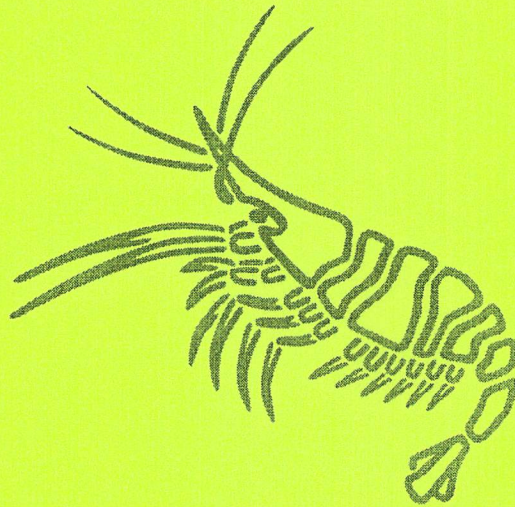


Fishery Resource Grant Program

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



Abstracts for Completed Projects 1995-1997

North Carolina Sea Grant
UNC-SG 03-01-A Updated March 2003

Fishery Resource Grant Program

Abstracts for Completed Projects

Funded in 1995, 1996 and 1997

The Fishery Resource Grant Program (FRG), the first U.S. program of its kind, was established in 1994 by the North Carolina General Assembly. As it enters its ninth year, the program is a model for other states considering innovative ways to improve their fishery resources. A basic principle of the North Carolina program is that people in the industry often have the best ideas for enhancing fisheries but lack the financial resources to experiment with innovations. FRG invests in the ideas of the fishing public through fair and competitive methods.

With annual appropriations from the General Assembly, the program funds four areas of research: aquaculture & mariculture, environmental pilot studies, fisheries equipment & gear, and seafood technology. The proposals and research are administered by North Carolina Sea Grant, which has established an out-of-state review process for all proposals. Final funding decisions are made by the North Carolina Fishery Resource Grant Committee, which includes representatives of Sea Grant, the N.C. Division of Marine Fisheries, the N.C. Marine Fisheries Commission, and the commission's regional advisory panels.

Full final reports are available on the 1995, 1996 and 1997 projects abstracted in this publication. To order a copy of a report, send \$5 and the grant number to North Carolina Sea Grant, North Carolina State University, Campus Box 8605, Raleigh NC 27695-8605. If you have questions about the program, call Sea Grant's Raleigh office at 919/515-2454 or its field offices in Wilmington (910/962-2490), Morehead City (252/222-6307) and Manteo (252/441-3663).

Abstracts for reports are also available on the Web at www.ncsu.edu/seagrant. Follow the research links to the Fishery Resource Grant Page.

Journal of the American Chemical Society
Volume 77, Number 1, January 1955

The following articles are included in this issue:

1. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 1-10.

2. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 11-20.

3. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 21-30.

4. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 31-40.

5. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 41-50.

6. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 51-60.

7. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 61-70.

8. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 71-80.

9. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 81-90.

10. The Structure of the Benzene Ring, by R. S. Stein and R. M. Waymouth, 91-100.

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1995 Aquaculture & Mariculture

- 95AM-09

Cage and Rack Method for Oyster Culture

This project investigated the cage and rack method of oyster culture. The goals were to 1) test effectiveness of the cage and rack system, 2) test effect of seed type and grow-out density on oyster growth rate and survival, 3) obtain long-term oyster grow-out data and 4) document profitability of small scale oyster culture.

Seed oyster survival was excellent during the first year to year and a half of grow-out. Generally, the percentage of legal-size oysters harvested per cage was greater in cages stacked at lower densities. Qualitatively, oysters from low-density cages were more rounded and wider, with a deeper cup than those from higher-density cages.

During the second summer, there was significant mortality of oysters. Surviving oysters were of poor quality also.

The cage and rack method has the benefit of not being visible to potential poachers and its materials have a long, useful life. The major problem is obtaining a consistent supply of quality seed that will grow and survive well.

- 95AM-27

Oyster Chub Demonstration Project in Onslow County

J&B AquaFood attempted a new method for raising oysters in commercial quantities — the “floating chub” system. The system required a water column lease because the oysters were grown in bags tied to floats so that they dangled in the water column. Oysters 25 to 30 mm were put in bags with floats and grown for two years. The system was successful, though problems arose with hurricanes. The report includes

material investment data and profit margin.

- 95AM-60

Hard Clam Grow-Out Technique

This study tested a hard clam grow-out method that combined two commonly used techniques. Two different-sized seed clams — one averaging 11.8 mm in length and the other averaging 13.6 mm in length — were started using three methods: mesh-covered bottom beds, tented soft bags and soft bags transferred to bottom beds after one year. After two years, the clams were sampled. In all cases, the large seed survived better than the small. Clams grown in bags for at least part of the time survived better than clams grown solely in the bottom beds. The clams that were transferred from the bags grew faster than those left in the bags for two years. There was some evidence that freezing temperatures may have been a source of mortality.

- 95AM-94

Development of New Seed Oysters

Bear Creek Shellfish experimented with six aspects of the Virginia oyster. Genetic selection has become standard at Bear Creek Shellfish with oysters chosen for their size and growth rate. Triploid induction is a delicate process involving dangerous chemicals, and the impact of the study is still being researched.

Late summer spawning is fraught with difficulties, including declining gamete quality and increasing bacterial problems. High-grading oyster seed when they reach about 10 mm in the hatchery has, to date, resulted in oysters that are bigger and grow faster. This trial is being repeated with oysters that have been high-graded at 1 mm. Combining two previously established techniques has successfully produced cultchless seed, but clumping at the grow-out site is still a problem.

Combining the above methods has produced a unique line of oyster seed. In 1995 and 1996, oysters were produced from select broodstock, induced for triploidy, set as cultchless seed and high-graded.

- 95AM-95

Control of *Pfiesteria* in Aquaculture Operations

Pfiesteria is widespread throughout the Bear Creek estuary. Although data indicate that there may be temporal or geographic hot spots, it does not appear that there is any place within the estuary that is totally void of *Pfiesteria*.

To reliably remove the dinoflagellate from culture tanks at Bear Creek Shellfish, it is necessary to sand filter, then filter with diatomaceous earth and either 1-micron-filter or UV-treat the water. A 1-micron air filter is necessary to prevent contaminating cultures from the compressed air line. Another source of contamination was discovered and corrected: airborne contamination during alga inoculation.

A proposed method for rapidly detecting *Pfiesteria* was tested using equipment available in most aquaculture operations. But this method was rejected for several reasons: extreme variation in *Pfiesteria* form, the high degree of microscopic resolution required to identify all the different forms and the high degree of training needed to properly recognize all the forms.

An alternative bioassay method was suggested, using marine phytoplankton cultures. A proposed method for mitigating the effect of the *Pfiesteria* toxin using activated carbon was tested but has not yet proven beneficial.

- 95AM-135

Demonstration Project of Off-Bottom Clam Culture

This grant funded student aquaculture

projects over a three-year period in the Aquaculture Technology Program at Brunswick Community College (BCC) and at the University of North Carolina at Wilmington (UNC-W).

Student projects included a floating plywood raceway system for clam culture and indoor recirculating systems. These systems were used to produce channel catfish, hybrid striped bass, tilapia, rainbow trout, largemouth bass, bluegill sunfish, yellow perch, hard clams, and oysters.

As a result of these activities, BCC signed an agreement with UNC-W that allows BCC aquaculture graduates to enter the UNC-W marine biology as juniors. Likewise, UNC-W students can take aquaculture courses at BCC for biology elective credit. This lets students at both institutions earn the A.A.S. in aquaculture technology and the B.S. in marine biology during a four-year period. It also lets students develop marketable technical skills through hands-on experience.

1996 Aquaculture & Mariculture

- 96AM-18

Low-Density Hard Clam Grow-Out Experiments

This project studied alternatives to bags and screens for controlling predators during the grow-out phase of clam aquaculture. Predation after seed clams are taken from nurseries to estuaries to be grown to a marketable size is a major concern for clam aquaculturists.

The goals were to find alternatives to expensive equipment and labor and to establish less-crowded, shallower growing areas where clams can mature more quickly and be harvested mechanically rather than manually.

Phase one of this project involved an intensive literature search and several experiments to determine how to control or eliminate the predators that destroy young clams. Behaviors of

predators such as whelks, blue crabs, stone crabs and mud crabs were studied, along with behavior and habitat preferences of oyster toadfish, which prey upon crabs.

From the research, it was determined to use small-mesh crab pots as stone crab traps and 18-inch lengths of sewer tile closed at one end to serve as oyster toadfish habitats.

The second phase involved planting clam seed in three different sizes using these predator control devices with no other type of protection. Random samples were taken at 18 and 30 months using a 1/8-inch mesh bottom-sampling device. The samples were then analyzed to determine the efficacy of this type of predator control with the different sizes of seed clams.

The results indicated no improvement in survival of any size clams with either predator control device. There were, however, three incidental successes. Nursery trays were designed to hang under docks and worked well. ADPI oyster cages proved superior to bags for growing seed clams on muddy bottoms. And clam nursery raceways made from fiberglass soft crab trays with a drain at one end and water supply at the other were successful.

In addition, data collected from this study may prove useful in future efforts to control predation in clam aquaculture.

- 96AM-33

Develop Stock of Dermo-Resistant Oysters

The purpose of this project was to raise Dermo-resistant oysters by 1) establishing a protocol for challenging oysters with the parasite; 2) assaying the oysters for evidence of infection; and 3) culturing and spawning oysters that did not become infected. By repeating the process, it was hoped that each new generation would show greater resistance to Dermo until a

resistant strain was developed.

A group of older oysters — four to five years old — were harvested from a lease on Stump Sound. It was hoped that the longevity of the oysters would be evidence of some inherent resistance to Dermo.

The harvested oysters were conditioned for spawning at Bear Creek Shellfish hatchery in 800-gallon tanks filled with water from Brown Sound that had been filtered with sand and diatomaceous earth. The water was heated with a titanium plate heat exchanger or cooled with a titanium coil cooler to a temperature appropriate for promoting spawning. The water was replaced and the tanks cleaned daily.

The oysters were fed phytoplankton produced at Bear Creek Shellfish. The amount of food was determined by availability and by the feeding rates of the oysters.

Once conditioned, the oysters were stimulated to spawn by using varying temperatures, high feeding rates, periods of emergence from the water, and by stripping gametes from a sacrificed oyster. The first spawning took place in May 1996. When sufficient numbers of gametes were produced, spawning oysters were removed from the tanks.

Gametes developed into veliger larvae within 18 hours, and, for the next three weeks, were cultured in aerated static tanks. When competent to metamorphose, gametes were introduced into a setting tank to become juveniles, commonly known as spat.

Spat were cultured on floating screens until approximately two mm, then grown in an upweller trough until large enough (approximately 10 mm) to be placed in floating nursery bags in Bear Creek.

Attempts to infect oysters by submersion in aquaria containing *P. marinus* cells proved unsuccessful. Therefore, instead of relying on the

oyster's own filtering system for challenging, a direct injection technique was used.

Despite direct injection with fresh *P. marinus* cells, attempts at challenging the first generation of oysters produced inconsistent assay results. By spring, 1998, only seven oysters had survived of the 17 that had tested negative for Dermo after exposure.

These survivors were conditioned at Bear Creek Shellfish as described earlier, but there were no successful spawn. Therefore, no resistant second generation was produced. An effective infection protocol was established, however, oysters were challenged and presumed resistant oysters were spawned.

Among problems encountered, researchers noted confirmation from earlier work that suggested oysters less than 10 months old might not develop detectable infections. It was concluded that developing Dermo-resistant oysters might still be possible with long-term institutional support.

- 96AM-70

Analysis of Growth and Survival of Seed Clam Plantings

A total of 380 soft-tented bags containing 484,165 seed clams were planted between 1992 and 1995. Clams planted in the summer experienced the lowest survival (average 24 percent) while fall and spring plantings had the highest survival (average 73 percent). Larger seed clams had greater survival.

The clam growth topped out in a year or two. This may have been a function of density. When these clams were taken out of the bags and put on the bottom, the growth rate increased. The soft-tented bags made harvest easy, but they also made poaching easy. Soft-tented bags are a good idea for starting seed clams, but after the first year the clams should be transferred to mesh-

covered beds for grow-out.

- 96AM-72

Investigate Improved Oyster Spat Collection Techniques

Due to low oyster production in leased and public bottom areas, attempts have been made to increase oyster yields by using hatchery-produced seed. This study examined seed collection from wild populations and sought answers to the following: 1) Can the optimal time for spat collection be predicted by monitoring oyster larvae? 2) Is spat collection enhanced by placing shells in raised cages instead of on bottoms? 3) How will bottom placement after initial settlement affect growth and survival of the collected spat?

Advantages of wild seed include potentially lowering cost, using natural selection to secure the hardiest seed, decreasing the potential for acquiring disease from other areas and obtaining oysters that are genetically suited to the local environment.

