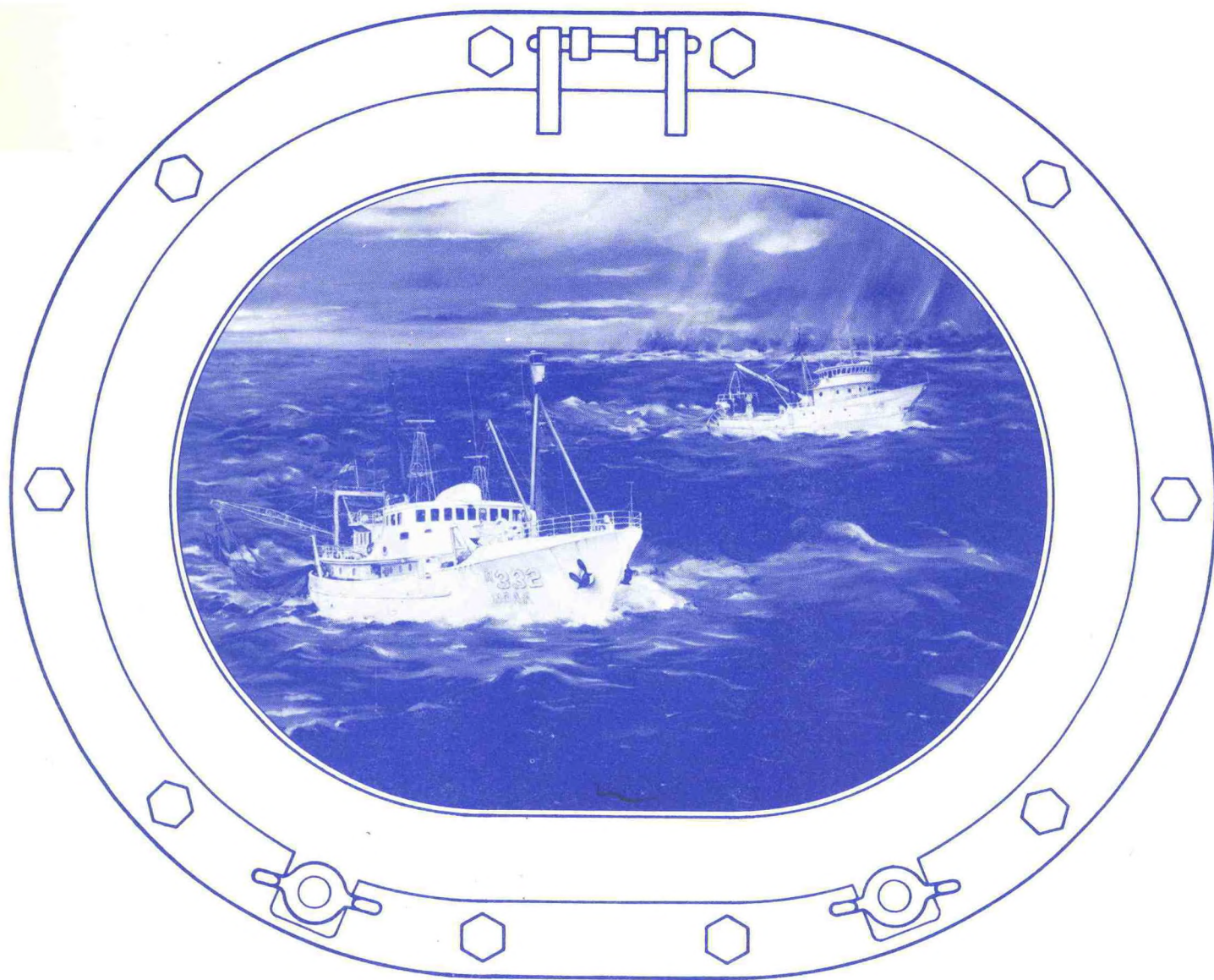


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Southeast Fisheries Center

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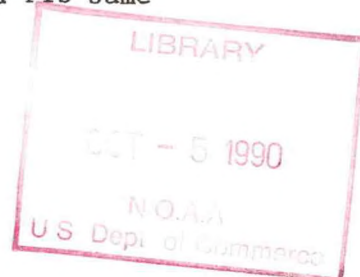
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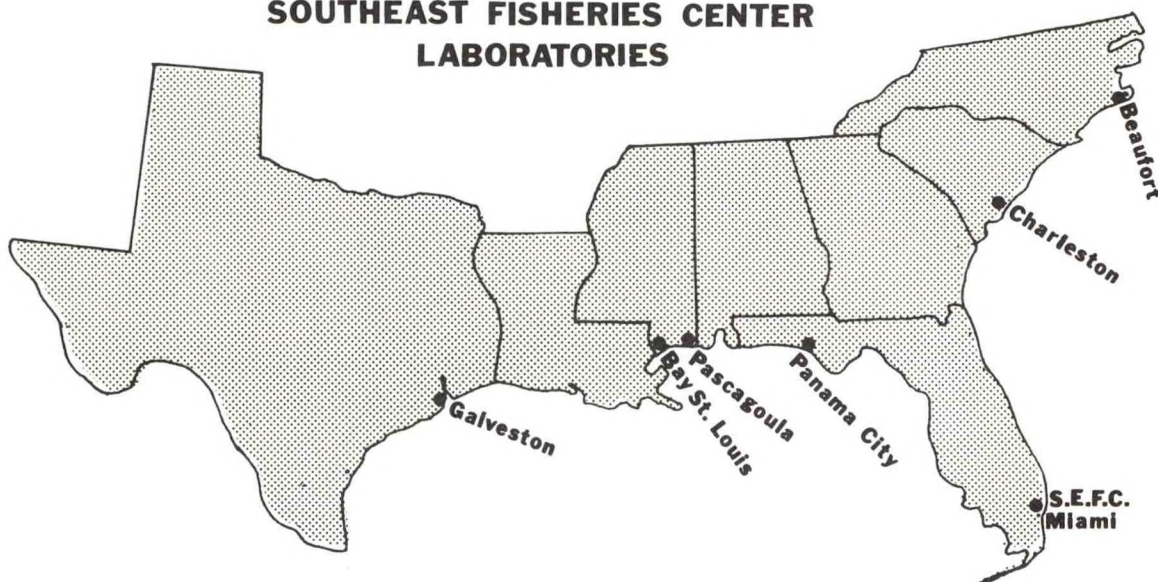
SOUTHEAST FISHERIES CENTER

The Southeast Fisheries Center (SEFC) is one of four fishery research centers of the National Marine Fisheries Service and is organizationally situated in the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. The SEFC conducts research in support of federal laws and international agreements relating to living marine resources in the Gulf of Mexico, Caribbean Sea, and Atlantic Ocean. Scientific and technical information developed by the Center contributes to numerous fishery management, development, and research organizations in the Southeast.

Each SEFC laboratory is responsible for conducting research in specific subject areas and for providing services to facilitate the work of other Center units. Annual research plans and resource allocations to the laboratories are based on priorities determined at national and regional levels. Extensive consultation and coordination to identify priorities of user groups is a continuing process. Results of the Center's research are distributed to interested groups through periodic newsletters, oral and written reports, publications, and personal contacts.

SEFC headquarters offices are located in Miami, Florida, and research is conducted at laboratories in Beaufort, North Carolina; Charleston, South Carolina; Miami, Florida; Panama City, Florida; Pascagoula, Mississippi; Bay St. Louis, Mississippi, and Galveston, Texas. Research is conducted from the 170-foot OREGON II and the 127-foot CHAPMAN, berthed at Pascagoula, and the 155-foot DELAWARE II, which operates from Woods Hole, Massachusetts. Commercial fishing and oceanographic vessels are used as needed through contracts and cooperative research projects. Fishery data are collected throughout the Southeast Region by Center agents located at numerous sites between North Carolina and Texas and through cooperative agreements with eight coastal states, Puerto Rico, and the U.S. Virgin Islands.

SOUTHEAST FISHERIES CENTER LABORATORIES



COASTAL PELAGICS

The fishery management plan (FMP) for coastal migratory pelagic resources has focused primarily on king and Spanish mackerel. Reassessment of stocks has led to indications that two migratory groups of king mackerel exist and that they should be managed separately. Thus, new yield estimates were made for the two migratory groups and allocations proposed. These proposals are under consideration for inclusion in an amendment to the FMP by the Gulf of Mexico and the South Atlantic Fishery Management Councils.

Emphasis during 1984 was placed on purse-seine observations, developing plans to extend our king mackerel studies cooperatively with Mexico, stock reassessment, and biological studies.

Purse Seine Observations

The Coastal Migratory Pelagic FMP allows experimental purse seining of mackerels for three years. The 1983-84 fishing season (July 1-June 30) was the second year that observations were made. Observers were placed on all vessels fishing for mackerels, as required by the FMP. Data on the vessel, gear, trip, purse seine sets, and the catch were recorded, and length and sex data were obtained from the catches.

Seven seiners made 127 trips with observers aboard. Trips lasted from a few hours to 11 days. Of the 199 days spent on seiners, 99 were in the Atlantic along Florida and 100 were in the Gulf of Mexico. Observations were made on 151 purse seine sets.

Catches (in pounds) by purse seine vessels
with observers aboard, 1983-84

Species	Atlantic	Gulf	Total
Red drum	0	597,000	597,000
Blue runner	170,850	376,900	547,750
Black drum	0	525,000	525,000
Crevalle jack	343,673	39,850	383,523
King mackerel	134,643	0	134,643
Spanish mackerel	67,766	37,055	104,821
Little tunny	30,000	26,540	56,540
Mullet	20,000	0	20,000
Sharks	0	11,650	11,650
Atlantic bumper	-	9,950	9,950
Thread herring	0	4,000	4,000
Total pounds:	<u>766,932</u>	<u>1,627,945</u>	<u>2,394,877</u>

As shown above, 11 species were recorded in the catches. Mackerels were not the target species of every set. When king or Spanish mackerel were the target species, successful sets were almost pure, that is, very little by-

catch of other species occurred. The quota for king mackerel was 400,000 pounds in the Atlantic and 400,000 pounds in the Gulf of Mexico; for Spanish mackerel, the quota was 300,000 pounds in each of the two areas. Thus, in the Atlantic, seiners caught 34% of their quota of king mackerel and 23% of their quota of Spanish mackerel. In the Gulf of Mexico, the seiners caught no king mackerel, but were able to catch 12% of their quota of Spanish mackerel.

