (DMF). This data has helped the DMF develop effort-control strategies, socioeconomic information for characterization of the fishery, and verification of fishing trip ticket information. DMF has used information from these projects in the development of the Blue Crab Fishery Management Plan, approved by the Marine Fisheries Commission in 2004. More specifically, the projects listed above provided a means of verifying catch-per-unit effort data and helped to establish the suggested size for trawl tail-bags in the crab trawl fishery.

Blue Crab Sanctuaries in North Carolina

- **01-EP-06** *Tagging of Adult Female Blue Crabs to Study Migration Toward and Use of Spawning Sanctuaries*

- **99-FEG-31** *Mapping of Geographic Features and Their Attributes and Marking of Hazards in and Between the Ocracoke and Hatteras Inlet Blue Crab Sanctuaries*

Information derived from these projects could help the N.C. Division of Marine Fisheries (DMF) to change the designated crab spawning sanctuaries from the old static boundary to a more dynamic boundary based on salinity. The boundaries could be contracted in times of high rainfall, and expanded in dry, high-salinity times.

The digital mapping of the Ocracoke/Hatteras sanctuaries (01-EP-06) occurred before Hurricane Floyd. Because this hurricane dramatically affected the physiography of the area, this project provides baseline data for researchers to measure changes due to the hurricane. In fact, the principal investigator in the mapping project has been contracted by the DMF to map those changes.

In addition, data from the mapping study was used in the Red Drum Fishery Management Plan to determine areas where certain fishing gear would be prohibited in order to protect juvenile red drum. Finally, a research ecologist cited data from the project to make recommendations for areas in which clam kicking should be prohibited.

Blue Crab Dynamics and Stock Assessment

- **00-FEG-11** *Population Dynamics and Stock Assessment of the Blue Crab in North Carolina*

- **99-FEG-10** *Stock Assessment of the Blue Crab in North Carolina*

These studies provided vital information on the status of the state's blue crab stocks. The N.C. Division of Marine Fisheries (DMF) has used data from the projects to develop and refine the Blue Crab Fishery Management Plan, particularly as it relates to allowable amounts of crab harvests. Several of the management recommendations in the plan, approved by the Marine Fisheries Commission in 2004, were based on results from this work.

Soft-Shell Crab Industry

- **01-FEG-03** *Blue Crab Mortality in North Carolina's Soft-Shell Industry: Biological and Operational Effects*

This project determined the main causes of mortality in soft crab production systems. Based on the results, some producers have changed the way they handle peeler crabs and sources of supply. Ultimately, these producers have lowered mortality in their systems and increased production of soft crabs.

Bycatch in Crab Pots

- **99-FEG-45** *Bycatch in the Crab Pot Fishery*

This project identified and quantified the major species components of bycatch in the crab pot fishery. The information has been used to develop and refine the state's Blue Crab Fishery Management Plan, as well as the Flounder Fishery Management Plan. Results from the study indicate that finfish bycatch in crab pots was not excessive. In addition, the project established a maximum sustainable yield figure for the fishery.

Environmental Pilot Studies

Environmental Pilot Studies examine the effects of natural events and human activities on various habitats, perform assessments of stocks of various species, study incidence of fish diseases, develop water quality monitoring prototypes and provide various educational opportunities.

Bay Scallops

- **03-EP-02** *Bay Scallop — Cownose Ray Interactions*

Historically, the harvest of bay scallops, *Argopecten irradians*, provided an important fishery resource in the central areas of North Carolina sounds and bays. The annual harvest of bay scallop usually occurs in December and January, providing a source of revenue for fishers during a period when harvests of other species are at a low. However, in recent years, landings of bay scallops have decreased from nearly 30,000 pounds of meat in 1999 to less than 150 pounds in 2004 and no landings in 2005.

Results of this study provided convincing evidence that the high mortality of bay scallops in the summer is caused by cownose rays (*Rhinpotera bonasus*). Further, the data suggest that cownose rays are choosing seagrass beds with high densities of bay scallops to feed. This observation has significant implication for bay scallop restoration. Bay scallop densities that are too low will likely result in low fertilization success because bay scallops are broadcast spawners. However, the project data suggest that densities that are too high will likely attract cownose rays, leading to high predation and mortality. Future efforts to restore the bay scallop fishery must include plans to manage around cownose ray predation.