Spat collectors containing layers of bivalve shells were placed in polypropylene cages and suspended approximately one foot off the bottom by PVC racks. Bivalve shells to equal the volume of shells in the spat collectors were placed in similar cages and staked to the bottom as a control. Water and plankton sampling was done weekly for 12 weeks from June to September, 1996, 1997 and 1998. Collectors were analyzed routinely for spat.

The study showed that spat (newly attached oysters) usually recruit in much greater densities to collectors held off the bottom. In addition, spat collected on racks have a higher growth rate than spat collected on the bottom. Growth and survival of spat placed on the bottom were highly variable.

Researchers also found that spat settling on

collectors placed in the water before the time of the peak settlement grow to a smaller size at the end of several months compared to those that settle on collectors placed during peak settlement.

The study recommends that sampling for larvae begin the last week of May and continue until a significant abundance of larvae is noted. Placing spat collectors when great numbers of the vigorously swimming eyed larvae are present can maximize spat production, according to researchers.

They recommend that the state design a small pilot project using timed off-bottom spat collection in its shellfish rehabilitation efforts.

● 96AM-73

Develop Cooperative Program for Mariculture Instruction Among Carteret Community College, Sea Grant and Industry

This project was designed to create a collaborative program of hands-on mariculture development and instruction among Carteret Community College (CCC), North Carolina Sea Grant and fishing industry participants.

Its objectives were to 1) experiment with the oyster chub ladder grow-out system for application at the community college, 2) investigate oyster toadfish as a mariculture candidate species and 3) relocate and reactivate Sea Grant's shellfish hatchery to CCC.

The oyster chub ladder system proved to be unfeasible at this location due to extreme wave action from boat traffic in Bogue Sound.

Oyster toadfish were successfully reared to the juvenile stage from a naturally collected egg mass. They were not induced to spawn in the lab.

Results indicate that they probably could be successfully cultured. Adult fish were successfully held and fed at the facility until water-

quality problems forced cessation of efforts.

The Sea Grant shellfish hatchery was successfully transferred to CCC. This is a positive asset for CCC and Sea Grant. Biology and environmental classes will use the facility for independent research related to mariculture and water quality, and Sea Grant will use the facility for demonstration purposes.

● 96AM-96

Demonstrate Use of West Coast Remote Spat Setting Technology for Eastern Oysters

This project tested West Coast style remote setting oyster culture technology for use with native eastern oysters in North Carolina. Eyed larvae of *Crassostrea virginica* were set on microcultch and two sizes of shell cultch in shell bags.

Clean large shells from an oyster shucking house were better than small shells collected from waterway shell banks. The setting was done in tanks made for the project. The set spat were placed in cultch bags onto intertidal submerged racks until they achieved a size suitable for planting.

The project tested growth and survival on three bottom types in shallow-water leases. The control consisted of data obtained from the N.C. Division of Marine Fisheries regarding the settlement and collection of oysters in a nearby planting site using standard cultch planting methods.

Better results were obtained by planting seeded cultch on netting or in firm/muddy bottom and firm/shell bottom than in soft/muddy bottom. This seed production method showed a projected cost of \$3.52 per thousand oyster seed, considerably less than the usual hatchery price of \$35 per thousand 20-to-25 mm seed.

This project demonstrated that the West

Coast oyster eyed-larvae remote setting techniques can be adapted for seed production with the eastern oyster in North Carolina. The positive results from this project have implications for improving oyster culture methods and state oyster management practices in the state.

1997 Aquaculture & Mariculture

● 97AM-8

Crab Shedding in Closed Recirculating Aquaculture Systems

Of the three standard methods for shedding soft shell crabs, two — the open-loop and float methods — are limited to those who have either water access or waterfront property. A third method, the closed loop recirculating system, has the advantages of control over water temperature and clarity. More importantly, it can be set up anywhere allowing increased growth of this coastal enterprise.

One disadvantage is potential water contamination from buildup of waste products in the closed loop system, potentially leading to high crab mortality.

This study compares four systems for controlling water quality in the closed-loop recirculating system. Water quality is dependent upon the presence of nitrifying bacteria to convert ammonia to nitrite and then to nitrate.

The study covered the crab-shedding seasons of 1998 and 1999. Periodical tests determined levels of ammonia, nitrite, nitrate and pH.

All four systems used shedding trays, protein skimmers made of PVC pipe and 4-by-8-foot rock filters. All except system one used venturi aeration devices that were used when warmer temperatures were likely to cause lower levels of dissolved oxygen.

System one was located indoors, thus operating when cool weather inhibited shedding in

outdoor systems. This system had four trays, a fluidized bed filter and a protein skimmer.

System two used four trays, a protein skimmer and a 40-gallon container. This system had a leak allowing a 10 percent introduction of new water daily.

System three also held 40 gallons of water and had 3 cubic feet of media. It had seven trays and was watertight with no capacity to replace.

System four had seven trays and a protein skimmer. Tray capacity in systems three and four were increased to hold seven additional trays each in 1999.

Systems one and two performed the best, resulting in lower crab mortality than systems three or four. It was determined that overstocking the systems led to diminished water quality, but that could be mediated with the use of biofilters and protein skimmers.

Problems arose in 1999 because of increases in water pH due to the proportion of seawater to well water in replacement water. This underscored the necessity of maintaining water pH within acceptable levels — 7.0 to 7.5 — for nitrification to take place.

● 97AM-9

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

Researchers evaluated the practical and economic aspects of holding and growing wild-caught southern flounder for off-season sale. With flounder fishing restricted to only a few months each year, intense fishing pressure leads to a supply glut and low market prices. By holding flounder to sell during off-season, it was hoped to sell larger fish at higher prices. The first part of the study was done in small-scale experimental tanks and the second at a commercial flounder holding operation.

Questions researchers hoped to answer were; 1) whether wild-caught flounder could be held in captivity and, if so, at what densities, 2) whether wild-caught flounder would grow in captivity, 3) whether wild caught flounder could be trained to eat chopped fish, and 4) is it economical to hold and grow wild-caught fish.

Flounder with an average weight of two pounds were stocked into 10 foot diameter tanks at densities of 10 or 20 fish per tank and fed either live mullet or chopped mullet at three percent of body weight per week.

Uneaten chopped fish was captured at the outside of the drainage pipe and counted to estimate food consumption. In tanks with live mullet, the mullet were counted twice weekly to estimate food consumption. Flounder were weighed monthly.

Brackish water from an adjacent creek flowed through the tanks at a rate of three gallons per minute. Temperature, salinity and fecal coliform counts were done monthly on samples of the freshwater and saltwater inflows as well as the outflow from tanks.

Results from the first part of the study showed that approximately 20 to 30 percent of flounder refuse to eat in captivity and must be sold as soon as identified. Findings suggest that temperatures may need to be below 12 degrees C. in order to maintain original stocking weights.

Fecal coliform counts were higher in inflow than outflow regardless of feed. Coliform counts for saltwater peaked in Feb. and caused a corresponding increase in tanks. The amount of fecal coliform generated by flounder never exceeded 20 cfu.

Flounder consumed chunk feed as readily as live fish. More feed activity occurred at higher stocking densities in both experimental and commercial tanks. In addition to holding flounder over winter for sale in spring, some fish at

the commercial plant were held through the summer as well in an attempt to grow them to larger sizes to command even higher prices. These fish grew from an average of 1.5 pounds to an average of 3 pounds in 10 months.

Economic analyses showed a return of 25 percent annually on the initial investment, not including the first year when there were no flounder fattened for sale. In the first year, the facility would earn back costs but without profit.

Magazine and newspaper articles have featured this project and findings were presented at a workshop during the 2000 North Carolina Aquaculture Development Conference in New Bern. Additionally, several commercial fishing companies have expressed an interest in constructing their own holding and growout facilities.

- 97AM-10

Seasonal and Spatial Variation in Clam Growth as Related to Grow-Out Procedures

This study was initiated to determine the seasonal and spatial variations of several clam growth components as they relate to three lease sites. Information can be used to evaluate and develop appropriate planting procedures for other sites.

Water sampling measurements were conducted over an 18-month period in the Westmouth Bay. Four transects, each with five stations for water sampling were established. The first transect was located in mid-Westmouth Bay starting at a point within the Straits channel and continuing toward the south shore of the bay. The transects then branched out into three areas, one on each lease: West Lease (stations WL-1 to WL-5), Main Lease (stations ML-1 to ML-5) and East Lease (EL-1 to EL-5).

All points were sampled weekly at mid-flood

to high tide for dissolved oxygen, temperature, salinity, current flow, current direction and depth. Duplicate water samples were taken from A and B substations at each station and returned to the lab for filtration and subsequent analysis of chlorophyll-a and organic/inorganic seston. Water was filtered down to a filtrate containing algae in the three to 20 micron size range — the size generally eaten by clams.

A study was conducted using an EPA-approved dye to further characterize the movement of water into the estuary and across the three shellfish leases. Three series of aerial and surface observations were made to record dye movement and document the water flow while simultaneous water quality samples were made at all 40 stations.

Results of the study led to the following recommendations:

- Use a water dynamics study to determine the water flow characteristics over each lease and develop layouts accordingly.

- If possible, determine the food flux across different portions of leases to develop effective growout procedures for each lease and develop planting schemes and densities accordingly.

- For new areas, start by planting low densities first and monitor growth rates as densities are increased. When growth rates slow, lower planting densities.

- When possible, handle clams in afternoon hours to take advantage of highest daily oxygen content of the water.

- Forewarn beginning clam culturists to study locations closely before committing to a certain area for leasing. If there is no choice about lease location, plant several calm beds with different densities and monitor growth over time. This is especially true as larger percentages of the lease are under cultivation.

- A general study conclusion for clam mari-

culture is that clams should be grown in lower densities than are currently the norm in the industry. Additional acreage will be required so that planting densities can be reduced while maintaining a level of production and profitability.

- Anything that causes a decrease in water flow across clam beds can slow the growth of clams. Specifically, perimeter fencing or even the clam bed covers themselves can slow water currents over the clams. Large mesh netting or fencing affects water flow less than small mesh.

At the time of this publication, the report for this project is to be made available to the Shellfish Growers' Association, North Carolina Sea Grant and the N.C. Fisheries Association. It is also to be presented to the North Carolina Aquaculture Development Conference.

- 97AM-16

- Developing a Simplified Technique for Estimating the Abundance of Oyster Larvae

- This project sought to develop a simple index of oyster larval abundance for use by growers to time placement of cultch material for spat collection.

- Maximum oyster larvae abundance relative to time of day, tidal cycle, and depth were determined for various sites in Carteret County, North Carolina.

- The data suggest that time, distance, and depth affect concentrations of both total bivalve larvae and eyed-stage larvae. The data suggest spat collectors be placed near inlets, in surface waters in early to mid-June and perhaps again in late August or early September.

- 97AM-17

Seed Oyster Production in Saltwater Aquaculture Ponds

This study was an attempt to raise oysters in aquaculture ponds stocked with hybrid striped bass by salinizing the water to a degree acceptable to both. The pond aquaculture was to prevent loss of oysters to the parasite, Dermo, which is becoming increasingly more prevalent in the state's coastal waters.

A problem with oxygenation resulted in the loss of both bass and oysters, yielding no results regarding the ability to raise both oysters and hybrid striped bass in the same aquaculture.

- 97AM-21

Publication of a Seafood Directory

The North Carolina Seafood Directory

Project developed indices of seafood availability in North Carolina by company name, product category, and season. This directory of seafood suppliers is on file.

- 97AM-25

Shrimp Trawl Webbing as a Base for Culture of Oysters and Hard Clams in Soft-Bottom Areas

In this study mats were successfully used to support oyster beds in areas where bottoms of deep, soupy mud typically yield low quantities of shellfish. The objective was to determine whether supporting oysters and clams on mats in such areas could increase production.

Two sites, labeled A and B, were selected in a muddy cove and mats of two sizes of mesh — 5/8-inch-by-1-inch nylon shrimp trawl webbing and .22 mm-by-.24-mm mono clam-cover webbing — were studied. Four mats of each size mesh — a total of eight mats — were constructed with rebar sides and chain ends.

Each site was staked off into equal plots for

oysters relayed from polluted waters, oysters from seed, and both relayed and seed clams. Relayed shellfish were supported by 5/8-inch webbing, and seed shellfish were supported by the .22 mm webbing. All beds were planted with the same numbers of clams or oysters. Seed shellfish were protected from predators by .22 mm clam-cover webbing. Yields from all beds were compared to contiguous unmatted test beds of the same size.

For clams, mats of both sizes made harvesting by hand in shallow waters easier. However, in deeper waters where the tongs, pitchforks or rakes could be snagged on the mesh, there was no harvesting advantage. And, while yields of both types of clams were higher on mats than in muddy, unmatted test areas, the increase in production did not justify the cost of the mats.

Results for oysters were more promising. Relayed oyster harvests from mats in area A, for instance, totaled 18.5 bushels contrasted with 13.25 bushels from the unmatted test area. In area B, the second site, relayed oyster harvests totaled 17.25 bushels from mats, while test area harvests were 12.5 bushels.