Tagging Studies

In December 1983, about 1,100 king mackerel were tagged from commercial fishing vessels off Grand Isle, Louisiana, to determine their movements. Five of these tags have been returned thus far--one from Veracruz, Mexico, and four from the Texas coast. Tagging of smaller "summer" king mackerel continued off Grand Isle until late October.

Attempts to acquire king mackerel off Panama City for tetracycline tagging have been initiated. This tagging technique is useful for validation of age and growth parameters, since a glowing mark is visible on the fish's hardparts when exposed to ultraviolet light. Fish tagged and released off Panama City should be vulnerable to the commercial fishery in south Florida this coming winter.

Charterboat Survey

In 1984, the charterboat survey included 31 contracted captains located along eight coastal areas of the southeastern United States. Budget constraints caused a 50% drop in area coverage and a 60% drop in vessel coverage from the 1983 charterboat survey. Nevertheless, the coverage through mid-September produced data from almost 15,000 hours of fishing effort during which over 100,000 fishes were caught. Of the top ten species caught by trolling, tunas and mackerels (Scombridae) made up 54.1% of the total catch, while croakers and drums (Sciaenidae) made up 55.4% of those fishes caught by methods other than trolling. Areas in the 1984 survey include five of the areas (North Carolina, south Florida, northwest Florida, Louisiana, and south Texas) covered in 1982 and 1983 plus three of the areas (east Florida, west Florida, and the U.S. Caribbean) covered in 1983.

A monthly newsletter, "Channel 68," reporting on monthly catch-per-boat-hour data from each survey area for the top five species caught by trolling and by methods other than trolling, was initiated in 1984. Copies are distributed each month to charterboat captains, resource managers, and others.

Bioprofiles

Bioprofile studies continued on coastal pelagics. The reproductive biology of king mackerel, Spanish mackerel, cero, bluefish, and blue runner was determined. Food habits of king mackerel, Spanish mackerel, bluefish, cero, and crevalle jack were defined, and the age and growth of Spanish mackerel, gray triggerfish, and blue runner were determined. Manuscripts of these studies have been published or are in preparation for publication.

Stock identification of Spanish mackerel was sought by electrophoretic and morphometric methods. Electrophoretic examination of 44 loci, 22.7% were polymorphic, supported the hypothesis that Spanish mackerel off Louisiana and northwest Florida are separate from Spanish mackerel off North Carolina and Georgia, with the possibility that those in south Florida are either a mixture of the two groups or a separate southern group. Morphometric studies based upon 172 fish from Florida and Georgia indicate that separation of groups of Spanish mackerel by this method is feasible.

Length Frequency of King Mackerel

A new project to determine the length and age distribution of king mackerel in the fisheries of the southeast was initiated. The data obtained will be used for reevaluating mortality estimates, which in turn will be used for reassessing yield estimates. Planned activities include: 1) development of an efficient system to obtain and process data; 2) accumulation of all available data from the United States and Mexico; 3) creation of a data bank such that both U.S. and Mexican biologists can add and obtain data; and 4) implementation of sampling for Spanish mackerel in addition to king mackerel in 1985. Accomplishments thus far include: design and construction of measuring boards and attachments that allow rapid measurement and data submission, rapid data entry into computer, satisfactory testing of equipment and system at king mackerel rodeos in North Carolina and Florida by port samplers and charterboat captains, acquisition of data from Mexico, entry of about one-half of the historical length data into a data bank, coordination of plans and procedures with Miami's Fishery Analysis Division, and obtaining necessary computer software for data analyses.

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HERRINGS

Herrings is a collective term applied to several small fishes of various families, such as round herring, Spanish sardine, Atlantic thread herring, scaled sardine, chub mackerel, round scad, blue runner, and others. These fishes often occur in large schools. Ichthyoplankton studies have indicated that large quantities of herrings are present in the Gulf of Mexico. Plans are being made to determine where and when concentrations of these fishes occur. Fisheries for some of these fishes presently are small scale, mainly to satisfy demands for bait. Expansion of the fisheries for these resources are believed to have considerable potential. The Herrings Program three major thrusts are: 1) to determine the biology of the species; 2) to determine the distribution and abundance of the species in offshore waters; and 3) to monitor near-shore fisheries for herrings.

Bioprofiles

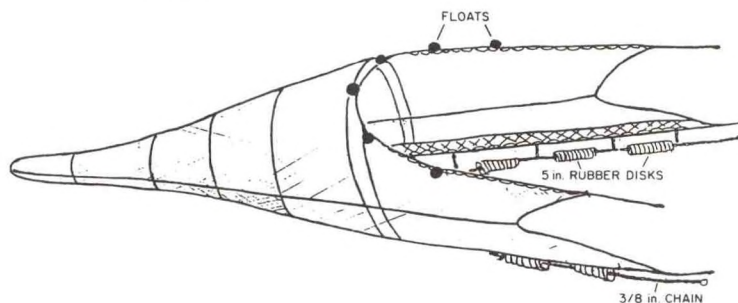
Bioprofile studies on herrings continued. The reproductive biology and the age and growth of blue runner were determined. Laboratory analyses of the reproduction and food habits of several herrings are nearing completion. Stock identification of Spanish sardine and Atlantic thread herring was investigated by electrophoretic analyses of muscle enzymes. Preliminary results indicate that this method is feasible for the Atlantic thread herring but not for the Spanish sardine. However, morphometric measurement of Spanish sardine does show promise for stock identification, as discriminant analyses of the data indicates distinct groupings of specimens from different localities.

Resource Surveys

Two cruises were conducted to determine concentrations of herrings and to evaluate trawls as sampling devices. The cruises operated in the eastern and northern Gulf, the OREGON II off the west coast of Florida and the DELAWARE II off the coasts of Louisiana, Mississippi, Alabama, and northwest Florida. Fish schools were located by sonar. Significant fish traces were observed from the OREGON II between Tampa Bay and Fort Myers within depths of 20 to 30 fathoms. Few fish were caught by the high opening bottom trawl, which was towed at 4 to 4 1/2 knots. The occurrence of round herring and Spanish sardine within the mesh of the trawl indicated that the fish were outswimming the trawl and swimming through the webbing. The DELAWARE II also used the high opening bottom trawl. During their tows, the trawl was operated at speeds ranging from 4.5 to 5.5 knots. Catches ranged from 1 pound to about 1,500 pounds. The catches included several target species of clupeids, carangids, and a scombrid.

TRAWL MEASUREMENTS

HEADROPE - 90 ft.
FOOTROPE - 136 ft.



HIGH OPENING BOTTOM TRAWL

Cruises were planned for the next several years aboard the R/V CHAPMAN. Herrings will be located with sonar in offshore waters of the Gulf and sampling of the sonar targets will be done with trawls. Associated environmental data will also be obtained. Data from these cruises will be used to assess herring stocks in the Gulf.

Monitoring Herring Fisheries

A logbook system for monitoring the herring fisheries was initiated this year. Captains of eight purse-seine boats in the northeastern Gulf agreed to maintain logs of their fishing activities. Data on number of sets, time, location, amount caught, species caught, and estimates of species composition were recorded. The captains were visited periodically and copies of the logs were made for our analyses. Thus far, the system appears to be working satisfactorily.

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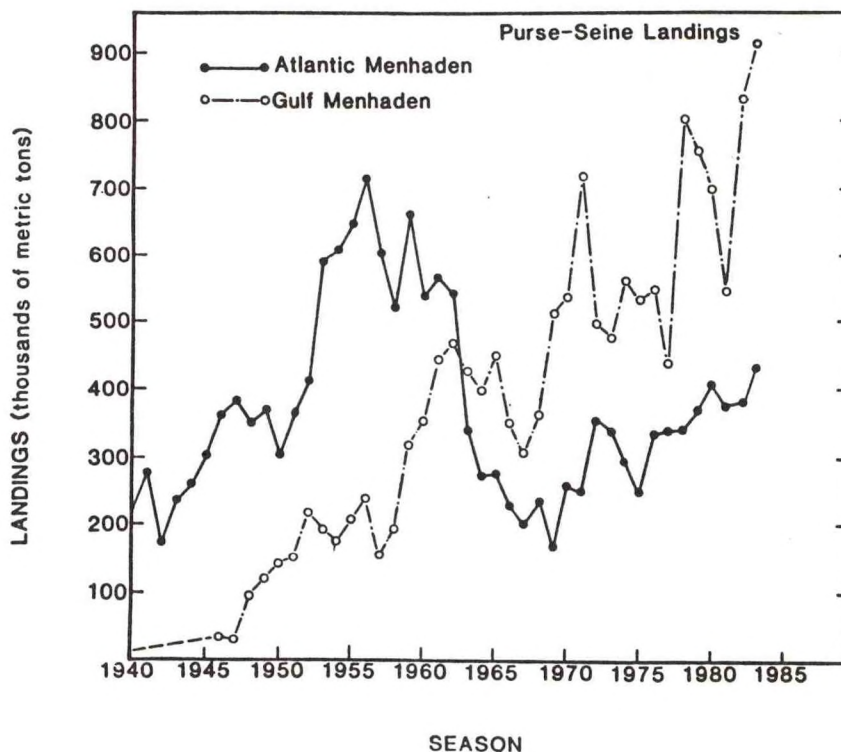
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MENHADEN

The research goals of the Menhaden Program are to determine 1) whether the gulf menhaden fishery can be sustained at the current high level of production or if the catch can be safely increased, and, if so, by how much, and 2) whether the Atlantic menhaden fishery can be rehabilitated to the late 1950's level of production, which was about 50% larger than the present landings, and then can it be sustained at that level?

The research objectives are similar in both the Gulf and Atlantic fisheries, i.e., 1) to assess the effects of fishing on the menhaden resources, 2) to predict annual changes in fish abundance, and 3) to advise user groups and regulatory bodies so that full utilization of the stocks can be made.