Results of the study will be used in developing the Bay Scallop Fishery Management Plan, currently in the early stages of development by the N.C. Division of Marine Fisheries.

Bottlenose Dolphin Populations

- **00-EP-02** *Mark and Recapture Survey of Bottlenose Dolphins in the Bays and Sounds of North Carolina*

This was the first mark and recapture survey of bottlenose dolphins conducted for North Carolina's estuarine waters. Results established a population estimate of 1,154 bottlenose dolphins. This estimate is almost half of the minimum population size of 2,482 coastal bottlenose dolphins from central Florida to New Jersey that had been used in stock assessments by the National Marine Fisheries Service (NOAA Fisheries).

Based on their previous estimate, NOAA Fisheries originally set the Potential Biological Removal (PBR) at 0 for bottlenose dolphins, meaning that if any dolphins died from entanglement in fishing gear, fisheries would be closed. As a result of this study, the PBR was adjusted upward. In addition, results from this study are also helping NOAA Fisheries reassess its estimate of the bottlenose dolphin population, which likely will affect the PBR further.

Finally, the abundance estimates produced by this project were incorporated into the Bottlenose Dolphin Take Reduction Plan. These estimates highlighted the inadequacy of previous estimates in other areas, and have become the accepted estimates for all areas along the Eastern Seaboard. Because the allowable take of bottlenose dolphins depends directly on the

population estimates, results from this study have helped reduce the burden placed on North Carolina fishers by the take reduction plan.

Dolphin Fish

- **02-EP-01** *Age, Growth, and Reproduction of Dolphin (*Coryphaena hippurus*) Caught in North Carolina Waters*

This study provides an updated age-length function for dolphin fish caught off the coast of North Carolina using both scale annual and daily growth increments. It also provides some of the first comprehensive data on their reproduction in North Carolina. Such data will be useful to stock assessment modelers that require age and growth information to determine future sustainable fishing mortality rates for dolphin fish stocks.

Oysters

- **05-EP-02, 03-EP-03** *Using Winslow's 1886 Pamlico Sound Oyster Bed Survey and GIS to Guide Future Restoration Programs*

These projects used modern GIS tools, GPS mapping and sidescan sonar to investigate the Winslow oyster bed survey of North Carolina conducted in 1886. The project assumed that areas where oysters existed in the past, have nearby spawning stock and that are environmentally similar to existing beds would be good places to try to restore oyster beds. Restoration is expensive, so prioritizing potential restoration sites to select those most likely to succeed reduces costly mistakes.

The data gathered by these projects have been converted into "bex script" shapefiles for GPS systems. This allows researchers to click on any former bed position and have the latitude and longitude of the bed loaded onto a handheld GPS unit to be used in navigating to the site for field investigation.

The N.C. Division of Marine Fisheries used information from the projects in considering the site for an oyster sanctuary in the Neuse River area. In the future, the Winslow data will be used in the Coastal Habitat Protection Plan as a guide to restoring former oyster habitat areas in North Carolina.

The results of these projects have also been presented at several oyster conferences in North and South Carolina.

Shrimp

- **04-EP-01** *An Assessment of the Bycatch Generated in the Shrimp Fishery in the Inland Waters of Southeast North Carolina*

Commercial trawling in inland waters supports a lucrative shrimp fishery for the state. There is much controversy surrounding the fishery however, due to the suspected high percentage of bycatch and discard of other commercially and recreationally important species. Researchers were interested in estimating the proportion of bycatch to shrimp caught at different times during the season. Also of interest was the survivability of species returned to the water after being caught in a trawl net.

The results of this study are being used by the N.C. Division of Marine Fisheries in developing the new Shrimp Fishery Management Plan.

Striped Bass

- **00-EP-14** *The Seasonal Food Habits of Striped Bass (*Morone saxatillis) *in the Albemarle Sound*

This project provides important life history information for striped bass within North Carolina waters. The study focused on seasonal food habits of the species, once believed to be opportunistic feeders. Prey availability estimates from the study indicated that striped bass are in fact more likely to be selective feeders.

Trawling

- **01-EP-04** *Potential Impacts of Bottom Trawling on Water Column Productivity and Sediment Transport Processes*

The disturbance of sediment, both by wind and trawling can degrade water quality by increasing nutrient concentrations within the water column. This study compared the amount of resuspension caused by natural and trawling-induced disturbances in a shallow-water estuarine system. Categorizing disturbances into natural versus anthropogenic causes provides a means of directly assessing human impacts.