Seed oyster harvests were equally promising. From the 13,750 planted in area A, 9,487 oysters were harvested from mats and 6,737 from test areas. In area B, mats yielded 9,900 oysters compared to 7,152 from test areas. The researcher found the increased harvest easily justified the cost and effort of using mats to support oysters in muddy beds.

- 97AM-27

Aquaculture Pond Construction for South Brunswick High School

This project was to construct four ponds on the property of South Brunswick High School, to be used in the school's aquaculture curriculum. Fishery Research Grant Program funds were

used with funds from other sources to build the ponds, establish vegetative cover and drainage structure(s), install electrical equipment, a well and a security fence, and construct a storage building.

1995 Environmental Pilot Studies

- 95EP-16

Oriental Tarpon Tag-and-Release Tournament

The Oriental Rotary Tarpon Tournament tagged and released 55 tarpon during two days of fishing (July 28-30, 1995). Sixty-four boats with about 200 anglers and 75 volunteer observers were involved. One-hundred tagging sticks and 300 tarpon tags were purchased, and each captain was allowed to keep his tagging stick and five tarpon tags for future use. The program was scheduled to continue in 1996.

- 95EP-33

Water Quality Testing in Pender County

The PenderWatch and Conservancy found fecal coliform bacteria in three Pender County tidal creeks, but it did not find point sources of the pollution. The group took 145 fecal coliform samples from 71 test sites over a 17-month period (July 1995 to December 1996). The levels of fecal coliform were all lower at the Intra-coastal Waterway-creek junction and higher in areas farther from the junction. The three creeks — Mill Creek, Old Topsail Creek and Virginia Creek — were drastically affected by Hurricane Fran and have higher runoff due to loss of timber. Contamination is expected to increase as the development becomes more pronounced.

- 95EP-48

Removal of Dam on Neuse River

The Quaker Neck Dam on the Neuse River near Goldsboro was built in 1952 by Carolina Power & Light Co. The 12-foot concrete dam cut off 1,000 miles of breeding habitat for anadromous fish. Funding by the Fishery Resource Grant Program and the National Fish and Wildlife Foundation allowed the N.C. Coastal Federation to serve as fiscal agent for removal of the dam. Demolition began December 17, 1997. The removal opened 139 miles of the Neuse River to striped bass, shad and other anadromous fish for the first time in 45 years.

- 95EP-66

Siltation Study in the Newport River

The Newport River estuary siltation study examined whether the estuary is filling with sediments. The project used several research methods: coring for radiometric dating techniques, a review of any pertinent literature and computation of infilling using bathymetric map comparisons. The findings showed that the Newport River estuary is trapping sediments and filling in at a higher-than-average rate. Reasons for this are complicated and unresolved, though possibilities include deforestation, changing patterns of land use and dredging, and channel realignments at the Morehead City state port.

- 95EP-76

Effect of Dam Removal on Anadromous Spawning Sites

Striped bass and American shad within the Neuse River historically migrated as much as 435 km upriver to spawn. However, migration was impeded in the 1950s by the construction of a low head dam at river kilometer 225. To determine the percentage of tagged fish that

migrated upstream of the dam and the characteristics of selected spawning habitat, researchers implanted sonic transmitters in 25 striped bass and 25 American shad in 1996 and 1997.

The researchers determined preferred depth, water velocity and substrate composition by measuring those characteristics at randomly selected sites and sites where spawning was observed. Of 13 striped bass and eight American shad that migrated to the base of the Quaker Neck Dam, only three striped bass passed the structure, indicating that the dam is an impediment to migration. Striped bass spawning was observed only in the area directly below (within 1.5 km) the Quaker Neck Dam. American shad spawning was observed from the base of the Quaker Neck Dam to 1.5 km downstream as well as 3 km above the Quaker Neck Dam.

Habitat preference was determined by comparing habitat variables within river sections used for spawning with habitat variables from randomly selected locations throughout the Neuse River. Striped bass selected areas with significantly higher water velocity and significantly larger substrate than the distribution of these variables in randomly sampled areas. American shad selected areas that were significantly shallower and with significantly larger substrate than the distribution of these variables in random samples.

- 95EP-77

Effect of Water Quality on River Herring

This project compared water quality parameters with egg-hatching success of blueback herring (*Alosa aestivalis*) at various sites in the Chowan River. Significant differences in the hatch rates of blueback herring eggs were observed among sites, ranging from 89 percent at

the Chowan River at Riddicksville to 26 percent at Dillard Creek.

Differences in water quality among sites were also observed. Of the water quality parameters measured, dissolved oxygen was the only parameter with values outside the reported range for normal development of blueback herring eggs. Based on correlation and regression analysis, dissolved oxygen appeared to be the primary cause of hatch rate differences among sites.

- 95EP-81

Educational Videos on Fisheries Issues

Meat-to-shell ratios for chub-reared oysters from North Carolina were compared to ratios for wild oysters from North Carolina, Louisiana, Florida and Texas. The North Carolina chub-reared oysters were grown in Alligator Bay, a semi-enclosed body of water near New River Inlet in Sneads Ferry.

Results indicated that North Carolina chub-reared oysters yield a greater meat-to-shell ratio than any of the wild oysters. This ratio was 19 percent greater than wild oysters from the New River, 21 percent greater than Louisiana wild oysters, 26 percent greater than Texas wild oysters and 30 percent greater than Florida wild oysters.

A video was produced showing high school students using the chub system.

- 95EP-84

The State of the Fisheries Video

The final report is a 40-segment educational video series entitled *The State of the Fisheries*. The video consists of short interviews with professionals on the condition of certain fisheries and their environments, including shellfish, finfish and fish habitat.

- 95EP-93

American Shad Passage Through Lock and Dam #1 on the Cape Fear River

This project studied the passage efficiency of adult American shad at Lock and Dam #1 on the Cape Fear River based on the assumption that man-made obstacles hamper shad reproduction.

After observing tagged fish, the researchers determined that "fish locking" methods were not as efficient as they could be. The report recommends that the locking procedure begin by March 1 and run through June. A seasonal fishing closure should be maintained to achieve the highest probability of upstream passage.

Lockages should be conducted as frequently as possible during the day, and no locking should occur before 6 a.m. or after 8 p.m. Shad lockages should be conducted every day during April and May, the peak spawning migration period. The outer, lower lock gate should be left closed to help aggregate fish in the chamber. A shoal should be created at an angle from the outside lower gate to mid-channel. Also, boat motor noise and activity near the dam should be reduced prior to lockages.

- 95EP-97

Speckled Trout Tagging Program

The project created a cadre of more than 50 trained volunteer taggers from all over North Carolina. Two-thousand eighty tags were distributed to them. As of April 22, 1998, 150 fish had been tagged with two returns.

- 95EP-113

Use of Crab Processing Waste

This project studied the use of wastewater from Mattamuskeet Seafood Inc.'s crab cooking and processing facility. The wastewater drip system channels wastewater to compost piles

instead of a septic system. This system has four benefits: 1) two systems are always available for the waste cooking water; 2) the wastewater can be recycled and the nutrient-rich crab waste put to good use; 3) the composting process is faster with the introduction of moisture during dry times of the year and 4) the compost is richer.

- 95EP-137

Monitoring Water Quality Parameters in Pamlico Sound

Levels of dissolved oxygen (DO), water temperature, salinity, conductivity, pH and turbidity were recorded in Pamlico Sound and sent to interested parties. The Pamlico Sound field data for deeper waters were supplied to various government agencies and are available for review. This project was different than most others funded through the Fishery Resource Grant Program because it collected data without drawing conclusions.

1996 Environmental Pilot Studies

- 96EP-05

Development of Environmental Programs for Middle School Students

Middle school students visited the Mitchell 4-H Center near Swansboro for a daylong curriculum of commercial fisheries, seafood preparation, careers, water quality, coastal ecology, wetlands protection, and fishing rules and regulations.

The report of this project includes a timetable for organizing the camp, the brochure that went to schools and survey results from participants.

- 96EP-20

The State of the Fisheries Video

This video, the same as FRG 94EPS-84, is on file. The grant was used to make copies.

● 96EP-26

Life History of Hickory Shad in the Albemarle Sound Area

The hickory shad (*Alosa mediocris*), which supports commercial and recreational fisheries in the Roanoke River and Albemarle Sound, is an anadromous species closely related to the American shad (*A. sapidissima*). The Albemarle Sound population has exhibited a surge in numbers since 1989, but the cause is unexplained. Little is known about the life history of this species, which now supports a fast-growing sportfishery on the Roanoke River near Weldon and increased commercial catches in Albemarle Sound.

The goal of this study was to characterize key life history aspects of hickory shad in the Albemarle Sound/Roanoke River watershed, including the age, size and sex compositions of the population, the sexual maturity schedule (age to maturity), potential fecundity of adults and identification of the nursery grounds. Fish examined in this study were captured in 1996 from the Albemarle Sound and Roanoke River.

The sex ratio (males to females) of adult fish sampled from Albemarle Sound and the Roanoke River at Weldon was statistically similar (0.73:1 and 0.76:1, respectively). A 57 percent agreement was found between aging fish with scales and otoliths; scales overestimated younger-aged fish and underestimated older-aged fish. Most males were age 3 and most females were age 4, few fish were older than age 4 and the maximum age was 7. Males were generally smaller than females; overlapping lengths and weights at age made estimates of size at age difficult. Some fish were mature by age 2, and all were essentially mature by age 3. Fecundity estimates ranged from 80,290 to 478,944 eggs with most fish spawning two or three times before leaving the population (from harvest or natural mortality).

Reduced visceral fat of fish in the Roanoke

River indicated they use stored lipid reserves during migration. Juvenile hickory shad apparently do not use the Albemarle Sound as a nursery ground in the same manner as American shad and river herring (*A. aestivalis* and *A. pseudoharengus*), but they may use coastal ocean water. A short life span and low fecundity make this population vulnerable to overharvest.

● 96EP-28

Study of Fish Use of Submerged Aquatic Vegetation in Pamlico River

This study provides preliminary support that Pamlico River SAV can serve as an important resource for some species of fish. Areas with SAV were significant for providing more fish, more species or both than unvegetated areas.

This study supported other research findings on the importance of SAV and helped set a precedent for stating that the loss/destruction of Pamlico River SAV should not go unquestioned. It allowed for resource managers to build ideas on how to manage and study this resource.

This study was not intended to be the end of SAV research on the Pamlico River but the beginning of questions about how to manage estuarine and riverine SAV resources. Most management is based on restricting human activities. This research was intended to provide the basis for questioning how and why we manage our coastal resources.

Most of the recommendations were based on previous studies about SAV. Other research, along with this study, should be used in planning future studies and making recommendations concerning SAV.

● 96EP-34

Study of Excess Nitrogen Sources in Neuse River Estuary
The Albemarle-Pamlico Sound System

(APSS), the second largest estuarine complex on the U.S. mainland, has been experiencing nutrient-driven eutrophication — a process by which high levels of nutrients lead to an overgrowth of aquatic plant life, resulting in depletion of dissolved oxygen.

Atlantic Ocean water exchange in the APSS is slowed by the Outer Banks' narrow inlets. This causes nutrients entering the system from the rivers to stay in the sound for up to several months. Nitrogen has been shown to be the primary nutrient implicated in the eutrophication of the system. The result is hypoxia and anoxia that lasts a long time, covers a large area, and leads to finfish and shellfish kills.

This study attempts to identify nitrogen sources in the Neuse River, a major tributary of the APSS, by identifying stable nitrogen isotopes in the river. Nitrogen isotopes are atoms of the element that vary in atomic weight making it possible to distinguish its sources.

From 1996 through 1998, biweekly water sampling was conducted at Streets Ferry Bridge near New Bern, representing water inflow and nutrient input near the head of the estuary. Physical, chemical (including nutrient) and biological parameters and stable nitrogen isotope composition were examined.

In addition, weekly sampling of atmospheric wet and dry nitrogen deposition was done at four locations in the Neuse River watershed and at the UNC-CH Institute of Marine Sciences (IMS) in Morehead City. This sampling was part of a larger weekly water quality program — a collaborative effort including UNC-CH IMS, NC State University and the N.C. Department of Environment and Natural Resources.

Atmospheric nitrogen deposition — a gaseous form of ammonium largely from stored and applied animal waste as well as emissions of fossil fuel combustion — was found to represent

39 percent of the total nitrogen reaching the Neuse River Basin. Combustion was found to be more of a contributing factor at New Bern and Raleigh sites. Agricultural emissions were responsible for atmospheric deposition in Kinston, Goldsboro and Sampson County.

Non-point sources of nitrogen, such as surface runoff from coastal urbanization and agricultural operations, become more prominent during periods of high water discharge. Point sources such as wastewater discharges increase in relative importance during drier seasons.

Nitrogen isotopes indicate that agricultural runoff and rainfall-based nitrogen dominate at the head of the estuary (Streets Ferry Bridge) during periods of high discharge. Discharge from the passage of Hurricane Fran was associated with agricultural runoff of commercial fertilizers and atmospheric deposition.