During 1983, menhaden purse-seine fisheries on the Atlantic and Gulf coasts represented 48% of the total fish landings by the U.S. commercial fisheries. With menhaden landings of almost 3.0 billion pounds, 1983 was the all-time record year for the combined fisheries. The commercial purse-seine harvest is for reduction to fish meal and oil, which reaches a major portion of the U.S. population as ingredients in poultry feed, paints, and cosmetics.



Landings of Atlantic and gulf menhaden purse-seine fisheries, 1940-83.

Juvenile Surveys

Analysis of juvenile survey data for Atlantic and gulf menhaden revealed a poor correlation between number of fish-per-tow in the estuary and estimates

of year-class strength from the commercial survey for Atlantic menhaden, critical assumptions were the timing of the annual survey, uniform distribution of juveniles in the estuarine system, and direct extrapolation based upon number of individuals caught regardless of body size. These factors are currently being reevaluated with field data obtained in a monthly survey of four streams on the Atlantic coast. Plans to reinstitute a survey that more closely associates juvenile menhaden populations in different geographic regions with spawning in those regions are being assessed. Salinity gradients and the abundance and distribution of phytoplankton are being evaluated as potential sample stratifying factors. The density-dependent growth aspect of juvenile menhaden presents an alternate, correlative survey approach. An implicit assumption of this approach is that annual production of food for juvenile menhaden in large geographic regions is less variable than the number of surviving juveniles.

The objective is to develop a survey methodology for forecasting year-class strength and subsequent harvests by the commercial fleet. By examining how salinity, phytoplankton abundance and distribution, and time of spawning affect the abundance and distribution of juvenile menhaden, valuable ecological information is being gathered on juvenile menhaden in the estuary.

Tagging

Juvenile menhaden in estuaries along the Atlantic and Gulf coasts are being tagged by inserting small numbered stainless steel tags into their body cavity and releasing them. Many of the tagged fish are recaptured in the purse-seine fishery and the tags are recovered by magnets in the fish processing plants. Tag information enables fishery scientists to monitor migration, determine recruitment patterns, and estimate mortality rates. Since these parameters can be estimated for the tagging areas, information gained from tagging will be directly applicable to the trawl survey results for developing the juvenile abundance forecasts of fish catches. During 1984, 17,000 juvenile gulf menhaden (October 1983) and over 17,000 juvenile Atlantic menhaden (September 1984) were tagged. Record numbers of juvenile Atlantic menhaden were tagged this year in the South Atlantic.

Menhaden Survey Design

The present menhaden port-sampling program most closely conforms to a two-stage cluster design. In recent years, we showed that unbiased estimates of mean fish weight, number of fish landed, and age composition can be calculated and confidence intervals can be specified if certain stated assumptions are met. The validity of many of these assumptions has been evaluated, and the direction and magnitude of bias has been assessed for the 1979 fishing season. This year principles of economic optimization were used to investigate the appropriate sample size (number of sets and fish within sets) required to estimate proportional age composition most efficiently. While the theory is well developed for the single parameter case (e.g., one age class), it is not so well defined when several parameters (e.g., multiple age classes) are measured simultaneously. A graphic solution was devised that is applicable to any two-stage, multi-parameter survey (e.g., trace metals, hydrocarbons, species composition). For the menhaden survey, the variability

of fish in a single set tends to be small compared to the variability among sets. Survey effort, therefore, should emphasize the number of sets sampled and should be most intense at times and places that historically have had high set-to-set variation.

Captain's Daily Fishing Reports

The Captain's Daily Fishing Report (CDFR) project is a cooperative industry, state, and federal activity. Data in these reports provide information about the process of purse-seine fishing as well as the Atlantic and gulf menhaden resources. As of September 24, 3,909 CDFRs received from the Atlantic in 1983 have been coded and key entered. Of the 9,810 CDFRs received from the Gulf in 1983, almost 91% (or 8,921) have been coded and key entered. These coded data from 1983 have resulted in 67,150 records on computer file. This file has not been edited. For the 1984 fishing season, we have received 2,230 CDFRs representing 35 vessels from the Atlantic and 7,603 CDFRs representing 79 vessels from the Gulf. None of the 1984 CDFRs have been coded (using the short form) or key entered.

Atlantic Menhaden Stock Assessment

A stock assessment analysis of the Atlantic menhaden, Brevoortia tyrannus, fishery was conducted with purse-seine landings data from 1940 to 1981 and port sampling data from 1955 to 1981. Virtual population (cohort) analysis was used to estimate historical stock sizes, rates of fishing, and numbers of recruits. Growth and mortality data were used to examine aspects of yield-per-recruit, both in terms of temporal and geographic fishing areas and for the entire fishery. Results of these analyses indicate that the Atlantic menhaden fishery suffers from growth overfishing. Although classical spawner-recruit relationships describe the data poorly, they are compatible with potential management schemes designed to increase yield per recruit. Size at age data, while supporting an earlier hypothesis of density-dependent growth, show a trend toward slower apparent growth in the 1970's than is explained by this hypothesis alone.

Gulf Menhaden Stock Assessment

A stock assessment analysis of the gulf menhaden, Brevoortia patronus, fishery was conducted with purse-seine landings data from 1946 to 1983 and port sampling data from 1964 to 1983. These data were analyzed to determine rate of growth, yield-per-recruit and spawner-recruit relationships, and maximum sustainable yield (MSY). Virtual population (cohort) analysis was used to estimate stock size, year-class size, and rates of fishing. During the period studied, an average of 30% of age-1 fish and 60% of age-2 and age-3 fish were taken by the fishery and 43% to 53%, respectively, were lost to other natural causes annually.

Yield-per-recruit estimates were obtained for an array of fishing mortalities and ages at entry. Surplus production models on 1946-83 catch and fishing effort data, with adjustments to effort for the period 1964-80, were developed and estimates of MSY made, ranging from 711 to 747 KMT for the

generalized production model. No significant relationship was found between population size and resultant growth of individuals. Recruitment to age-1 on April 4 ranged from 6.3 to 30.2 billion fish for years 1964-80. Although there was substantial scatter about the fitted curves, Ricker-type spawner-recruit relationships were found suitable for use in a population simulation model. Estimates of MSY from population simulation model runs ranged from 650 to 725 KMT with F-multiples of the current mean rates of fishing ranging from 1.08 to 1.61. Although recent short-term harvests in excess of MSY do not appear detrimental to the stock, long-term harvesting above MSY cannot be maintained given our current understanding of the resource and uncertainties in our estimates of MSY.

Forecasting Menhaden Landings

An evaluation of the statistical properties and forecast performance of the multiple linear regression forecast model was completed as a preliminary step in developing alternative modeling strategies. The current model employs the previous year's catch, the previous year's effort, and current effort projections as independent variables to predict catch. In general, this model is well-behaved statistically, but there is some evidence to suggest that additional relationships are present in the data which are amenable to the newly-developed Box-Jenkins forecasting methodology. Box-Jenkins models, constructed for the univariate catch series (1940-1983), were not as successful as the regression model in fitting the existing data, but under simulated forecast conditions, they worked about as well. Techniques for building advanced, multivariate Box-Jenkins models (transfer function-noise models) which used relationships between the catch and effort series were more successful, and represent a promising line for future research.

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OCEANIC PELAGICS

The Oceanic Pelagics Program is concerned with the Atlantic bluefin tuna, billfishes, swordfish and other large, open ocean fishes. These species are much sought after by both recreational and commercial fishermen. Because these species have a relatively long life, the numbers of older animals may be reduced by fishing to the level that catches may need to be regulated. Consequently, research on these species is directed primarily at providing the scientific information needed for management. Oceanic pelagic resources are managed under a Preliminary Management Plan for Atlantic Billfishes and Sharks. A fishery management plan for swordfish is being prepared by the joint effort of five councils on the Atlantic coast.

Bluefin Tuna Research

In 1984, research on Atlantic bluefin tuna was directed to critically reviewing the assessments which had earlier indicated that the numbers of large bluefin tuna were greatly reduced during the 1960s and had remained at low levels. Tagging studies and chemical studies of vertebrae showed that there is a low mixing between bluefin tuna in the eastern and western Atlantic. Therefore, analysis of assessment information was done primarily for western Atlantic data where bluefin catches had declined from 47,000 tons to 9,000 tons during 1962-73.

The possible effects on catch per effort data were studied of non-reporting of shark-damaged bluefin and bias due to aggregation of longline sets, and it was determined that these factors did not seriously affect the data. Consequently, indexes of abundance for large fish and for small fish in the western Atlantic were developed using the catch-per-unit-effort (CPUE) data and selected index areas. The indexes were adjusted by a generalized linear model to remove variations in the ability of fishing effort to catch fish, which are due to season of the year, area fished, type of gear, and target species. The resulting index of abundance for large bluefin was high during the early 1960s, declined sharply with the large catches in the mid-1960s and stabilized at a fraction of its former level after 1968. The index for small bluefin was more variable, but was generally high during the 1963-1966 period, then declined sharply, and remained level since 1970, even though catches have decreased because of regulation.

The method of virtual population analysis (VPA) was applied to catch-at-age and CPUE data and several procedures were applied to calibrate the VPA. The several analyses produced findings that differed in detail, but the general results agreed. The VPA calibrated to the CPUE indexes, considered the best grounds for providing management advice, showed that under the catch regime since 1970 the stock sizes of both large and small fish declined sharply until recently, when catches were curtailed. The average recruitment in recent years has been about 300,000 to 350,000 age-1 fish. This number is apparently too low to maintain the stock at fishing mortality rates that existed prior to 1981. This recruitment would result in an equilibrium yield of about 2500 mt, the current (1984) ICCAT quota. The stock probably will not further decline under this catch level, but whether this catch level will result in rebuilding the stock cannot be determined until several more years have passed.