Results indicated that wind stress more effectively mixed the water column than did trawling. The most consistent impact of trawling was a 1.5 to 3-fold increase in total suspended solids found in the water column and only minor impacts on nutrient and *chlorophyll a* concentrations.

Assessing the impacts of trawling is important because previous studies have suggested that trawling may lead to loss of target and nontarget species of shellfish and finfish and alteration of bottom habitat.

- **99-EP-07** *The Role of Trawl Discards in Sustaining Blue Crab Fishery Production*

This project demonstrates that discards from the trawl fisheries, particularly the shrimp fishery, are unintentionally augmenting food supplies for blue crabs. Results from field experiments and onboard monitoring showed that birds and blue crabs were the primary scavengers on the discards. In addition, laboratory experiments revealed a preference by blue crabs for discards over their typical benthic invertebrate prey. These results have implications for the pending fishery management plans dealing with trawl fisheries such as the shrimp management plan under development by the N.C. Division of Marine Fisheries.

- **98-EP-21** *Shrimp and Crab Trawling Impacts on Estuarine Soft-Bottom Organisms*

This project addressed questions about the possible impacts of trawling for crabs and shrimp in North Carolina estuaries on populations of organisms living on soft-bottom habitats. Researchers sampled several estuarine locations both before and after experimental trawling. They also sampled areas actively trawled and areas closed to trawling. Finally, researchers sampled during a two-year period to address seasonal and interannual effects.

Researchers concluded that there is little evidence of direct negative impacts of trawling activity on these soft-bottom organisms. However, there are differences between trawled and non-trawled habitats that merit further investigation, especially regarding intensity and frequency of trawling efforts. Researchers noted that seasonal differences were more noticeable than other differences. This type of information, regarding the direct, immediate and long-term effects of trawling on fish habitat, helped in the development of the state's new Coastal Habitat Protection Plan.

Seafood Technology

This category includes projects with commercial applications including the development of new products and processing techniques, evaluation of sanitizing agents and a video perspective of the North Carolina Blue Crab Industry.

Safety Processes

- **00-ST-02** *Methods to Improve the Monitoring of the Crabmeat Picking/Packing Critical Control Point in Accordance with the HACCP (Hazard Analysis and Critical Control Point) Regulation*

- **97-ST-02** *HACCP Program Assistance for Small Seafood Processors and Dealers*

The first project, with assistance from the staff of the North Carolina State University Seafood Laboratory, developed *A Self Guide to HACCP Inspection for Small Seafood Dealers, Packers and Processors.* This material is used to train seafood dealers and processors in methods to comply with federal and state HACCP requirements. The Seafood Lab has conducted workshops since January 1997. The workshops use real examples from the seafood industry and teach participants how to develop a HACCP plan for their own businesses. North Carolina Sea Grant later published a follow-up publication containing more specific examples. Both publications were distributed nationally.

The second project examined a potential change in the picking/packing critical control point for crab processors. If accepted by the Food and Drug Administration, it would lessen the burden of HACCP-required paperwork for processors without compromising product safety. The results indicated that as long as standard operating procedures are implemented properly, there is no need to label the picking/packing step as a "critical control point" under the HACCP plan. The benefit to processors would be fewer critical control points to monitor and less paperwork.

- **99-ST-04** *Evaluation of Ozone as a Sanitizing Agent to Improve the Safety, Quality and Shelf Life of Raw, Vacuum-Packed Fish Fillets*

This project evaluated ozone as a sanitizing agent in fish processing. Results demonstrated that ozone could be an effective agent for sanitizing equipment, reducing bacterial levels in fish products and extending shelf life of vacuum-packed fish fillets. This information could lead to the use of ozone in fish processing plants as a sanitizing agent for food and food-contact surfaces, thus reducing the use of toxic chemicals.