Researchers conclude that while the study was useful for characterizing major sources of nitrogen in the Neuse River Estuary, further investigation of both nitrogen loading sources and their isotopic composition would provide more details of dominant anthropogenic and natural sources. They recommend a seasonally intensive, multi-annual study of both atmospheric and terrestrial nitrogen inputs.

- 96EP-50

- Sediment Effects on Habitat in New Hanover County**

- Loss of nursery habitat is often seen as a major cause of declining fishery yields in North Carolina, according to the Northeast New Hanover Conservancy, leading to restrictions on bottom-disturbing activities in waters designated as Primary Nursery Areas (PNA). Yet dredging of the mouth of Futch Creek was found in a study by the conservancy to improve water quality by enhancing tidal flushing.

The conservancy cites research showing a negative correlation between fine sediment loading and the abundance of benthic microalgae, i.e., the more sediment, the less the availability of food in the estuarine food chain. Sediment and nutrient loading from development may have significant impact, researchers say, on habitat quality within the tidal creeks systems.

This study looks at the effects of sediment type on the abundance of demersal zooplankton, fish, shrimp and crabs in Bradley, Howe and Pages creeks from May 1, 1996 to April 30, 1997. Researchers hypothesized that abundance of demersal zooplankton would be lower in muddy or silt-dominated sediments and in Bradley Creek, the creek most heavily impacted by sediment and nutrient loading from adjacent areas. Howe Creek is moderately impacted, and Pages is the least impacted.

Reentry trapping was used to sample demersal fauna at each substrate type at upstream and downstream areas of Bradley and Pages creeks. Juvenile fish sampling was conducted at Bradley, Howe and Pages creeks using a 40-foot bag seine at sand and silt substrate sites in upstream and mouth areas. Larger fish were sampled using a 150-foot gill net and the same sites. Epibenthic crabs and shrimp were sampled using sweep nets over sand and silt substrates in all three creeks.

No support was found for the hypothesis. Bradley Creek had much higher abundance of demersal zooplankton than Pages Creek. Neither substrate composition nor position within the creek showed any effect on abundance. No animals were caught at upper levels of the creeks, and capture at the mouths of creeks was highly variable. No fish were caught in either gill or seine nets.

Researchers say the occurrences of two major hurricanes, Bertha and Fran, probably obscured their findings.

- 96EP-56

Bulletin Board to Post Fishery Regulations

The Pungo River Sport Fishing Association built and maintained a bulletin board at a public boat-launching facility in Belhaven to provide timely postings of information such as size limits, creel limits, etc. from the N.C. Division of Marine Fisheries and Wildlife Resources Commission. The board was installed in May 1997 and has successfully informed facility users about fishery regulations covering both inland and coastal waters of the Pungo River.

- 96EP-59

Informing the Public About Findings of the Moratorium Steering Committee

Ten events and a publication were organized to help fishers, media, public officials and the public become more informed and involved in the Fisheries Moratorium Steering Committee process. Descriptions of the events are listed.

- 96EP-65

Catching, Tagging and Releasing Salt-water Fish in North Carolina

This is a video on the proper methods for safely releasing and tagging marine fish.

- 96EP-66

Establish Water Quality Testing Pilot Program for the Cape Fear River

Cape Fear River Watch, in conjunction with researchers at University of North Carolina at Wilmington, provided weekly comprehensive monitoring of key nursery areas in the Cape Fear River for 1996 and 1997.

The project increased community and media involvement in conservation efforts along the river including monitoring of the Cape Fear

tributaries by the all-volunteer Creek Keepers program.

Weekly testing assured the ability to rapidly detect pollutants and other factors that could affect fish health and viability. Measured parameters included water temperature, salinity, conductivity, dissolved oxygen, pH and turbidity.

UNC-W researchers interpreted the project data, which was included in a report, *Environmental Assessment of the Lower Cape Fear River System, 1996 – 1997*.

- 96EP-67

Feasibility Study of Mobile Exhibit for Marine Environmental Education

Plans were developed for a Coastal Resources Mobile Exhibit designed to convey to students and citizens throughout the state an understanding of the complexity of our coastal fisheries and the coastal environment.

- 96EP-98

Effects of Shellfish Harvesting on Clam & Oyster Populations of Intertidal Reefs

This study showed that harvesting for clams and oysters had clear, negative effects on oyster populations of intertidal reefs. Clamming also had significant negative impacts on clam populations, but the effects of oystering on clams were significant at only one of two sites.

Maintaining high densities of oysters, and possibly clams, on intertidal oyster reefs will require protection of some reefs from both types of harvesting.

1997 Environmental Pilot Studies

- 97EP-6

The Biological and Economic Value of Restored Intertidal Oyster Reef Habitat to the Nursery Function of an Estuary

This project attempts to measure the economic return of oyster reef restoration by looking at the functions oyster reefs serve in the estuary. Oyster harvests alone do not justify costs of oyster reef habitat restoration.

Reefs were restored in three areas that resemble the most common settings for natural oyster reef formation — the edges and points of a salt marsh away from sea grass beds (salt marsh landscape), a site between sea grass beds and salt marshes (sea grass landscape) and on a mud flat isolated from vegetated structure (mud flat landscape).

All three landscapes were compared to similar control landscapes without reef habitat to determine whether restoration influenced fish, shrimp and crab recruitment to and utilization of estuaries and to determine how the landscape affects the reef. Sampling began shortly after reef construction in Middle Marsh, Carteret County from August until November 1997 and from April to November 1998. Samples were collected from fish traps, minnow pots, crab pots, gill nets and hooks and lines during days and nights in control and study areas.

Stomach contents of fish caught in gill nets were analyzed to determine whether the fish were using the reefs as foraging grounds.

Subtidal reefs were relatively more important than reefs in intertidal areas for commercially valuable fish, but the value of fish in both areas was greater than the potential harvest value of oysters.

Comparisons between tidal areas were

complicated by the fact the two areas were very different and were in spatially isolated areas.

Subtidal reefs are the only structured habitat, providing high densities of invertebrates as prey, whereas intertidal reefs are surrounded by other structured habitats such as salt marshes and sea grass beds. Additionally, sampling periods only partially overlap.

A wide diversity of mobile animals used the restored reefs as juveniles or adults during days and nights throughout the year. White urchins, right and lightening whelks, banded tulips, moon snails, grass shrimp, mud crabs and spider crabs were all found in higher abundance on reefs than in controls.

Among fishes found to make use of the reefs were the red drum, gulf and southern flounder, speckled trout, gag grouper, gray snapper, blue fish, spottail pinfish, pigfish, toadfish and sheephead. Analyses of stomach contents suggest that oyster reefs are valuable foraging grounds for economically valuable fish.

Juvenile fishes were found around all reefs, whether in sea grass, salt marsh or mud flats. In control areas without reefs, juveniles were found in significant numbers only in sea grass landscapes.

- 97EP-8

- Spatial and Temporal Incidence of Fish Disease in the Lower Cape Fear River**

- Funding for this project was used to continue, through May 1998, a survey of fish populations in the tidal freshwater portion of the Cape Fear River. Begun in January 1997, this study sought to document the incidences of fish disease, characterize fish community structure and track the effects of Hurricane Fran in the Cape Fear and Northeast Cape Fear rivers.

- The survey was a cooperative effort between

the Cape Fear River Program, the N.C. Division of Marine Fisheries and the North Carolina Wildlife Resources Commission. Sampling was done using trawl nets, gill nets and electroshocking gear.

A specific objective was to assess the incidence of fish disease and to compare research catches to those made by fishers using commercial gear.

Fishers in the river basin have, for years, said that resident fish communities are dominated by only a few species and that the incidence of fish disease is high. A separate survey noted a proliferation of hardy non-native species in the lower Cape Fear, such as flathead catfish, hybrid striped bass, blue catfish and common carp.

Using data from the funded study, the incidence of fish disease at stations in the Cape Fear and Northeast Cape Fear rivers was evaluated and these levels of disease were compared to those reported by commercial fishers working in the same areas.

1995 Fisheries Equipment & Gear

- 95FEG-02

- Artificial Reef High-Profile Units**

- The Carteret County Sportfishing Club constructed 31 high-profile artificial reefs (tetrahedrons 11 feet tall with 15-foot sides) and delivered them to the staging area for deployment by the N.C. Division of Marine Fisheries. The division was responsible for deploying the reefs at three sites: AR255, AR285 and AR355. Two years of monitoring the reefs and annual reports are forthcoming.

- 95FEG-06

- Software Development for Trip Ticket System**

- Salsbury Associates Inc. developed software

(Salsbury Associates' Trip Ticket program version 2) for the trip ticket system. The final report is the manual for this software, which includes the company's address (610 Madam Moore's Lane, New Bern, NC 28562). A more comprehensive manual will be prepared if the program is approved for commercial use.

- 95FEG-11

Crab Trawl Selectivity and Bycatch Reduction

Pamlico County schools studied the effects of manipulating tailbag sizes in the estuarine crab trawl industry. The study had two objectives: to determine 1) the percentage of bycatch reduction in the larger tailbags and 2) the percentage of loss of legal species in the larger tailbags. The two major species of concern were blue crab and southern flounder. The use of a larger tailbag mesh size might substantially reduce the bycatch of sublegal species without making estuarine crab trawling economically impossible. Part of the project examined whether earlier research by the N.C. Division of Marine Fisheries (McKenna and Camp, 1992; McKenna and Clark, 1993) would remain consistent with a much larger database of test tows. Using paired towings, the research tested two tailbag sizes (4-inch and 4.5-inch) against the current legal standard 3-inch tailbag as a control. Each tailbag received test tows during three seasons, which showed significant differences in the amounts and percentages of crab, flounder and other finfish caught. Bycatch of finfish other than sublegal southern flounder was almost nonexistent during winter and spring.

The study compared 3-inch and 4-inch tailbags. The 3-inch tailbag caught a total of 844.3 kg of blue crabs compared to the 4-inch tailbag, which caught 775.4 kg. The 3-inch caught 123 kg of southern flounder, and the 4-

inch caught 104.8 kg. The 3-inch caught 66 kg of other finfish, and the 4-inch caught 50.2 kg. The 3-inch caught 79.2 kg of rays, jellyfish and other invertebrates, and the 4-inch caught 71.9 kg. The 3-inch caught 504.3 kg of miscellaneous organisms, mostly tunicates (sea squirts) with some shell and detritus, and the 4-inch caught 469.7 kg. Total catch weight was 1,616.8 kg in the 3-inch and 1,473 kg in the 4-inch.

Also compared were the 3-inch and 4.5-inch tailbags. The 3-inch caught 1,037.7 kg of blue crabs, and the 4.5-inch caught 680 kg. The 3-inch caught 131.7 kg of southern flounder, and the 4.5-inch caught 35.4 kg. The 3-inch caught 66.2 kg of other finfish, and the 4.5-inch caught 10.5 kg. The 3-inch caught 62 kg of rays, jellyfish and other invertebrates, and the 4.5-inch caught 56 kg. The 3-inch caught 457.3 kg of miscellaneous organisms (mostly tunicates with some shell and detritus), and the 4.5-inch caught 329.7 kg. Total catch weight was 1,754.9 kg in the 3-inch and 1,111.7 kg in the 4.5-inch.

Bycatch reduction is a major concern in every fishery, and estuarine crab trawling is no exception. While blue crabs are the primary species being sought, southern flounder are also economically important to the fishery during winter and spring. Other types of marketable finfish are sometimes caught incidentally to the target species and may be sold to increase the revenue. With adoption of a 4-inch tailbag, expect a 5 percent reduction of legal crab catch and no reduction of legal flounder. About 10 to 20 percent of sublegal crabs and 20 to 30 percent of sublegal flounder will escape the 4-inch tailbag depending upon the season. With a 4-inch tailbag, expect finfish reduction of 25 to 30 percent during the summer. With the adoption of a 4.5-inch tailbag, expect a 15 to 20 percent reduction of the legal crab catch and 40 percent reduction of legal southern flounder catch. With

the 4.5-inch tailbag, expect escapement of 40 to 50 percent of sublegal crabs and up to 80 percent of sublegal southern flounder depending upon the season. With a 4.5-inch tailbag, expect 85 percent of all other finfish to escape.

- 95FEG-18

Use of Peeler Crab Pound Nets

The economic viability of peeler pounds was assessed during the spring, summer and fall. The pounds were fished in the lower Currituck Sound in the 1995 season. Too few peelers were caught to justify the expenditure in equipment, cost or effort.

- 95FEG-29

Tests of Modified BRD in Shrimp Fishery

A modified large-mesh extended-funnel (MLMEF) bycatch reduction device (BRD) was tested in 1995 in the shrimp fishery in North Carolina's estuarine waters. Based on 126 usable tows, the study found few places in Pamlico Sound or its tributaries where these devices cannot be used. The best results occurred when the MLMEF was installed behind the turtle escape device (TED) about halfway from the end of the tailbag to the TED and the MLMEF accelerator was tied 20 meshes back of the BRD to the sides of the tailbag. Calm weather (<15-knot wind) resulted in better catches and lower bycatch, while muddy or brown water eliminated the effectiveness of MLMEFs.