Billfish and Swordfish Research

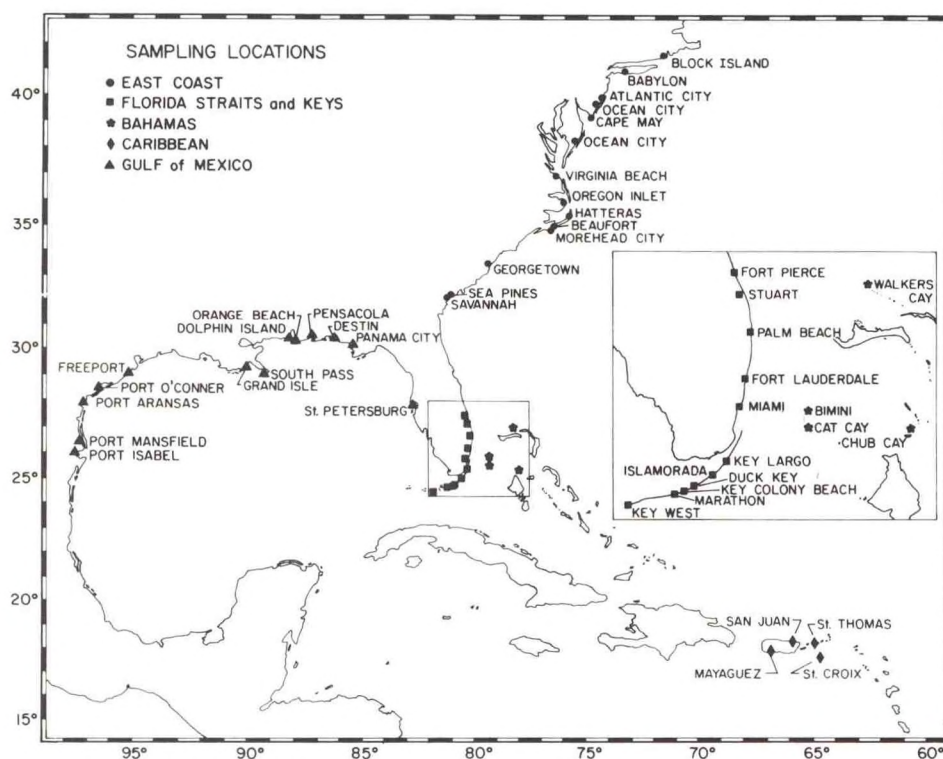
Research on billfishes and swordfish covered a number of activities. The Cooperative Gamefish Tagging Program celebrated its 30th anniversary at the beginning of 1984. The program enlists the cooperation of recreational anglers in

tagging and releasing blue marlin, white marlin, sailfish, swordfish, and tunas. Tag returns from these fish provide valuable data on migration, stock separation, age, growth, and other vital information needed for scientific analysis. Without the cooperation of anglers, it would be impossible to collect this information on these species which are caught relatively infrequently. Program cooperators tagged and released 3,975 fish in 1983 (1,852 sailfish, 1,007 white marlin, 405 blue marlin, 63 swordfish, 1 black marlin, 583 tunas, and 64 miscellaneous species). In 1983 there were 109 tag recoveries reported: 25 sailfish, 17 white marlin, 14 swordfish, 1 blue marlin, 20 yellowfin tuna, 15 bluefin tuna, 7 blackfin tuna, and 10 amberjack.

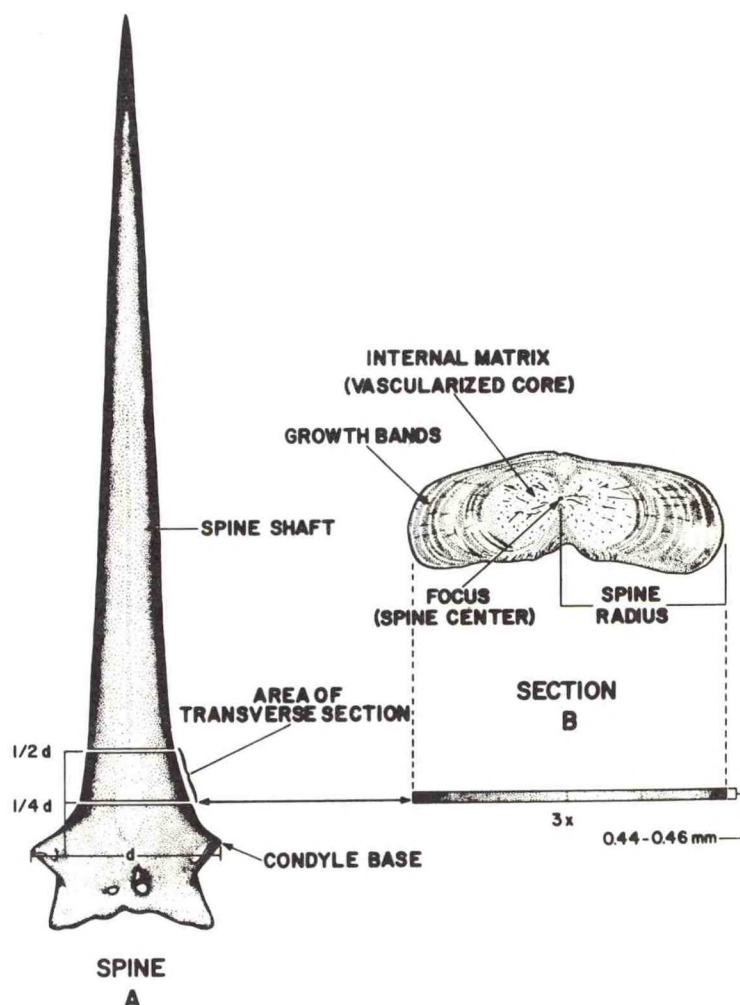
In 1984, anglers tagged and released 2,423 fishes of more than 12 species as of October. Tag recaptures reported for the same period include 2 blue marlin, 10 white marlin, 9 bluefin tuna, and 17 sailfish.

Two important tag recoveries were made in 1984. One sailfish, originally tagged and released off the Florida Keys in March 1973, was recovered after 10 years and 10 months at liberty. This time is 6.5 years longer than the previous recorded time at liberty and provides important new information on the growth and longevity of Atlantic sailfish. For many years, researchers had believed that sailfish had a rapid growth rate and a relatively short life span of 3 or 4 years. The second most notable return in 1984 was a tagged blue marlin recaptured in January 1984 by a French tuna seiner operating in the Gulf of Guinea, off the Ivory Coast, West Africa. This fish had been tagged and released off St. Thomas, U.S. Virgin Islands, in September 1983. This recapture is the second recorded trans-Atlantic migration for blue marlin and is evidence that this may be a consistent seasonal migration pattern.

Over 100 billfish tournaments were sampled for catch and effort statistics along the U.S. east coast, Caribbean Sea, Bahamas, Florida Straits, and Gulf of Mexico. Two new tournaments were added to the 1984 survey. Data collected contribute to the estimates of total catch long-term trends in abundance of billfishes.



Samples of otoliths, spines, and vertebrae from oceanic pelagic fishes are being used to estimate age and growth rates. Processing of marlin otoliths and analysis of dorsal spines is continuing. A new visual analysis system for analyzing zonations for skeletal structures is almost complete. This system will provide more rapid and accurate identification and measurement of growth bands.

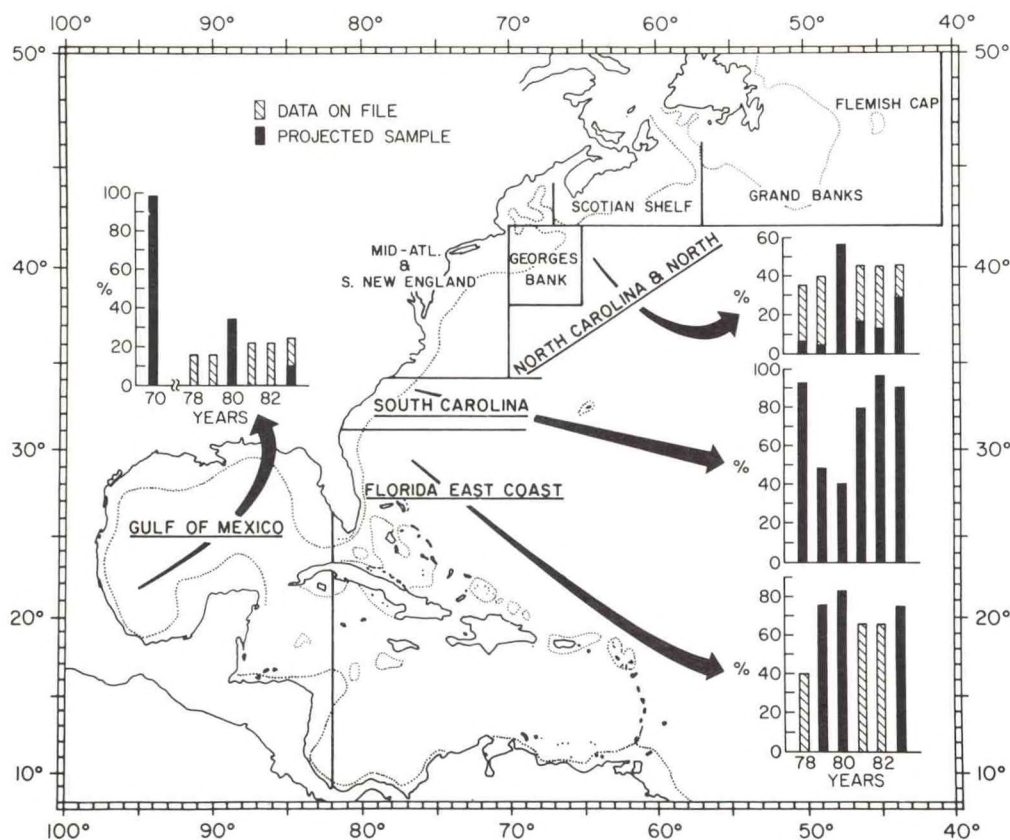


Schematic of the fifth dorsal spine from a 137-pound blue marlin. (A) whole spine showing location of cut and external structures; (B) spine section (3x) showing measurements, internal structure and dimensions.

The Oceanic Pelagics Program Summary for 1983, reporting on the Cooperative Gamefish Tagging Program, recreational billfish surveys, and research on age and growth of big game fishes, was issued in June.

Information on the Atlantic swordfish fishery, provided by dealers and vessel operators on trip weighout sheets covering 1978-84, was computerized and will be used in stock assessment analyses scheduled for 1985.