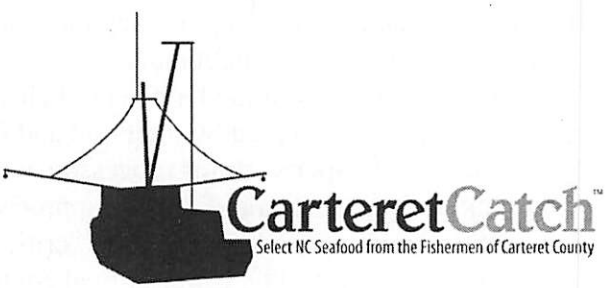
This technology is currently being cited and evaluated by other processors, especially in international markets, who continue to build upon this work.

Value-Added Seafood

- **03-EP-03** *Developing a Marketing Strategy for Selling Value-Added Seafood Products for the Retail and Food Service Markets*

Several coastal processors have begun to transform their operations to satisfy the market for pre-prepared seafood; however, their success in the value-added market will require more than appealing products. Processors must create promotional programs that will persuade retail or wholesale buyers and the public to try new seafood products. Companies must not only be efficient manufacturers of processed seafood but effective marketers of new products as well. The objective of this project was to develop a blueprint of a generic marketing program that shows small seafood businesses how to develop a brand identity for value-added seafood and promote the brand through sales brochures and media advertising. The "Coastal Treasure" brand is a generic marketing strategy that seafood processors may follow when creating their own label.

The results gleaned from this project enabled a group of community volunteers in Carteret County to establish a promotional program for local seafood called "Carteret Catch." The branding program was unveiled at the 2005 NC Seafood Festival and will debut in local restaurants in Spring 2006.



- **02-ST-05** *Development of Ready-To-Eat Seafood Meals for the Institutional Market*

This project resulted in four new entrées: deluxe deviled crab casserole; stir-fry shrimp with noodles; seafood jambalaya; and shrimp paella. After completing development at the North Carolina State University Seafood Laboratory, an independent food technology consultant with expertise in frozen foods adapted each entrée to processing parameters suitable for mass manufacturing. Finally, more than 75 consumers were recruited from the North Carolina State University Department of Food Science to evaluate consumer acceptability of the entrée line.

In addition to these entrées, the project also initiated the development of a line of bacon-wrapped seafood appetizers (shrimp, oyster, scallop and tilapia nuggets) manufactured in partnership with Southern Farm Tilapia (SFT) of Bailey, N.C. SFT is a subsidiary of a large North Carolina agriculture business that processes bacon from its hog operation. SFT is only buying its shrimp and oysters from North Carolina fishers, and it has formed a partnership with a North Carolina seafood distributor to sell the bacon-wrapped line to high-end restaurants

throughout the state. Distribution began in the Fall of 2004. So far, sales have been a modest $10,000, but interest in the product line is increasing, including a favorable reception at the 2005 N.C. Aquaculture Development Conference.

Since 2001, North Carolina Sea Grant has assisted six companies in commercializing 29 of 53 value-added seafood products.

- **01-ST-01** *Value-Added Crabmeat Products for the Retail and Internet Markets*

For over a decade, global competition in the seafood market has placed financial pressure on small and medium-size coastal seafood processors. As commodity producers, local seafood businesses are at a competitive disadvantage with their foreign counterparts because of cost. Yet the domestic demand for seafood is steadily increasing because consumers are craving high-protein, low-fat foods. Furthermore, Americans are selecting ever more easy-to-prepare food options because they no longer have the time or desire to cook their own meals. Retail and especially wholesale markets offer profit opportunities for the consumer-focused seafood company. The objective of this project was to demonstrate how to use textured vegetable proteins to formulate a line of economical pre-prepared crabmeat and crawfish products. The company developed 12 main-meal and appetizer foods. Two of the 12 products were accepted by Lowes Foods, Piggly Wiggly and Acre Station grocery stores. A small processor of seafood spreads, based in Harbinger, N.C., began using textured wheat protein in 2004, which allowed him to achieve a 5 percent profit margin on his line. Prior to incorporating wheat protein in his crab spreads, the processor was losing money on his product line.

- **97-ST-05** *Development of a Process to Achieve Strong Binding of Seafood Flakes for Restructured Products*

This project demonstrated the use of a simple, enzyme-based process to create value-added products from underutilized seafood. Unmarketable scallops — ranging in size from 150 to 200 pieces per pound — were fused together to produce a more desirable product in the 30 piece-per-pound range. Wanchese Fish Company Inc. employed this technology to create the "Scallop Medallion" line, which has been enormously profitable in both the wholesale and retail markets.