- 95FEG-49

Development of Trip Ticket Computer Software

The final report on the landing trip ticket system by Seaside Management Systems is the manual for its software.

- 95FEG-53

Development of Shrimp Pound Nets and a Comparison to Trawls

An alternative gear for harvesting shrimp — the pound net — was tested from May to August 1995. Three pounds were compared to trawls that were fished in the same locations. Brown shrimp accounted for 75.9 percent of the combined total of the first two pounds and 68.1 percent of the third pound. Brown shrimp also accounted for more than 95 percent of the trawls. No white shrimp were captured in the trawls or the pounds. The pounds caught consistently larger shrimp than the trawls, and both methods produced similar counts. The pounds resulted in little or no bycatch, which was released alive.

- 95FEG-82/83

Fyke Net Alternative to Gill Nets

Four fyke nets with lead, wings and tailbag were redesigned to place the entry tunnel at the bottom of the bag rather than in the middle. The nets were set with anchors rather than poles to make them easily moveable. Three nets were set for 350 days. One net was set for 75 days. The gear was not successful at catching flounder because water movement caused the wings and lead to lie over the entry tunnels.

- 95FEG-90

Striped Bass Bycatch in Flounder Gill Nets

Striped bass bycatch was measured in flounder nets from May 1995 to April 1996. As the water cooled, the flounder catch declined and the bass catch increased. Three flounder gill nets were used: 1) NTD-flounder nets equipped with no floats or tie-downs; 2) TD-flounder nets equipped with 30-inch tie-downs and 2-ounce floats every 10 yards; and 3) RNTD-flounder nets with no tie-downs and 2-ounce floats every

10 yards, set and fished with a hydraulic net reel. All were about equal in striped bass catches. Other bycatch species are listed.

- 95FEG-99

Design of Trip Log System for Crab Potters

The project had two objectives: 1) to evaluate the use of trip logs to record catch-effort data for each trip taken by a selected group of crabbers; and 2) to distribute a general survey to crab potters throughout North Carolina to help create a socioeconomic profile of the people involved in the fishery. The selected group of crab potters recorded information in specially designed logs. This information included daily catch totals, grade of catch, numbers of pots fished, number of crew members, movement of pots, missing pots, dockside values, expenses, dead/diseased crabs and observations of water conditions. The information was collated into a database by the project's primary investigator. The general survey was sent to everyone who held a North Carolina crab potting license and reported at least 6,000 pounds of crabs landed in 1994. These criteria produced a mailing list of 960 people. More than 25 percent of the surveys were returned. The geographic spread of the returned surveys very closely mirrored the geographic distribution of the licenses, lending credence to the validity of the survey's results. According to the survey's responses, about 1,000 people in North Carolina are at least significantly dependent on crab potting for their income. Among them, 67 percent depend primarily on crab potting for their livelihood.

The extension phase of the project had two objectives: 1) to disseminate pertinent information to crabbers and 2) to initiate another season of the trip log project. The project concluded that there is no average crabber in North Carolina.

The crabbing season, number of pots used, frequency of moving pots and catch per unit effort all vary widely. Also, while a significant majority of commercial crab potters see the need for some type of effort management in the fishery, the project found that there is no clear consensus on what form that management should take.

- 95FEG-100

Live Shrimp Research and Development

The market for live shrimp as bait or food is currently nonexistent in North Carolina. This research shows how it is possible to catch, hold, cull, handle and transport live shrimp. Six methods of catching were analyzed: channel nets, skimmer trawls, traditional trawls, cast nets, shrimp pound nets and hand seines. Survival rates for each were: 80 to 95 percent for channel nets, 80 to 95 percent for skimmer trawls, low rates for traditional trawls, 95 to 99 percent for shrimp pound nets and 100 percent for cast nets and hand seines. The traditional trawls, cast nets and hand seines were all ineffective for commercial use for various reasons. The shrimp pound net was effective, but there are few acceptable areas (due to N.C. regulations) where they can be fished. Channel nets and skimmer trawls remain the most effective catching methods. The main factors in catching shrimp were tow time, culling time and bycatch composition. Tow times should be kept to a minimum. Culling times should be kept under seven minutes for maximum survival. A wet culling tray has a 50 to 75 percent higher survival rate than a dry culling tray.

Water quality was important. Dissolved oxygen (DO) should be between 5 ppm and 10 ppm. Ammonia should be below .2 ppm. The pH should be maintained between 6.5 and 7.5. Temperature, the most important aspect, affected

the other three components of water quality. In general, keeping the water as cool as possible allowed it to hold the maximum amount of DO and reduced the toxicity of any ammonia present.

Survival was increased by carefully holding, handling and transporting the shrimp. Onboard holding requires a live well with water circulation and aeration. It should hold a maximum of 1 pound of live shrimp per gallon of water. On-shore holding has the same requirements as onboard holding. Handling should be kept to a minimum. Water quality and density should be monitored when transporting shrimp. Tank designs for each application are discussed in the report.

- 95FEG-104

Biodegradable Panels for Ghost Crab Pots

Commercial fishers studied three types of biodegradable panels to determine which would provide the maximum service while posing the least threat to sea life if the pot were lost, becoming a ghost pot. The overall choice was the panel (a 4.5-inch by 3-inch panel made of .5-inch by 1-inch wire) attached with cotton cable. The panel allowed large crabs and fish to escape, and the cotton cable lasted almost the entire season.

- 95FEG-114

Improvements on the Large Mesh Extended Funnel Bycatch Reduction Device to in the Shrimp Fishery

This report describes the design of the modified LMEF/BRD, includes a handout for installation instructions and displays a picture of the device. One hundred of these devices were constructed and distributed to fishers.

1996 Fisheries Equipment & Gear

- 96FEG-01

Develop Statistical Models from Gill Net Data in Albemarle Sound Fisheries

Models were developed to estimate the mean catch rate of striped bass, blueback herring, hickory shad, American shad and white perch using gill nets near the mouth of the Roanoke River.

- 96FEG-11

Test Multiple Tie-Down Flounder Nets

This study compared flounder nets tied down at a controlled height of 48 inches to nets tied down at 36, 24 and 12 inches. The study determined that 24-inch tie-down was sufficient to catch flounder while minimizing bycatch.

Results also suggested a need for concern about bycatch of largemouth bass and undersized flounder in the upper tributary system. The findings are discussed in relation to previous flounder studies and suggestions are made for future fisheries management.

- 96FEG-15

Bycatch Reduction in the Inshore Shrimp Trawl Fishery

This study determined the percentage of finfish reduced and the percentage of shrimp lost during the use of three bycatch reduction devices (BRDs). The research method used was paired towing, and each of the three BRDs received a minimum of 10 experimental tows.

A total of 2,800 kg of finfish was caught in the control net. A total of 1,279 kg of finfish was caught in the nets with BRDs. For all tows, BRDs reduced finfish by 54.3 percent.

Spot made up 58 percent of the finfish catch in the control and 60 percent in the nets with

BRDs. Croaker made up 33 percent of the catch in the control and 30 percent in the nets with BRDs. Weakfish made up 5 percent of the catch in the control and 6 percent in the nets with BRDs. Miscellaneous finfish made up the rest of the catch.

The control net caught 5,420 kg of all species, and the BRD net caught 3,753 kg. The control net had a combined shrimp catch of 408 kg, and the BRD net had a combined shrimp catch of 370 kg for a reduction of 9.3 percent.

- 96FEG-16

Improving Passage Efficiency of Adult American Shad at Low Elevation Dams

Three low-head dams on the Cape Fear River, constructed between 1915 and 1934, obstruct upstream migration of adult American shad. Fishways incorporated in the dams are ineffective for fish passage. The researchers examined the efficiency of “shad lockages” as aids to upstream migration in 1996. Study indicated that 75 percent of shad at the base of the dam entered the lock chamber, but only 31 percent successfully passed upstream.

Changes to the locking procedures were instituted in 1997, which included positioning the lower lock gates to retain fish in the chamber for longer periods and increasing the frequency of lockages. Also, a steep pass Denil fishway was installed on one lock. Ultrasonic tracking was used to determine whether passage of American shad improved during 1998.

Results indicated an almost twofold improvement in passage of American shad — from 31 percent in 1996 to 61 percent in 1998 — as a result of the changes in locking procedures. The steep pass fishway performed poorly with only 8 percent of fish tagged below the dam using the fishway.

- 96FEG-19

Design of Trip Log System for Crab Potters II

This report presents information gathered during the second year of the project. Activities were essentially the same as those during the project’s first year (95FEG-99). The intent was to provide the Division of Marine Fisheries with more data on catch-effort ratios and other socio-economic information pertinent to North Carolina’s crab pot industry.

The project had two objectives: 1) to use trip logs to record catch-effort data for each trip by a selected group of crabbers and 2) to help create a broader profile of the fishery by distributing a general survey to North Carolina crab potters. Some of the data gathered by this study were distributed in a newsletter to commercial crab potters statewide.

- 96FEG-31

Statistical Analysis of Long-Term Blue Crab Data

This study provides information needed for providing a more comprehensive stock assessment for the blue crab in North Carolina. The following objectives were addressed: 1) to identify long-term trends in blue crab abundance as measured with fishery-independent research surveys; 2) to describe the relationship between fisheries-independent catch-per-unit-effort (CPUE) and commercial harvest; 3) to identify potential stock-recruit and recruit-juvenile-adult relationships; 4) to quantify crab mortality rates; 5) to estimate historical biomass and fishing mortality rates; and 6) to estimate fisheries management targets such as Maximum Sustainable Yield.

Researchers analyzed data from N.C. Division of Marine Fisheries (NCDMF) and from scientific studies. NCDMF fishery-dependent

data included both voluntary and mandatory reporting of commercial blue crab harvests. Fishery-independent data were available from two NCDMF research surveys — Programs 120 and 195. These data were compared with other published scientific data.

Researchers conclude commercial landings have increased systematically over the last 10 years. During this time fishery survey CPUE remained relatively stable while spawning stock abundance was well below average between 1992 – 1996. Mortality rates did not increase.

This study identified biological patterns that should be considered in management of the state's blue crab fishery including: 1) a strong spawning stock-recruitment relationship; 2) females harvested at the beginning of their sexual maturity; 3) high annual variability in recruitment; 4) strong density-dependent mortality rates, which are destabilizing to population dynamics at low abundances; and 5) steadily decreasing biomass and sharply increasing fishing mortality rates, the latter of which are 2-3 times levels that are sustainable.

Researchers make recommendations for further and ongoing studies of the blue crab emphasizing that this study is an initial step towards a more comprehensive fishery stock assessment.

- 96FEG-48

Gill Net Selectivity Study

This project was a sinknet mesh-size selectivity study focusing on kingfish, weakfish and other marketable species. The objective was to quantify the size of kingfish, weakfish and other marketable species that a particular net size captures and to calculate the catch per unit effort of each net (1 1/4, 1 5/16, 1 3/8, 1 7/16, 1 1/2 bar mesh size of 100 yards.)

In the course of this study, 8,304 fish were

measured with bycatch of 1,952 fish of assorted species and scrafish (menhaden, herring, hickory shad, bumperfish, butterfish, spotted and red hake, highhat and banded drum) weighing 4,042 pounds. Each of the 89 trips is listed with water temperature, wind direction, depth and location.

- 96FEG-53

Study Atlantic Sturgeon Populations in North Carolina

This project conducted a tagging study of Atlantic sturgeon in southeastern North Carolina, collected tissue samples for genetic analysis, and kept records of catch per unit of effort and condition of fish collected in gill nets over the period 1996-98.

Fish were collected using a sink net having 10.16 centimeter stretched mesh. Nets were set overnight and fished daily in coastal waters off Lockwood Folly Inlet in Brunswick County, North Carolina. Incidental captures of sturgeon in regular operation of a 3.8 centimeter stretched mesh net set in the same area also were recorded. Fish collected were measured to the nearest millimeter total length and fork-length photographed. Each fish was tagged with at least two dart tags: one (or two) with U.S. Fish and Wildlife Service reward information, and one bearing Cape Fear River Sturgeon reward information. A small fin clip was taken from the left pectoral fin and preserved in 70 percent ethanol for genetic analysis.

- 96FEG-71

Develop Improved Bycatch Reduction Device for Inshore Shrimp Fishery

The objective of this project was to develop a bycatch reduction device (BRD) with greater shrimp retention and less capture of non-targeted species. Four designs were tested: 1) Florida fish

excluder (FFE) in conjunction with cyalume light sticks; 2) Florida fish excluder in conjunction with a Dukane sonic device; 3) a rigid semicircular frame encompassing the top half of the tailbag with an extended horizontal or vertical opening and 4) a Plexiglas version of a Florida fish excluder.