SIZE FREQUENCY DATA FOR U.S. SWORDFISH FISHERY



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PROTECTED SPECIES

Sea Turtles

Sea turtles are the major endangered or threatened species of concern to the Southeast Fisheries Center. Our goal is to obtain research data needed for conservation of endangered and threatened sea turtle stocks in the western Atlantic area. Research is being conducted on the loggerhead (Caretta caretta), green (Chelonia mydas), olive ridley (Lepidochelys olivacea), Kemp's ridley (Lepidochelys kempii), leatherback (Dermochelys coriacea), and hawks-bill (Eretmochelys imbricata) turtles.

These species of sea turtles were listed under the U.S. Endangered Species Act (1973) based on evidence that their stocks were severely reduced and declining. Research is being carried out to determine population levels and conservation methods.

The primary users of the Center's results are the federal managers charged with the protection and recovery of endangered and threatened sea turtles, the fishing industry, and the concerned public.

Trawling Efficiency Device (TED). During 1984 the TED design was significantly improved. The new design is collapsible, made of steel or fiberglass, and has better durability and handling characteristics. The new model performs well with no significant shrimp loss, and has consistent finfish reduction rates of 50% or better during both day and night. The new designs were demonstrated to Sea Grant extension agents from North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. Plans to facilitate technology transfer to the shrimp industry have been developed in cooperation with the NMFS Southeast Regional Office.



Collapsible trawling efficiency device.

Sea Turtle Stock Assessment. Aerial pelagic surveys were flown along the Atlantic coast from North Carolina to Florida. Experiments were simultaneously conducted to help refine analysis of the sighting data: the minimum size of turtles observable from aircraft, and the affects of glare, sea state, and time of day. Correction factors have been calculated from the results of these experiments and the final analysis of data will provide estimates of sea turtle stocks off the southeastern United States.

Sea Turtle Head-Start Research. The 1983 year-class Kemp's ridley turtles were tagged with monel flipper tags and released on June 5, 20 miles off Mustang Island, Texas, in cooperation with the U.S. Coast Guard. Of the 191 tagged yearlings released, 172 had been "imprinted" at Padre Island, Texas, and 19 at Rancho Nuevo, Mexico. Hatchlings of the 1984 year-class were received from the National Park Service. The 1,179 surviving hatchlings appear to be in good health. Experiments on sea turtle pathology are ongoing.

Sea Turtle Research Management. The three-volume Proceedings of the Western Atlantic Turtle Survey (WATS) was published and the English edition distributed. The second Spanish edition of the Sea Turtle Manual was also published and distributed. Additionally, SEFC personnel visited several WATS nations to stimulate interest in WATS II: British Virgin Islands, French West Indies, Jamaica, Haiti, Dominican Republic, Panama, and Costa Rica.

Sea Turtle Biochemical Analysis. Improved biochemical analysis techniques have been developed using isoelectric-focusing. This method analyzes the protein composition in sea turtle tissue samples and it is hoped that it will be possible to determine individual breeding populations with further refinements. Biochemical techniques have been developed that have helped law enforcement officials identify confiscated turtle eggs and meat.

Sea Turtle Tracking Technology. An ARGOS satellite transmitter tag has been developed that will enable scientists to follow sea turtle migration patterns. The new transmitter turn on switch is controlled by a surface sensing device so that more position fixes can be made. Also, a new battery powered receiver/recorder package was designed to monitor the satellite tags at remote sites.

Sea Turtle Stock and Habitat Survey. Preliminary analysis of the Cape Canaveral sea turtle data have shown that size and sex structure of Canaveral loggerhead turtles changes radically during the course of the year. During spring and summer months there is an influx of adult turtles, which changes to subadult turtles in the fall and winter months. Growth rates of loggerhead turtles were estimated using tag and recaptive techniques, concluding that these turtles may reach maturity at age 26 and continue to reproduce through age 62.

Sea Turtle Biology. Several studies on sea turtle biology were contracted out. Two very interesting studies are summarized as follows:

- (1) **Sea Turtle Sex Determination.** Serum testosterone titer, tail length, and straight carapace width/length ratio were evaluated as possible indicators of the sex of immature loggerhead sea turtles. Serum testosterone titer proved to be an accurate indicator of sex. Tail length and straight carapace width/length ratio were not accurate indicators of

sex. The testosterone sexing technique was used to sex immature loggerhead sea turtles that were captured at four locations along the Atlantic coast of the United States. The predicted sex ratios obtained at the four sampling locations were not significantly different from one another. The pooled sex ratio of the captured turtles (1.93F:1.00M, n=255) was significantly skewed toward female. Additionally, the results indicate that immature loggerhead sea turtles do not undergo sex specific migrations and therefore represent an efficient means of estimating population sex ratios.

- (2) Effect of forced submergence and low sea water temperature on the physiology and behavior of sea turtles. Without doubt, low temperature has a very marked effect on the biology of sea turtles. Behavioral disturbances were noted in some animals at temperatures less than 20°C and were manifested in most at 15°C. Severe physiological malfunctioning occurred at 10°C. However, between 10°C and 30°C, there is evidence of a rather complex system of physiological adjustment. The respiratory data suggested some stress effect at 30°C in that several individuals showed hyperventilation at this temperature with a depressed oxygen consumption. However, all animals showed a very sharp breakdown in physiological mechanisms at 10°C. It is now clearly apparent that for a loggerhead to survive in temperatures around 10-15°C for any considerable time, it must be in a quite different physiological state from normal, i.e., hibernation. We now have sufficient information on the normal state of loggerheads and the effect of cold stunning to be able to unambiguously recognize hibernation, but unfortunately since the Cape Canaveral study was started in 1979, a sufficiently cold winter has not yet appeared.

Undoubtedly, forced submergence is a severe trauma for sea turtles. Sooner or later, submerged sea turtles lapse into a death-like comatose condition with a severe bradycardia. Under these conditions, a turtle brought on deck may show no outward sign of life, including response to stimuli or breathing for up to one hour. Recovery appears to be very slow. It is recommended that under no circumstances should a released turtle showing no outward sign of life be declared dead until at least three hours have passed. Sharp agitation or pressing on the plastron after 15-30 minutes on board may stimulate breathing. Comatose or sluggish turtles held on deck should be placed belly side down with the posterior end elevated to assist sea water drainage from the lungs. Although ideally turtles should be held for 24 hours to allow for full recovery from the severe acidosis, it is probably sufficient to hold active turtles for two to five hours. Special precautions are necessary at temperatures less than 20°C and turtles must be sheltered from temperatures greater than 30°C.

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Marine Mammals

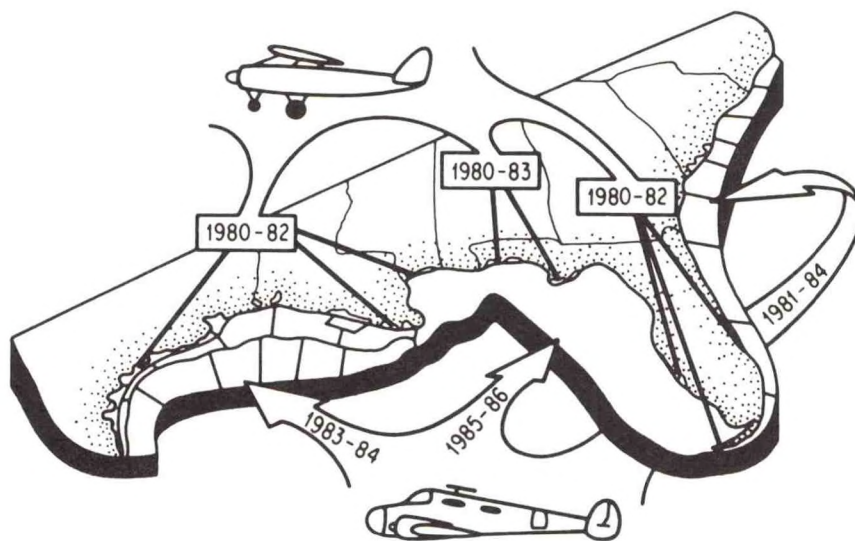
Since the inception of the Marine Mammal Protection Act of 1972, over 350 Atlantic bottlenose dolphins, Tursiops truncatus, have been permanently removed from the wild gene pool for public display and scientific research. The majority of these animals have been taken from the coastal estuarine waters of the southeastern United States. The NMFS is responsible for management of the live-capture fishery for this species and the SEFC is the agency research arm responsible for management recommendations for the fishery in southern United States jurisdictional waters.

Marine mammal research at the SEFC has been shaped to its present form by recommendations developed during a series of internal and external reviews, the most recent occurring during the SEFC Stock Assessment Workshop held in Miami during June. The goals of the Program are 1) to provide estimates of abundance and live-capture quota recommendations for stocks(s) of Tursiops occurring in the southeast, 2) to determine the dynamics and discreteness of along-shore and inshore-offshore populations of Tursiops, and 3) to determine the validity of the live-capture quota guidelines developed by the Marine Mammal Commission. Research focuses on abundance estimation, stock differentiation, and life-stage modeling to address these goals.

Abundance Estimation. The principal research methodology used for estimating the abundance of Tursiops stocks has been the application of aerial sampling surveys. The survey designs used have been for two purposes. First, localized surveys were designed to provide data for estimating the abundance and for recommending quotas in "priority" inshore areas for which there were live-capture permit requests or where requests for live-capture were expected. Second, regional surveys were designed to provide a more geographically comprehensive data base for estimation of the abundance of Tursiops and other cetacean species in southeastern U.S. jurisdictional waters, and for indexing stock boundaries to density distribution patterns.

The localized surveys were conducted under contract and were completed in 11 geographical locations in 1982. Abundance estimates for those locations where quota recommendations were required have been made using line transect analytical techniques.

With the completion of the localized aerial surveys in inshore priority areas, the regionalized effort was initiated. In 1983-1984, four seasonally spaced samples of the northwestern Gulf of Mexico were completed. During these surveys, 767 observations of over 46,000 individual Tursiops were recorded. In addition to bottlenose dolphins, six other cetacean species, two marine turtle species, plus numerous species of sharks, rays, billfish and other fish were observed and recorded. Sampling is planned for the north-eastern Gulf of Mexico beginning in June 1985.



Abundance surveys in the southeast.

Stock Differentiation. Tagging studies involving fin notching, roto tagging, and freeze-branding have been used to examine the dynamics of herd associations and to help define the discreteness of localized populations of Tursiops. SEFC-sponsored research using this methodology has been conducted

in the Indian/Banana Rivers and Sarasota Bay, Florida, and in the Mississippi Sound, Mississippi. Work conducted in the Sarasota Bay, however, involved only resightings and summarizations of ten years of previous work.

On initial capture, biological samples were obtained from individual dolphins including blood, tissue biopsies, morphometric data, bacteriological samples, and teeth. These data are useful in defining the health, age, growth, and genetic profile of the population being studied. A total of 76 dolphins have been captured, tagged, and released in the Indian/Banana Rivers and 57 in the Mississippi Sound. Results of the Indian/Banana River study, completed in 1982, indicate that animals marked within the system tend to either remain in or return to the system over a period of at least two years. In Sarasota Bay, animals that were tagged up to 10 years before resighting were observed in that system in 1980. Final results are not available from the Mississippi Sound but are expected by early 1985.

In October 1983 the SEFC contracted for a study of genetic variability in Tursiops based on samples obtained from captive animals with known capture locations. The objective was to compare the genetic profiles of animals collected from different geographical locations and to test the hypothesis of resident stock structuring as indexed by hematological, allozyme, and chromosome banding analysis. The comparative analysis is being conducted using data from the Indian/Banana Rivers and the Mississippi Sound samples, as well as samples collected from captive animals with known capture locations. Results from this analysis are expected in early 1985.

Life Stage Modeling. Tagging studies have provided data relevant to age and growth of bottlenose dolphins in the southeast. Long-term observation studies and literature sources provide estimates of birth and death rates, while photogrammetric studies yield large length-structured samples of the populations of interest.

The photogrammetric method is presently being used to investigate the application of length-structure data to estimate vital rates and for use in population projection models. Test samples were obtained off Cape Hatteras, North Carolina, in September 1983 and mensuration of a sample of the imagery is in progress. Results from these tests are expected in early 1985 and application to projection models will immediately follow.

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REEF RESOURCES

The Reef Resource Program is responsible for planning, overseeing, reviewing, and reporting on data collection and research programs for reef resources. Reef resources include those fishes and invertebrates inhabiting hard-bottom and coral reef habitats and consist of such species as snapper, grouper, other fishes which inhabit hard bottoms and reefs, spiny lobsters, stone crabs, and corals. These resources support important recreational and commercial fisheries. However, little is known about the size of reef resource stocks, their responses to fishing pressure, and the impact of environmental changes on their abundance and species composition. Knowledge of these characteristics is essential to provide scientific advice to NMFS managers and the Fishery Management Councils. Reef resources are currently managed under Fishery Management Plans for reef fishes, spiny lobsters, stone crabs, and corals.

Stock Assessment

The second Southeast Stock Assessment Workshop was held in Miami in June. The workshop included sessions on reef fish resources, as well as on groundfish and coastal pelagics, marine mammals and turtles, menhaden and coastal herrings and shrimp. Stock assessments were completed for reef fishes and spiny lobsters in the South Atlantic, Gulf of Mexico and U.S. Caribbean areas and for stone crabs in the Gulf of Mexico.

In 1984, data collection and research on reef resources were conducted at the Beaufort, Miami, and Mississippi Laboratories.

In the south Atlantic the majority of fishing effort for reef fishes occurs from shore to 300 feet, although some effort for deeper-dwelling snappers, groupers, and tilefishes extends offshore to depths of 800 feet. The increasing trend in total landings is due to geographic expansion of traditional fisheries and development of the Florida bottom longline fishery for tilefish. Growth and mortality rates and trends in catch per unit effort and equilibrium yield-per-recruit relationships have been determined for major reef resource species. Generally, results from the species analyzed were similar. Yield-per-recruit increases with fishing mortality less than or equal to $F = 0.3$ and decreases thereafter with increasing fishing mortality. Ratios of natural to fishing mortality tend to be relatively high, consistent with the observed flat-topped curves of yield-per-recruit versus fishing mortality.

Status of vermilion snapper stocks in the South Atlantic Bight was closely examined. Virtual population analysis indicated an overall decline in the number of mature female vermilion snapper in the South Atlantic Bight over 1973-1982. The number of mature females will continue to decline as the future population becomes dominated by younger age groups, and numbers of individuals belonging to older age groups diminish. Continued maintenance of high mortality rates will reduce survival of fish to the mature female ages. Although spawning stock abundance will increase as the strong 1978-80 year classes mature, it will subsequently decline if survival to maturation remains low.

South Atlantic Headboat Catch

Estimates of the South Atlantic headboat catch and angler participation for 1982 were completed. The 100 headboats operating between Cape Hatteras and Key West allowed 390,244 angler days of recreation and produced a catch of over 4.5 million pounds, a slight decline from 1981's 4.8 million pounds. Most fishing took place off southeast Florida (Ft. Pierce to Miami), where 154,717 angling days of effort were expended. The best catch rate (25 pounds per angler day) was off Cape Lookout, North Carolina, and the rate trended uniformly downward south to the Florida Keys (7.6 pounds), except that the catch rate for the Dry Tortugas (14 pounds) was the best on the east coast of Florida. Species taken varied greatly by region. By weight, red porgies and vermillion snapper were most important in North Carolina; red porgy and black sea bass in South Carolina; vermillion snapper and black sea bass in north Florida; king mackerel and yellowtail snapper in south Florida; yellowtail snapper and white grunts in the Keys; and yellowtail and mutton snappers in the Dry Tortugas.

Substantial progress was made toward completing our estimate of the 1983 South Atlantic headboat catch and the survey was conducted for the thirteenth year. By the end of 1984 we will have collected size information on about 30,000 individual fish and landings records for about 12,000 headboat trips during the 1984 season.

With more than a decade of survey results available we are now able to document trends in the fishery, and during the year completed an intensive investigation of mortality rates of reef fishes caught by headboats. In summary, it appears that mortality rates of deep reef groupers have increased dramatically since 1976 but that the species supporting the bulk of the Carolina catch, red porgy and vermillion snapper, have had relatively stable mortality rates.

Minimum Size Limits for Reef Fish

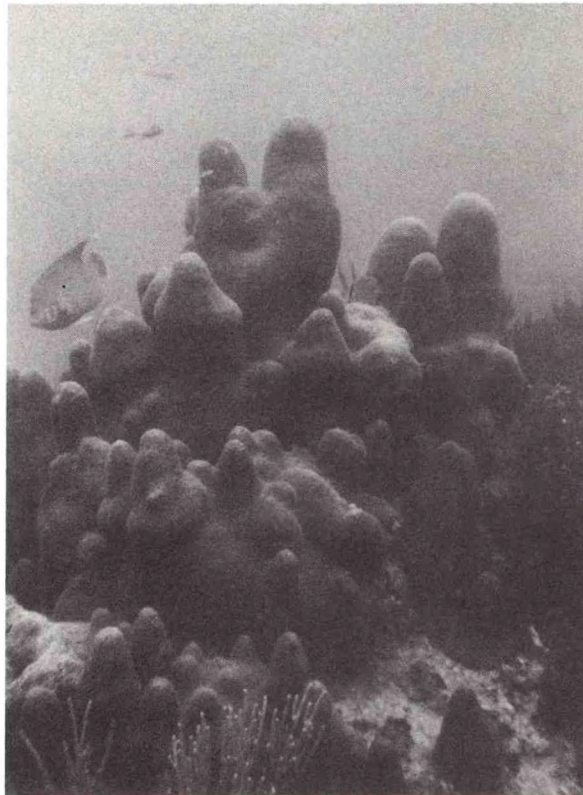
Our reef resources groups made a substantial contribution to the management of red snapper in the Gulf of Mexico. A proposal in the Reef Fish Management Plan to establish a size limit for red snapper had provoked controversy and dissention. Critics questioned the predicted benefit of a size limit and, especially, the supposition that released undersized red snapper would survive to produce the benefit. At the request of the NMFS Southeast Regional Office and the Gulf of Mexico Fishery Management Council, our scientists worked on two fronts to gather information and clear impediments to institution of the management plan.

In the Laboratory, a major innovation in the prediction of yield per recruit occurred as investigators built models incorporating variable survival rates for released fish. These models, built for red snapper and several other important reef species, demonstrated that size limits can increase yield per recruit even at less than perfect survival of undersized fish. In the field, our workers mounted a carefully controlled study to determine the true survival rate of released red snapper. From planning through execution the research involved cooperation between many agencies and groups, including the NMFS Southeast Regional office; Gulf of Mexico Fishery Management Council; the

NMFS SEFC Beaufort and Galveston Laboratories; LGL Inc., a consulting firm; Reel Fun Inc., a headboat firm; Texas Sea Grant; and very importantly the Tenneco Co. whose hospitality allowed the work to occur on a gas production platform and greatly facilitated the project. The research demonstrated conclusively that small red snapper ($< 13"$) have a high (90%) survival rate at the normal depth of headboat fishing and at normal summer temperature. Taken together our two research products offer strong evidence that a size limit can be useful in managing red snapper in the Gulf of Mexico.

Reef Fish Assessment

Visual surveys were conducted of reef fish fauna associated with reef habitats in Key Largo and Looe Key National Marine Sanctuaries in Florida. Reef fishes were quantitatively classified according to abundance, distribution, frequency of occurrence, activity patterns, and food web level. Data are being used to better describe reef fish resources and to optimize sampling strategies for reef fish assessment. Scientists at the Miami Laboratory completed an inventory of reef fish populations at Looe Key. Their report contains information on abundance of over 100 species according to the various habitat types on the reef.



The high diversity of marine life and lush coral growth distinguish Looe Key National Marine Sanctuary.

Accurate censusing of fish populations on coral reefs is difficult because of the uneven bottom and the high diversity of coral reefs. Recently, scientists have developed several techniques based on visual assessment

(species identification and counting) by divers. The counts of fishes obtained from these studies are statistically reliable and provide a valid method of monitoring the fish populations and providing data needed to determine whether population changes are due to natural or to man-made changes. Because the several techniques have slight differences, it was necessary to compare them together at a single location. This was accomplished during a visual assessment workshop held in August. The studies completed provided a calibration of the several techniques in use by various researchers and will allow comparison of estimates of abundance made in different studies at several locations.