Cyalume light sticks in conjunction with a Florida fish excluder proved to be unsuccessful as did the Dukane sonic device.

The rigid semicircular device and Plexiglas Florida fish excluder showed more promise. The rigid device showed a reduced bycatch rate over a standard Florida fish excluder but at a lower shrimp retention rate.

Several Plexiglas Florida fish excluder designs were tried with mixed results in bycatch reduction and shrimp retention. None seemed significantly better than the standard FFE.

The researcher notes that further experimentation with rigid semicircular devices and Plexiglas Florida fish excluders might be worthwhile.

- **96FEG-89**

- Evaluate Larger-Mesh Gill Net Catch of Flounders and Reduced Bycatch of Striped Bass**

- This project determined the variations of striped bass bycatch and mortality in flounder gill nets of different mesh sizes. Flounder gill nets of 5.25-, 5.5-, 5.75-, 6- and 6.5-inch stretched mesh were used. A logbook showed the total number of flounder and striped bass caught for each mesh size per fishing trip. The condition (alive or dead) was noted for captured striped bass.

- All samples were obtained from the east and west Albemarle Sound. Not all meshes were fished, and 5.25-inch mesh nets were not used during months when crab bycatch was high

because the crabs could destroy them within days. This practice is common in the commercial gill net fishery in the Albemarle area.

The striped bass bycatch (320) in flounder gill nets was 3.2 percent of the total flounder catch (9,745). The majority of bycatch (87.8 percent) occurred from November to April, when the commercial season for striped bass was open, minimizing waste.

- **96FEG-104**

- Use of Restored Oyster Reef Habitat by Economically Valuable Fishes and Crabs in NC: An Experimental Approach With Economic Analyses**

- The objective of this project was to determine experimentally whether economically valuable fishes, crabs and shrimps (target species) recruit to and utilize subtidal oyster reef habitat in North Carolina.

- North Carolina spends a substantial sum of money annually restoring oyster reefs to maintain oyster harvests. Unfortunately, oyster harvests have continued to decline primarily due to the introduction of diseases, degradation of habitat through fishing practices (dredging and trawling) and reduced water quality in some areas. Therefore, it is of great interest to the N.C. Division of Marine Fisheries (DMF) and others to determine whether oysters and restored oyster reefs provide other ecological and economic services, including habitat for target species.

- To achieve that goal, the researchers 1) compared patterns of target species recruitment and utilization on the three types of cultch material (oyster shell and two sizes of marl rock) in West Bay, Pamlico Sound; 2) determined how bottom water hypoxia in the Neuse River influenced target species utilization of reefs located at different water depths; and 3) compared target species abundance on natural and restored reefs

near Ocracoke Island. In addition, the relative fishery value of restored and natural oyster reef habitat was compared, and the total fishery production on restored oyster reefs was evaluated economically.

Target species were sampled monthly or more frequently on experimentally restored oyster reefs (i.e. cultch plantings) located in West Bay, Pamlico Sound, the Neuse River estuary and near Ocracoke Island during the spring, summer and fall of 1996 and 1997.

Sampling was conducted using fish traps, gill nets, visual observations, habitat traps and minnow traps.

The target species *Callinectes sapidus* (blue crab) and *Orthorpristis chrysoptera* (pigfish), as well as the nontarget species *Bairdiella chrysoura* (silver perch) and *Lagodon rhomboides* (pinfish), recruited to restored oyster reefs in West Bay and the Neuse River in 1996 and 1997. A total of 15 target species were found to utilize restored oyster reef habitat: blue crab, pigfish, *Anguilla rostrata* (American eel), *Archosargus probatocephalus* (sheepshead), *Chaetodipterus faber* (spadefish), *Cynoscion nebulosus* (speckled sea trout), *Cynoscion regalis* (weakfish), *Leiostomus xanthurus* (spot), *Micropogonias undulatus* (croaker), *Mycteroperca microlepis* (gag grouper), *Parlichthys lethostigma* (southern flounder), *Pogonias cromis* (black drum), *Pomatomus saltatrix* (bluefish), *Scomberomorus maculatus* (Spanish mackerel) and *Trachinotus carolinus* (pompano). Oyster toadfish (*Opsanus tau*) and gray snapper (*Lutjanus griseus*) also utilize oyster reefs. No evidence was found that economically valuable shrimps recruit to or utilize oyster reefs.

Most of the target species were present on reefs from late May to late September in West Bay and the Neuse River, and several species

were found on reefs at Ocracoke in mid-October. The relative ages of target species on reefs ranged from the zero-year class to at least the third-year class but probably much older (ages were estimated from lengths only). All target species except bluefish were found in higher abundance on oyster reefs than on the unstructured sand bottom away from reefs at all sites.

In West Bay, greater numbers of fishes were sampled in traps and gill nets on small marl reefs compared with large marl and oyster shell reefs. This is mainly because relatively high numbers of small pigfish, silver perch and pinfish were sampled in traps, and larger croaker, flounder and black drum were sampled in gill nets on small marl reefs than in the other habitats. Other target species showed no preference for reef type, and there was no difference in the number of species found on the reef types.

Results from habitat-trap sampling showed that oyster reefs support large numbers of small benthic crustaceans (amphipods, mud crabs and grass shrimp) and gut content analysis indicate that many fishes (e.g. spadefish, spot, croaker, pigfish and southern flounder) and blue crab prey upon the crustaceans. The large piscivorous fishes (e.g. weakfish and speckled trout) were found to prey upon the smaller fishes foraging for crustaceans. Sheepshead apparently forage on reefs primarily for mussels.

Results indicate that oyster reefs attract target species in relatively high numbers, apparently provide important foraging habitat to blue crabs and many fishes, are potentially important refuge for mating blue crabs and represent recruitment substrate to several fishes and blue crabs.

Stratification and associated bottom-water hypoxia/anoxia had a dramatic influence on the patterns of target species utilization of oyster reefs in the Neuse River Estuary. The most common target species in the Neuse River were

blue crab, sheepshead, pigfish, southern flounder, spot and croaker. Weakfish and gag grouper also utilized oyster reefs in the Neuse River. Prior to a major hypoxic/anoxic event in July 1997, the target species utilized equally short and tall oyster reefs located at both 3- and 6-meter depths.

During more than three weeks of hypoxia/anoxia in water deeper than 5 meters in July, fishes and blue crab were forced to flee from the short reefs at 6-meter depths and move onto the tall reefs at 6-meter depths and the reefs at 3-meter depths. Hypoxia killed all benthic prey species (amphipods, mud crabs and grass shrimp) located on the short reefs at 6-meter depths.

The rapid increase in fishes and blue crabs on reefs without hypoxia was followed by a rapid decrease in the number of benthic prey species, apparently due to the increase in the density of feeding fishes and crabs. Results of this experiment indicate that 1) restored oyster reefs in the Neuse River provide important recruitment and foraging habitat for many target fishes and blue crabs; 2) restored oyster reefs in shallow water, and perhaps tall reefs in deep water, provide important spatial and structural refuge from low oxygen disturbances; and 3) destructive oyster harvesting practices reduce the overall fishery value of oyster reefs.

Restored and natural oyster reefs at Ocracoke were found to support several target species, including pigfish, sheepshead, black sea bass, gray snapper and weakfish. There were no differences in the numbers of target species found on these two types of oyster reefs when sampled in October 1997.

Economic analysis showed that the combined commercial fish and crab landing value was greater on the three oyster reef types (oyster shell, small marl and large marl) than the un-

structured sand bottom in West Bay.

On reefs, the potential long-term commercial value of fishes and crabs to the fishing and crab industries was greater than the value of oysters to the oyster industry in West Bay. The small marl oyster reefs provided the greatest value in overall fishery landings than any of the other reef material.

The commercial value of fishes and crabs on reefs at both depths in the Neuse River was greater than the value of fishes and crabs on the surrounding sand bottom. The value of fish landed on shallow-water reefs was greater than the value on deep-water reefs because fishing conditions were poor in deep water during the periods of bottom-water hypoxia/anoxia in summer 1996 and 1997.

The commercial landing value of restored reef habitat near Ocracoke Island was equal to the value of fish caught on natural reefs in the same region.

The analyses suggest that restoring oyster reef habitat enhances fish production and potential harvest levels in North Carolina estuaries.

- 96FEG-105

- Evaluation of Escape Panels in Eel Pots

- The objective of this project was to evaluate under commercial fishing conditions the best method for grading undersize American eels (*Anguilla rostrata*) in their natural habitat. The research took place between April and October 1996 in the Pamlico River in Beaufort County. For the control and experimental tests, the total weight and number of eels for each sampling trip was divided by the number of pots fished to produce a standardized variable for analysis. During this study, 4,057 eel pots were fished and an estimated 14,380 eels were harvested. A total of 6,443 eels were evaluated, measured and

cataloged.

The mean length value for the experimental pots was 11.8 inches, while the mean length value for the control pots was 12.8 inches. Both pot types appear to retain eels starting at about 8 to 10 inches. The study results also showed that legal-sized eels are being lost from control pots with the required escape panel. Harvest of legal-sized eels was reduced about 88 percent by number and 63 percent by weight. This reduction is a substantial cost to the few remaining commercial eel fishers. No illegal-sized eels (6 inches) were caught.

1997 Fisheries Equipment & Gear

• 97FEG-2

Gill Net Selectivity for Striped Mullet

This study provides data on gill-net selectivity in the striped mullet run-around sink net fishery. Commercial fishing vessels provided samples from May through November 1997 in eastern Pamlico and Roanoke sounds.

Six monofilament nylon gill net mesh sizes were tested — 3.125-, 3.25-, 3.5-, 3.75-, 4- and 4.125-inch. Each mesh size was hung in two 200-yard shots. Twine size was 139 (.40 mm) for all except the 3.5-inch mesh, which used 177 (.47 mm). The nets were 30 meshes (3.125 inches) to 50 meshes (4 inches) deep with hard plastic floats placed at 4-foot intervals along the top line. The bottom line consisted of 50 pounds of lead core line per 200 yards, and nets were hung on the half.

A typical sample involved the fisher running two or three shots of joined net (400 to 600 yards) in a circle around sighted fish. Mesh sizes were chosen by the commercial fishers based on the size of the sighted fish. Each mesh size that contained approximately 50 pounds of striped mullets was sampled. Fish gilled or wedged in

nets were measured and weighed when possible. Sets yielding few or no fish were not used as samples.

Of the six mesh sizes tested, generalizations cannot be drawn on the smallest or largest sizes because both ends of a length frequency distribution need comparison to the next most similar size.

The results of the last mesh size comparison (4.0 vs. 4.125 inches) should be viewed with caution due to low sample size (30 fish) in the 4.125-inch mesh.

Selectivity decreases from the 3.250 through the 3.75-inch mesh. Researchers relate the decrease in selectivity to the increase in fish girth rather than length during late summer and fall. Lack of distinction of fish length in the 3.500 vs. 3.750-inch selectivity curves indicates that seasonal mesh size distinctions may be necessary if restrictive mesh sizes become implemented for striped mullet management.

Tests on the 3.75-inch vs. 4-inch and the 4.125-inch meshes indicate that these meshes select for at least two different cohorts. Researchers conclude that, although valuable data have been obtained toward development of management of striped mullet, no specific recommendations can be made based on this study alone. Further study is recommended using equal soak times for all mesh sizes and that other methods of gear testing be developed for testing mesh selectivity of striped mullet.

• 97FEG-3

Bycatch Reduction With Hoop Net Seine

This project compared the mortality of bycatch in hoop net seine and gill nets by making 75 trips in five different bodies of water.

The hoop net seine was constructed with a 600-yard #15 seine, 2 .25-inch mesh by 60

meshes deep, with a 20-foot one-tunnel hoop net with 4-foot hoops, sewn in 40 yards from beginning end. The gill net was constructed with 600 yards #139 mono. webbing, 3.25 inches by 25 meshes deep.

When setting the hoop net, the researcher started at shore anchoring the beginning end. Then he backed out at an angle until reaching the hoop net. After reaching the hoop net, he turned making a funnel shape enclosing the shoal. He anchored the ending end at shore. Once the net was set, he pulled the hoop net out and anchored it. Next, he moved in the water encircled by net to make noise by beating the water with paddles and hitting the boat. This ran the fish toward the hoop net. After running the fish, he pulled the net at the hoop to collect fish.

While fishing the hoop net seine in Pamlico Sound, Albemarle Sound, Perquimans River, North River and Little River, there was no variation in the amount of fish caught. All 15 trips to each body of water produced little or no fish in the hoop net.

After several day trips with no success of catching fish with the hoop net, night trips were attempted. This resulted in better gill net results and a few fish in the hoop net. The fish types caught in the hoop net were mostly white perch and yellow perch, some turtles, nanny shad and a few striped bass. All bycatch in the hoop net was put in a holding pot for 24 hours to check mortality rates. Mortality from the hoop net was 0.

The gill net catch was much greater with more varieties of fish. The mortality rate of the gill net was also 0 because the nets were not left unattended and most of the fish caught were marketable.