A comprehensive review of over 400 references on artificial reefs was completed. The references were annotated and compiled by a computer program for rapid retrieval. The authors conclude their report with 29 recommendations for future studies and for improving the usefulness and effectiveness of artificial reefs.

Other studies on assessing reef fish abundance were conducted by scientists at the Mississippi Laboratories. In cooperation with the Harbor Branch Foundation, surface research vessels and a submersible surveyed deep water areas of the Gulf of Mexico off western Texas for tilefishes and yellowedge grouper. The research compared actual fish densities determined by visual observation with estimates of relative abundance from catch rates of longline gear. When calibration of the fishing gear is complete, it may be possible to use catch rates from fishing data collected over broad areas to provide estimates of actual abundance. During the study period, yellowedge groupers were observed to be occupying burrows of a specific type and different from the burrows made by tilefishes.

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SHRIMP AND BOTTOMFISH

The objectives of the Shrimp and Bottomfish Program are directly related to research priorities established by the Gulf of Mexico Fishery Management Council. Decisions on closures for the shrimp fisheries off Texas and off the Florida Keys are based on the best and most timely scientific data available. Research efforts were directed towards evaluating the impact of such closures, obtaining scientific information concerning the biology and ecology of major shrimp and bottomfish species, and collecting reliable recreational and commercial catch and effort statistics to provide the Council with knowledge needed for the development of management plans.

Gulf of Mexico Shrimp Landings

The Gulf of Mexico shrimp fishery continues to be one of the most valuable commercial fisheries in the nation. The 1983 shrimp landings reported for the Gulf of Mexico totaled 200,266,000 pounds of shrimp (heads on) worth \$415,852,000. This catch was slightly lower than the catch in 1982, which was 210,436,000 pounds worth \$426,866,000. However, both the 1982 and 1983 catch were lower than the five year average (1978-1982) of 228,257,000 pounds. The preliminary data for the last quarter available (March-May 1984) indicate 1984 may be a better year than 1983. Total landings reported for the quarter are 36,264,000 pounds compared to 27,124,800 pounds for the same period in 1983.

Tortugas Sanctuary

The Tortugas sanctuary was established in 1981 as a cooperative closure between the state of Florida and the U.S. Department of Commerce. All trawling was prohibited in the sanctuary so that small pink shrimp (less than 69 tails to the pound) could mature before harvest. Previous research had indicated that the area at the foot of the sanctuary served as a major pathway for the migrating pink shrimp (*Penaeus duorarum*), and that as they grew larger than the minimum legal size of 69 count, they moved north and west into deeper water where they could be harvested.

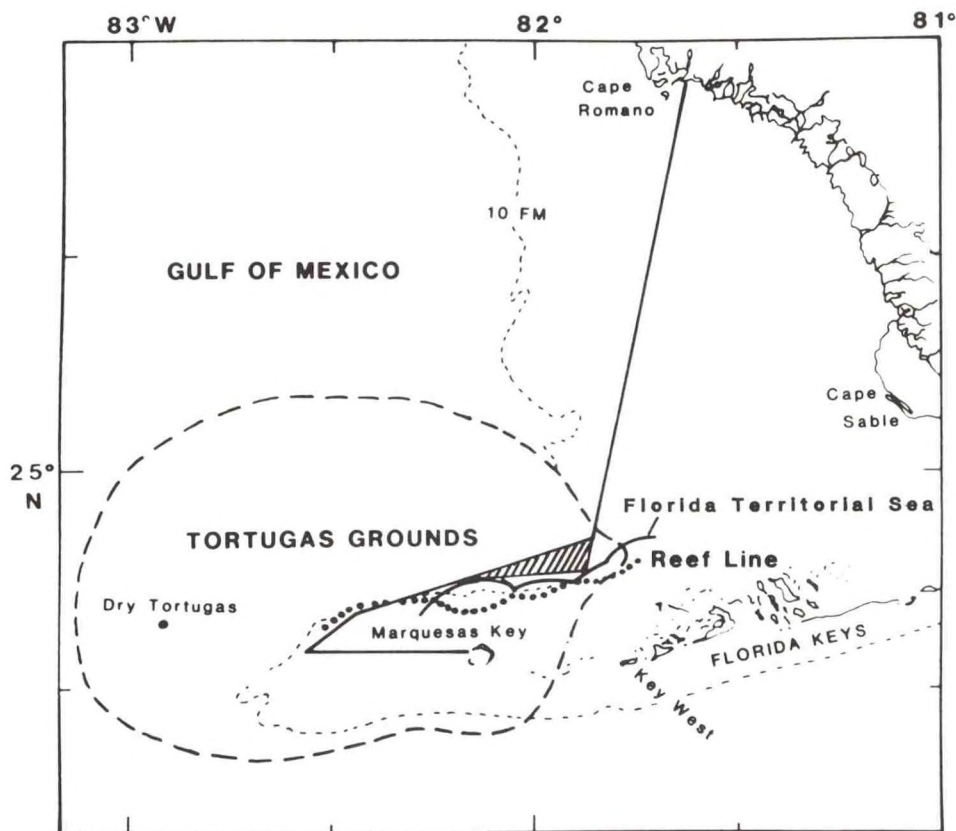
The shrimp industry expressed concern over the decline in catch of large shrimp in recent years and pointed out that modern technology (freezer boats and new peeling-processing plants) enabled them to use smaller shrimp profitably with very little waste (in the plant or at sea as discards). A two-year study of shrimp size and abundance distribution and a one-year tagging study of shrimp movements were completed in 1983 to answer the questions raised by industry over the need for a sanctuary to protect small pink shrimp.

These studies were reported to the Gulf of Mexico Fishery Management Council (GMFMC) in January and February 1984, and supported the conclusions of previous researchers on the distribution of shrimp and their movements on the Tortugas grounds. Most small shrimp were found inside the sanctuary and, except for one to three months a year, larger shrimp were not found in great abundance inside the sanctuary. Highest shrimp density occurred inside the sanctuary and decreased with increasing depth, but shrimp size increased with increasing depth. Residence time for pink shrimp in the sanctuary was generally less than one month, and then they moved into deeper water on the fishing grounds to the north and west outside the sanctuary. However, there

was no detectable impact by the sanctuary on annual shrimp landings for 1981 and 1982. Probably reasons for the inability to detect an impact were the wide variations in annual catch (1981 was a record high year and 1982 was a record low year) and a widespread lack of compliance with the law prohibiting trawling inside the sanctuary.

The GMFMC, after considering these studies and recommendations and testimony, requested that all of the sanctuary foot outside the Florida territorial waters and north of the reef line (about 62 square nautical miles) be opened to trawling. The rationale behind the request was that the combined area of 62 square nautical miles represented only 5.4% of the 1,128 square nautical mile sanctuary (that portion outside Florida territorial waters), and there was little or no waste of small shrimp due to changes in vessel characteristics, processing methods, and elimination of Florida's minimum count law. Also, the NMFS study showed there was a consistently higher CPUE within the sanctuary, which provides for greater efficiency and higher catch rates at lower costs.

The Council concluded that the proposed change conforms to the FMP criteria, that there was no cause for concern over recruitment overfishing, and that the requested management action will not affect the status of the stock. The NMFS, after considering the Council's request and reviewing public testimony and scientific analyses of the studies, concluded the change in the geographic boundaries of the Tortugas sanctuary was not consistent with the objective of the FMP to protect small pink shrimp from overfishing. As a result, a management decision was made to permanently close the Tortugas sanctuary in August 1984.



Texas Closure

Since 1981, the state of Texas and the National Marine Fisheries Service have cooperated in closing shrimp fishing from 4 fathoms to 200 nautical miles offshore of Texas between late May and mid July as part of the Gulf of Mexico Shrimp Fishery Management Plan. The purpose of the closure is to allow small brown shrimp to migrate offshore and increase in size before harvest, thus increasing yield per recruit and the total value of the annual harvest.

The annual catch observed after the Texas Closure went into effect exceeded the yield predicted by yield per recruit models had the Texas Closure not been in effect by 6% to 9% (4.2 million-8.9 million pounds). This represents an added economic benefit of \$41.3 million to \$54.5 million for 1982 and 1981, respectively. The market size category of the catch also showed higher yields of large shrimp, primarily in the 31-40 tails per pound and larger categories. However, the actual benefit of the closure varies between years because the management plan is aimed at improving yield per recruit and does not affect the size of the population available for recruitment. One factor that can affect offshore recruitment by increasing shrimp mortality is the inshore-nearshore fishery. Inshore fishing effort has shown a marked increase between 1981 and 1982, and about a three-fold increase since the early 1960's.

Offshore Ecology

Summer studies of fish predation upon brown shrimp leaving Gulf of Mexico estuaries during 1981-82 identified several of the common (but not abundant) bottomfishes as predators of shrimp. A study of nine species was conducted with samples collected during OREGON II trawl surveys in the fall of 1982 and spring, summer, and fall of 1983. Specimens were collected on the continental shelf between western Florida and the Texas-Mexico border. Analyses of their stomach contents revealed not only their general food habits but also their lack of dependence upon commercial shrimp as food. Rock sea bass, dwarf sand perch, and inshore lizardfish were the only species found with Penaeus spp. in their stomachs, and these shrimp represented less than 1% of each species' diet. Smaller penaeid shrimp, such as roughback shrimp (Trachypenaeus spp.) and rock shrimp (Sicyonia spp.), were more frequently found in stomachs of these and six other species. The nine fish species and their primary foods are: 1) bank sea bass and bighead searobin - crabs; 2) red snapper, dwarf sand perch, and blackfin searobin - shrimps (not penaeids); 3) rock sea bass and southern kingfish - shrimp and crabs; 4) inshore lizardfish - fishes; and 5) ocellated flounder - fishes, shrimp, and stomatopods. Most species diets were affected by age, area, depth, season, or time of capture. For example, the general trend over all fish species was that crab were eaten most frequently by older fish, off Texas, in shallow water, during summer, or at night. In contrast, shrimp of all kinds were preyed upon most often by younger fish, around the Mississippi Delta, in shallow water, during fall, or at night. Only the inshore lizardfish and bighead and blackfin searobins did not have variable diets. A secondary objective of this study was to note seasonal reproductive activity in the nine fish species. Ripening gonads were most frequently seen during fall in ocellated flounder and bighead searobin, during spring in rock sea bass, southern kingfish, blackfin searobin, and inshore lizardfish, and during summer for the hermaphroditic dwarf sand perch. No reproductive activity was noted in bank sea bass (collected only during summer) or in immature red snapper.