The hoop net was difficult to set correctly, and many attempts were needed to establish the best setting position. It was also very bulky and almost completely filled the boat. Use of the

bycatch reduction seine eliminates all mortality of nonmarketable and undersized fish.

The biggest problem with the hoop net was that few or no fish were caught. The researcher concluded that the bycatch reduction seine did not work because it failed to catch a sufficient amount of fish.

- 97FEG-4

Gill Net Selectivity for Flounder

Undersized flounder present a serious bycatch problem in the flounder gill net industry. Though undersized flounder are immediately released and are handled with the least trauma possible, their survival is not guaranteed.

This study compares the catch rate of 5.5-inch webbing versus 6-, 7-, and 8-inch webbing. The overall reduction of catch with 7- and 8-inch webbing makes these unattractive. However, this experiment suggests that 6-inch webbing may be harvest-friendly, as well as economically superior to 5.5-inch webbing.

The findings are discussed in relation to previous flounder studies as well as the management concerns of future fisheries.

- 97FEG-9

North Carolina Fishery Assessment

The striped mullet, *Mugil cephalus*, has supported a commercial fishery in North Carolina since the 1800's and today ranks in the top ten of commercially valuable fin fisheries. In an effort to provide unknown life history information from the state for future striped mullet management, this study was developed to determine striped mullet reproductive seasonality, fecundity and size and age of maturity.

Monthly samples were made using both fishery independent sampling strategies. Otoliths were removed from the inner ear and sectioned for aging, and gonads were fixed and histologi-

cally prepared for fecundity estimation and maturity indices.

Based on the presence of recently post-spawned fish, spawning began in October and continued through December. The collection of a hydrated female less than one km from an inlet, coupled with the presence of post-ovulatory follicles from fish sampled within the estuary, provided strong evidence for limited near-shore spawning and/or short offshore residence times during the spawning season.

Males matured at a smaller size than females — 285 mm fork length and 335 mm fork length respectively. Fecundity correlated well with body size and ranged from 0.5 to 4.2 million eggs for fish between 302 to 597 mm fork length. Differences in the timing and the biology of striped mullet reproduction occurred when results were compared to other research efforts.

This study represents the first detailed description of striped mullet reproductive biology from North Carolina, and should provide fishery managers with the initial data needed to develop management strategies.

● 97FEG-10

Gill Net Selectivity for Coastal Shark Species

Sharks are frequent bycatch of other fisheries off the North Carolina coast. This two-year project studied sinking gill nets for selectivity, location and amount of shark bycatch in southeastern North Carolina. Timing and duration of pupping was also examined.

A total of 76 trips were taken from May through the first week of October in 1997 and the same months in 1998. A study net made of 208-mm nylon monofilament with five panels of different sizes (3, 4, 5, 5.5, and 6 inches) was used to test for selectivity. Locations ranged from the surf zone to 2.5 miles offshore in the area

from Long Beach to Shallotte Inlet.

Commercial nets were set occasionally for additional gill net selectivity information. Long lines were sometimes used to compare species selectivity between the two types of gear.

Small non-commercial sharks often dominated the catches, especially the Atlantic sharpnose. Distribution or behavioral characteristics may account for the abundance of this species in catches, but researchers speculate that the numbers may reflect actual numbers of the sharpnose in these waters. Mark-recapture studies would confirm this finding.

Results indicate that nearshore waters in the southeastern area may be nursery grounds for several species such as the Atlantic sharpnose, spinner and the scalloped hammerhead sharks. There is also evidence a protracted pupping season exists for the Atlantic sharpnose in these waters.

Commercially important sharks were rarely caught although this may be due to lack of susceptibility of large sharks to nets. Evidence of larger species was found by catching them with longlines set near the gill nets. Further study using longlines would establish abundance and distribution of commercially important species.

High juvenile catch rates occurred in commercial nets with mesh sizes of 2.75 and 2.625 inches in the summer months. This finding argues in favor of restricting use of these meshes close inshore during the summer. Most findings, however, indicate little selectivity for sharks relative to mesh size or soak time. Researchers found that sharks tend to get tangled rather than gilled in the nets. They die rapidly, once entangled, due to stress. The research suggests shark bycatch might be more effectively managed by timing and location of gill nets rather than by restricting mesh sizes or soak times.

- 97FEG-11

Selectivity of Square Mesh Escape Panels in the Sciaenid Pound Net Fishery of North Carolina

This project measured the effectiveness of escape panels of various twine size and mesh size for reducing bycatch of undersize fish using an experimental pound net with a retention pound attached.

The experimental pound was set north of Big Foot Slough Channel near Ocracoke. It and the attached retention pound were constructed of #18 strand, 2-inch stretched mesh, nylon webbing. The net lead was about 500 yards long and constructed of #24 strand, 6-inch stretched mesh nylon.

Three square mesh escape panels were tested: 1) a #42 strand, 3-inch stretched mesh nylon panel; 2) a #84 strand, 2.75-inch stretched mesh panel; and 3) a #84 strand, 3-inch stretched mesh panel. Each panel was 10 feet by 10 feet in dimension and was installed in the center of the west side of the standard pound. Eleven samples were collected from each panel from July 1, 1997, to October 7, 1997.

Results showed that the 3-inch #84 strand escape panel warrants further testing. Gilling was not a problem and fish escapement was good.

The use of this experimented pound net configuration was inadequate for determining fish reductions. Installation of escape panels in pound nets is critical. In Pamlico Sound, due to wind-driven tides, the direction of water flow can change daily and the experimented configuration does not allow flexibility in location.

The "covered bag" design also has faults. Fish growth and recruitment through the season affects catches, and larger fish moving through the test area prevented testing each panel on the same size distribution of fish. This skewed the results and prevented comparisons between

different mesh and twine size combinations.

Testing will continue during the summer of 1998 as part of the N.C. Division of Marine Fisheries' Atlantic Coastal Fisheries Cooperative Management Act project.

- 97FEG-12

Juvenile American Eel Migrations in the Cape Fear River Drainage/
Parasitic Infection of the American Eel in the Cape Fear River

Although the American eel (*Anguilla rostrata*) once supported a commercial fishery in the Cape Fear River drainage, such a fishery no longer exists in this area. Possible reasons for the decline are decreased market, reduced fishing effort or a decrease in eel abundance.

Anecdotal reports of population declines for this species in the Cape Fear River led researchers to suspect that low-elevation dams on the Cape Fear River were preventing juvenile eels from reaching freshwater nursery grounds.

Eels are catadromous — living in fresh water and going to the sea to spawn. While there has been investigation of effects of low-elevation dams on anadromous fish — those that swim upriver to spawn — effects on catadromous species are not known.

Eels were collected from March through September 1998 using eel pots and electrofishing. The sampling area extended from Wilmington to above Fayetteville, and included Lock and Dam numbers 1 and 2. Eel pots were used at sites above Lock and Dam #2. Eel pot dimensions were 23 cm by 79 cm with .05-cm mesh. Areas below Lock and Dam #2 were sampled using both methods. Various baits were used based on information from local fishers.

Electrofishing was done using a Smith-Root GPP Shore Electrofisher with a 16 horsepower generator from an aluminum jon boat. Frequent-

cies depended upon site conductivity

No eels were captured above Lock and Dam #2, and only 40 eels were caught below Lock and Dam #2, in spite of extremely high effort. Of the 40 caught, six were tagged and released and 34 were dissected and found to be infected with the parasite *Anguillicola crassus*.

A. crassus leaves eels open to bacterial infections and causes a thickening of the swimbladder. It can result in fibrosis and, in some cases, rupturing of the swimbladder.

Data from this study suggest a dramatic decrease in eel abundance may be responsible for the decline of this fishery. The high infection rate of eels with *A. crassus* suggests the parasite may be responsible for the decrease in eel abundance. The parasite can also develop in other fishes found on the East Coast.

Researchers conclude that further investigation should be focused on the apparent decline of the American eel in the Cape Fear River drainage and on *A. crassus* infestation in other fishes and invertebrates.

- 97FEG-15

Video on Commercial Fishing Gear and Bycatch Reduction Devices

This video is on file.

- 97FEG-21

TED Development for Small Trawls

The objectives of this project were to reduce the loss of shrimp associated with the mandatory use of TEDs in small trawls used in inside waters, and to eliminate the frequent twisting of TEDs used in small trawls.

The National Marine Fisheries Service in 1989 required trawls in all North Carolina inside waters to use TEDs to protect sea turtles. Virtually all small trawlers operating on inside waters use single-grid, bottom-ejecting TEDs. When

trash (grass, horseshoe crabs, driftwood etc.) begins to accumulate on the grid, a bottom excluder catches the trash and opens a gaping hole through which a large percentage of shrimp escape.

In 1995, the NMFS revised TED regulations requiring additional flotation on the bottom-ejecting TEDs. This only compounded the problem, as over-floated, bottom-ejecting TEDs on small trawls can easily lift off the bottom, dumping even more shrimp out the hole caused by the amassed trash.

Twisting of TEDs is the other problem that frustrates TED users. Water pressure has a tendency to twist or roll TEDs. Once a net is twisted, the catch piles up in front of the grid. When the lazy line is used to haul the net up, all the catch is dumped back overboard. Although the additional flotation required by the NMFS eliminated some of the twisting, it still occurs much too frequently.

To attempt to solve these two major problems, a top-ejecting, hooped TED with a larger metal grid than normally used in small trawls was constructed.

The hoop in front of the grid is one inch larger in diameter than the grid. Floats were added to the top of the hoop and in the inside of the webbing behind the TED. This, along with the increased size of the TED, hopefully will stop the TED from twisting. Results of the tests are tabulated.

- 97FEG-24

Size of Flounder Caught by Gill Nets and the Catch of Marketable Bycatch

This project compared sizes of flounder caught and amount of marketable by-catch caught in flounder gill nets of mesh size 5.5-inch, 5.75-inch, and 6-inch. The nets were fished 90 times each, and the sizes of flounder caught

and marketable by-catch caught were documented.

● 97FEG-28

Biological Characterization of the North Carolina Spiny Dogfish (*Squalus acanthias*) Fishery

The spiny dogfish comprised a lucrative fishery from 1990 to 2000 when quota allocations between the winter fishery in North Carolina and the spring, summer and fall fishery in New England resulted in its closure in this state.

This study presents results of five separate tag-and-release efforts over a three-year period. Two were trawl surveys (1997 and 1998 SEAMAP cruises) and three were sink gill net studies funded through the N.C. Fishery Resource Grant Program. During the study, 10,132 spiny dogfish were tagged and released along the North Carolina coast, primarily in shallow coastal waters north of Cape Hatteras but also in the Wilmington area.

Assuming an average of six pounds as a marketable fish and a 60 percent tag reporting rate, the adult (harvestable) population size of the East Coast spiny dogfish stock is between 1.155 and 2.38 billion fish for the three-year period. The exploitation rate was 1.92 percent under these assumptions.

Researchers recommend reconsideration of the quota allocation for spiny dogfish bycatch in North Carolina gill net and trawl fisheries. They also recommend further studies, including those to determine if more than one stock exists for the east coast, and studies for age validation and reproductive development.

● 97FEG-29

Species and Size Selectivity in the Southern N.C. Ocean Gill Net Fishery

This project studies sizes and quantities of the species caught by a variety of mesh sizes — 2 1/2, 2 5/8, 2 3/4, 2 7/8, 3 and 3 1/8 inches of stretch.

Two 100-yard gill nets of each size were used. The test nets were fished along beaches off West Onslow and Onslow Beaches for 20 days in the spring and 10 days in the fall.

The nets were set overnight and fished every morning. The nets were rotated through the sets each day so that each net fished each site.

The 2 1/2-inch stretch mesh caught 1,263 sea mullets (650 pounds). All were sellable. Also caught were 533 weakfish (191.5 pounds), 50 percent of which were a legal size for selling. Other species caught were eight to 10 pounds of large shrimp, 14 pounds of ling and three pounds of black bass that were sellable.

The 2 5/8-inch stretch mesh caught 868 sea mullets (579.5 pounds), all of a sellable size. In addition, 303 weakfish (187.25 pounds), 69 percent of which were sellable. Thirteen pounds of ling and 10 pounds of black bass were also caught and were all sellable.

The 2 3/4-inch stretch mesh caught 722 sea mullets (505.5 pounds), all of sellable size. Other species caught were 569 weakfish (366.25 pounds), 88.5 percent sellable; 1005 spots (234.5 pounds), most of which were sellable; ling (4.5 pounds); black bass (16 pounds); and one grouper (6.11 pounds). All these were of legal size.

The 2 7/8-inch stretch mesh nets caught 375 sellable sea mullets (317.75 pounds), 446 weakfish (387.5 pounds — 88.2 percent sellable), 2,405 spots (756.5 pounds — all sellable), 81 pounds of sellable bluefish and nine pounds of sellable black bass.

The 3-inch stretch mesh nets caught 225 sea

mulletts (223.75 pounds — all sellable), 363 weakfish (335.75 pounds — 96 percent sellable) and 1340 spots (536.25 pounds — all sellable). Other sellable fish were 11 pounds of ling, 12 pounds of black bass and 200 pounds of shad.

The 3 1/8-inch stretch mesh net caught 139 sea mulletts (147.75 pounds — all sellable), 352 weakfish (356 pounds — 95 percent sellable) and 834 spots (417 pounds — all sellable). Also caught were 46.5 pounds of bluefish, 16 pounds of ling, 12 pounds of black bass and 250 pounds of shad. All of these were sellable.

The researcher says the data have implications for management decisions about gill net restrictions to protect undersize weakfish.

- 97FEG-30

Shrimp Trap Development to Reduce Shrimp Trawl Bycatch

This project sought to develop a shrimp trap as an alternative to the trawl net for purposes of reducing bycatch. Traps of several sizes and configurations were tried. After one week of trials, a modification was made so that the trap design used during the 39-day study period (June 1 to September 1) consisted of a rectangular trap 3 feet deep by 2 feet wide by 18 inches high. The entry funnel opening was 2.5 to 3 inches in diameter and the funnel extended to within about 4 inches of the back of the trap. Wire used was .5-inch mesh hardware cloth.

Traps were placed in three distinctly different areas: 1) flats, areas of shallow water, light current and near to marsh areas; 2) channels, relatively deep water, strong currents and soft bottom sediments; 3) bulkheads, positioned against bulkheads and seawalls so that the side of trap actually touched the bulkhead. Soak time for all tests was five to six hours.

During the tests, the harvest included more than 117 pounds of shrimp, 217 pounds of more

than 24 species of fish and nearly 330 pounds of blue crab and stone crab. Channels and flats proved to yield the best shrimp-to-bycatch ratios. Shrimp-to-bycatch ratios were relatively constant over the study period at about 1 pound of shrimp to 4.4 pounds of bycatch.

- 97FEG-31

Development of a Submerged, Anchored Pound Net to Reduce Bycatch and Water Hazards Created by Poles

This study sought to minimize the hazards of pound net poles while reducing bycatch.

The hazards presented by pound net poles to other fishers were reduced or eliminated by the design of a pound/fyke net held by mud anchors. Tallies were kept of targeted and non-targeted species caught with this net.

Three submerged pound nets were constructed by the principal investigator and a net company. The 20-foot-long nets were made of No. 18 twine with one square inch mesh. Tail bags were six feet in diameter with seven fiberglass hoops two feet apart. Photographs of the nets and more construction details were provided with the final report.

The researcher found the overall catch of targeted species was reduced slightly with the pound net when compared to similar-size gill nets. Bycatch, however, was significantly reduced and all bycatch and undersized fish were released alive, reducing bycatch mortality.

- 97FEG-33

Evaluation of a Daily Log Data-Gathering Effort and Surveys of the Blue Crab Potting/Crab Shedding Industry (Year 3)

The goal of this project was to gather data on catch-effort ratios and other socioeconomic

information from crab potters and soft-crab producers.

The objectives were 1) to distribute a general survey to crab potters throughout North Carolina to help the N.C. Division of Marine Fisheries (DMF) create a profile of the fishery; 2) get a selected group of crab potters from different geographic areas to keep daily trip logs to provide DMF with catch-effort data, dockside value and other socioeconomic information; 3) distribute a general survey to crab shedders to help understand the characteristics and economics pertaining to the peeler/soft crab industry; and 4) get a selected group of crab shedders to keep daily logs to provide DMF with data to assist understanding the biological and socioeconomic characteristics of the fishery. Extensive data are presented for each of these objectives.

- 97FEG-37

Characterization of Shallow-Water Mullet Gill Net Fisheries by Species, Bycatch and Fishing Method

Objectives of this project were to evaluate shallow-water mullet fishing to determine the bycatch of non-marketable species, provide resource managers with data regarding net sizes, open/closing dates for roe mullet season, and to determine how long nets may be left unattended with minimum mortality.

All fishing was done in the Albemarle Sound Management Area from August through November 15, and restricted to water depths of seven feet or less.

The number and pounds of edible/marketable species and the number of non-edible/non-marketable species were recorded for each mesh size.

Nets with a mesh length of three to four inches were used, not exceeding 1000 yards on any one fishing day. Nets with mesh sizes greater

than 3.5 inches were used only during the roe season (October 15 through December).

The study concludes that shallow waters can be fished for mullet without an excessive bycatch of non-marketable species. Striped bass averaged 1.2 fish per 100 yards of net and puppy drum averaged 1.4 fish per 100 yards of net.

- 97FEG-40

Certification of Bycatch Reduction Devices for North Carolina

This project in the Pamlico County schools was designed to help the N.C. Division of Marine Fisheries certify bycatch reduction devices in the shrimp trawl fishery. The Atlantic States Fisheries Management Council (ASFC) has adopted a protocol that Atlantic states within their jurisdiction must follow for the certification of bycatch reduction devices. In order for any bycatch reduction device to be used in North Carolina, it must be certified according to this protocol. In addition, bycatch reduction devices create a substantial reduction in the bycatch of all finfish and particularly weakfish without making shrimp trawling economically impossible.

Another objective was to ascertain the percentage of shrimp loss while using each bycatch reduction device.

When all tows for the control net were combined, 2,807 kg of finfish were caught. When all tows using bycatch reduction devices were combined, 1,720 kg of finfish were caught for an overall reduction of 1,087 kg or 2,391 pounds of finfish released. The overall finfish reduction for all tows was 39 percent in the bycatch reduction devices.

Weakfish made up 357.75 kg or 13 percent of the catch in the control and 234.5 kg or 14 percent of the catch in the bycatch reduction devices. The overall reduction by weight for weakfish was 33 percent in the bycatch reduction

devices. There were 6,250 weakfish in the control and 3,812 in the bycatch reduction devices for an overall reduction of 39 percent by number.

Spot made up 1,393.3 kg or 50 percent of the finfish catch in the control and 827 kg or 48 percent in the bycatch reduction devices.

Atlantic croaker made up 733 kg or 26 percent of the catch in the control and 438 kg or 25 percent of the catch in the bycatch reduction devices. Miscellaneous fish comprised the remaining 11 to 13 percent of finfish catch.

When all tows for the control net were combined, the catch for all species was 4,721 kg. The combined catch for all bycatch reduction devices was 3,557 kg.

The control net had a combined shrimp catch of 610 kg for all tows. The bycatch reduction devices had a combined shrimp catch of 576.4 kg for a reduction of 33.6 kg or 74 pounds of shrimp. The overall percentage of shrimp loss was 5.5 percent for all bycatch reduction devices.

The ASFMC has established the protocol to use in certifying bycatch reduction devices and is primarily concerned about reaching a 40 percent reduction in numbers of weakfish and Spanish mackerel. North Carolina must have adequate data to meet the protocol for bycatch reduction devices in the shrimp trawl fishery, although bycatch reduction is of concern across fisheries.

Shrimp trawling takes place in a very fragile ecosystem. Inshore shrimp trawling is adjacent to primary and secondary nursery areas, where most of the finfish are young of the year or juveniles that are nonmarketable and therefore wasted other than as cull scrap returned to the water to feed larger predatory fish, crabs and seabirds.

The shrimp trawl industry is working in areas that are already severely stressed because of human/animal waste, agricultural/urban runoff

and industrial pollution. The trawling industry must preserve the limited reproductive and growing capacities of our waters.

The industry benefits from reducing the volume of the catch. Less volume in the catch translates into more profit and less work for the shrimpers.

- 97FEG-41

- Gill Net Selectivity for Mullet Related to Fishing Depth

- Investigators employed drop lines as tie-ups to 3-inch mesh and 3.25-inch mesh stationary gill nets. Striped mullet (*Mugil cephalus*) catch rates were evaluated as they compared to the bycatch data of the control versus the catch rates of the tied-up (variable) nets.

- The reduction of sub-legal red drum bycatch shows promise. However, an increase of striped bass catch is a potential downside.

- The experiments and findings are described, as well as suggestions for fisheries' management concerns.

1995 Seafood Technology

- 95ST-42

- Development of New Value-Added Blue Crab Products

- Osprey Seafood Inc. developed and marketed frozen Steamed Crab Clusters. The product is a cluster of blue crabs, steamed, packaged, frozen and sold as a value-added product. Efforts are now being made to enter new markets.

- 95ST-52

- Development of New Product Line for Crab, Shrimp and Clams

- Sea Snacks Inc. developed and marketed two seafood dips — shrimp and crab. There was a problem with long-term flavor stability for the

dips, but an alternative method of freezing solved the problem. Value-added seafood can make a business more profitable. Distribution of the seafood dips is scheduled for January 1997.

- 95ST-112

- Automating Process and Record-Keeping Requirements Under HACCP**

- The U.S. Food and Drug Administration mandated inspection of seafood based on the Hazard Analysis Critical Control Point (HACCP) program. Effective December 18, 1997, this program requires all seafood packers, processors and importers to maintain a preventive program for ensuring the safety of seafood consumed in the United States. Industry bears the burden of proof through monitoring and record-keeping requirements during daily operations.

- This project was designed to prepare North Carolina's seafood industries to comply with the new HACCP regulations. The goal was to establish an automated process-monitoring and record-keeping capability that would comply with mandatory HACCP inspection. The project installed and operated a data acquisition system for use in process monitoring and HACCP record keeping. Industry workshops were held to train other North Carolina seafood companies and demonstrate the new technology.

- Results from the project have been disseminated through a North Carolina Sea Grant publication to provide simple installation and user-friendly directions for seafood industry personnel and through presentations at trade association and scientific society meetings.

1996 Seafood Technology

- 96ST-13

- Develop Seafood Handling Program for Restaurants**

- This project developed a handbook and videotape to give seafood restaurant personnel a better understanding of the importance of safe food handling practices. The material discusses the specific illnesses associated with seafood and ways to prevent seafood-related illness from occurring.

- 96ST-42

- New Techniques for Handling Fish for the Live Fish Market**

- Live Maine shrimp were bought and packaged three ways: in seawater, in seawater treated with Ammonia Lock and in seawater treated with pH Buffer. The plain seawater allowed for higher shrimp survival. Shrimp survival was then tested by a ratio of water (liter) to shrimp weight (kg). Nontreated seawater at a 1:1 ratio worked best.

- Based on these findings, the researchers decided that flounder shipment trials should be done with nontreated seawater. The experiments used flounder with a cut nerve (causing paralysis and theoretically saving oxygen) and flounder without a cut nerve. The cut nerve system did not help survival.

- Finally, the researchers attempted to keep flounder alive for a demand market. The best method was a mechanical cartridge filter made by aquanetics and a fluidized sand filter made of a fiberglass tube.

1997 Seafood Technology

• 97ST-2

HACCP Program Assistance for Small Seafood Processors and Dealers

This project showed coastal seafood businesses how to conduct a hazard analysis of their operations and to develop and implement a hazards-prevention plan for each product they manufacture. Hazard Analysis and Critical Control Point monitoring is an FDA-regulated food safety program for the seafood industry that became law in December 1997. To help industry comply with HACCP, organizations such as the Association of Food and Drug Officials (AFDO) and the National Seafood Alliance held three-day workshops beginning in 1997.

Because many of North Carolina's seafood businesses are sole proprietorships, owners lacked the staff to keep their operations open while they attended a workshop. This grant enabled an individual to travel to coastal businesses and provide one-on-one HACCP training.

This work resulted in the publication of two concise manuals to help processors comprehend the principles of HACCP and create a plan of their own.

A Self-Guide to Hazard Analysis and Critical Control Point Inspection for Small Seafood Dealers, Packers and Processors explains the seven principles of HACCP and how they build on one another to create a HACCP plan. *Model Safety Plans for Small Seafood Dealers, Packers and Processors* illustrates sample HACCP programs for the five kinds of seafood businesses that fall under the HACCP regulation. These are available through North Carolina Sea Grant.

• 97ST-5

Development of a Process to Achieve Strong Binding of Seafood Flakes for Restructured Products

Much of the value placed on seafood is dependent upon portion size and uniformity. Although shrimp, scallops, lump crabmeat and other seafoods are routinely graded for size, smaller non-uniform pieces can be equal in freshness, taste, flavor and texture. This study sought to increase the value of small or non-uniform seafood pieces by using binding agents to create larger, more highly valued seafood products.

Three binding agents were investigated: a beef plasma fibrin/thrombin clotting mixture already proven in red-meat applications; surimi (minced fish paste), known to gel at low temperatures; and a naturally occurring enzyme, transglutaminase.

Large, uniform scallops, called scallop medallions, were successfully created using transglutaminase to bind together small scallops. Because the binding agent acts at low temperatures and becomes stronger with cooking, the product can be sold fresh. One-inch casings are used to mold the scallops, which are then sliced to a prescribed thickness. The value of the small scallops was doubled at a small cost to the processor. Scallop medallions were produced by the Wanchese Fish Company in Dare County, and have been sold to food distributors, retail chains and grocery clubs throughout the United States and Europe.