Estuarine passes were felt to be a potentially major site for fish predation upon shrimp, because the shrimp must funnel through passes during their seaward migration and, at that time, would be relatively concentrated in confined areas. Preliminary results from a summer gill net study around the Galveston Bay entrance indicate predation is minor around the passes. Only 9 of the 429 fishes and sharks examined (ranging between 175 mm and 965 mm total length) were captured with whole or parts of Penaeus spp. in their stomachs. Species occasionally eating brown or white shrimp included croaker, Atlantic sharpnose shark, speckled trout, hardhead catfish, bighead searobin, and ladyfish. The primary prey of these and the other 10 species collected was fish, usually menhaden or silversides. The shrimp eaten usually fell into the middle of the size ranges of shrimp present near the gill nets (as indicated by trawl catches), even though predation upon smaller sized shrimp was expected.

Bottom water hypoxia, ≤ 2.0 ppm dissolved oxygen content, occurs frequently off the upper Texas and Louisiana coasts. Although not directly linked to declines in shrimp catch, its presence during portions of the shrimp life cycle implicate it as a possible source of variation in annual shrimp yield. Shrimp response to hypoxia in the natural environment has not been documented. It is believed that their migration patterns can be altered by oxygen deficient water. This is supported by laboratory tests in which brown and white shrimp detected and avoided water with low oxygen levels. Avoidance was pronounced at 1.0 and 1.5 ppm for white shrimp, 1.5 and 2.0 ppm for brown shrimp, and variable at higher levels for both species. Behavioral responses of brown and white shrimp to hypoxic water included 1) an increase in activity level, 2) walking or swimming retreat, and 3) rapid eye movements. In addition, white shrimp exhibited notable abdominal flexing, periods of exhaustion, and sometimes death. The latter behaviors were not observed during 75 hours of experimentation with brown shrimp. This may be due to quicker retreat from hypoxic water into normal seawater by brown shrimp. Dissolved oxygen levels used in the laboratory experiments are common in the nearshore Gulf of Mexico during the summer and early fall. Therefore, it is not unreasonable to assume that migrating juvenile shrimp exhibit similar behavioral responses in nature.

South Texas Transboundary Shrimp Migration

Data from a cooperative mark-recapture study of brown and pink shrimp, conducted during 1978-1980 by the Texas Parks and Wildlife Department, Mexico's Instituto Nacional de Pesca, and NMFS, were analyzed in response to the Gulf of Mexico Fishery Management Council's concern over shrimp migrations during the Texas closed shrimp season. Shrimp marked and released in Texas and Tamaulipas estuaries and later recaptured offshore demonstrated no preferred movement directions. However, of the 121,400 marked shrimp released in estuaries, only 1,828 (1.5%) were recaptured and only 72 of these were captured offshore. Offshore releases of 70,000 brown shrimp and 20,400 pink shrimp resulted in 10.1% and 16.8% recaptured, respectively. Brown shrimp moved up to 620 km (335 nautical miles) and remained free up to 430 days. Net population movement was southerly after spring through fall releases off Texas and upper Tamaulipas. South of 25°N, brown shrimp movements were diffusive or, rarely, northward. In contrast, pink shrimp usually diffused in all directions from release sites even though maximum distances (428 km = 231 n. mi.) and days free (446) were similar to those of brown shrimp. The data, although sparse along the south Texas coast, indicate an exchange of shrimp

across the border, but a directed tagging effort is needed there for a definitive statement. Brown shrimp migrations are a concern of U.S. shrimpers because they are not allowed into Mexican waters and because the Texas coast is closed to shrimping during June and part of July. The shrimpers perceive a portion of their potential catch slipping away and would like to have data upon which to propose changes in management regulations.

Prediction of Shrimp Yield

In response to requests from industry and other interested parties, the Galveston Laboratory issued a forecast concerning the prospects for the 1984 brown shrimp season based on indices of postlarval and juvenile shrimp abundance. Brown shrimp postlarvae (6-12 mm total length) enter the bays and passes from the Gulf of Mexico, usually after water temperatures reach 16°C. In 1984, bay waters were generally above 16°C by the first week in February. Extremely high catches of postlarval brown shrimp were observed at the Galveston entrance throughout the spring (February-May) and were much higher than the 15-year average postlarval index for Galveston Bay. Unfortunately, water levels were dramatically lowered by two northerners (February 27-29 and March 29) with sustained high winds resulting in tides 1.5-2.0 meters below normal. The low water exposed the juvenile shrimp on the shallow mud flats for several days, and many dead shrimp were observed.

Shrimp abundance was also estimated by tagging experiments in Sydnor Bayou, a Galveston coastal pond. In 1970, an above average year, the standing stock was estimated to be 6,500 shrimp per acre, while it was 2,600 per acre in 1983 and 3,500-4,900 per acre in 1984. Another tagging study in Sydnor Bayou later in the year indicated the white shrimp population was higher, averaging 5,800 shrimp per acre. Supporting evidence that 1984 would be a better year than 1983 was provided by another method for estimating the standing stock which used a drop-sampler to calculate shrimp density in the marsh. Samples of juvenile brown shrimp in a salt marsh at Galveston Island State Park indicated much higher densities in March and April 1984 compared with 1983, and densities similar to 1982. However, catch rates by commercial shrimpers during the Texas inshore shrimp season (opened May 15) were low compared to 1983 (20-32 lbs/hour vs. 45 lbs/hour) in Galveston and Matagorda Bays. Catch rates in Aransas and San Antonio Bay were higher (70 lbs/hour) indicating a high inter-bay standing stock variability. In comparison, good catch rates from other years averaged 75-100 lbs/hour.

The most reliable estimate of the relative magnitude of the brown shrimp crop comes from data collected from the Galveston Bay bait shrimp fishery during May and early June. The 1984 index is slightly below average, and the prediction for the July 1984-June 1985 catch was set at 22.9 million pounds. For comparison, the average offshore brown shrimp production off Texas from 1960-1983 was 27.4 million pounds.

Oil Spill off Galveston, Texas

On July 30, the British tanker ALVENUS split open at the bow releasing about two million gallons of heavy crude oil into the sea off Cameron, Louisiana. Because of possible detrimental effects of the oil on the shrimp fishery, a three-day cruise was scheduled for August 3-5 to observe any changes in biological, water, and sediment samples taken near the oil.

Fifteen stations were sampled at random from near shore to 10-12 miles offshore. Samples at each station consisted of surface and bottom water temperature, salinity, and dissolved oxygen, a sediment sample, and a 30-minute tow with a 32-foot flat trawl. Samples were taken shoreward of, under, and seaward of an oil slick off Galveston as well as along the path of the oil between Sabine Pass and Galveston. There was no evidence of oil (sight, smell, and touch) in the bottom water, sediments, or trawl samples, nor was there evidence of hypoxia in the water samples. Comparison of the trawl catch with catches made by the commercial shrimp fleet before the oil spill indicated no change in the quantity or quality of shrimp.

Although there were no observed detrimental effects of the oil spill offshore, the oil that washed ashore on Galveston Island coated the beach sand and rocks along the seawall. Most damage appeared to be aesthetic rather than environmental and subsequent work concentrated on cleaning up the oil on the beaches. Little progress in cleaning the oil was made, because much of the oil was concentrated in the surf zone and would then wash ashore during windy weather to recontaminate the beach and rocks.

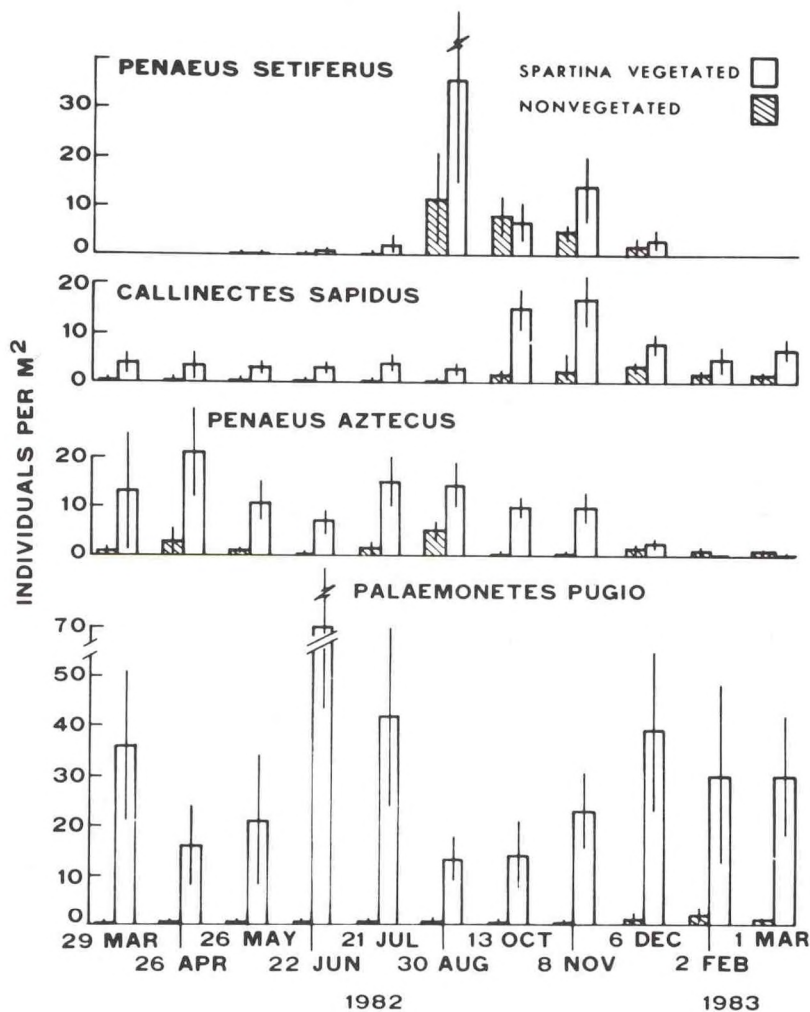
To facilitate oil cleanup on the rocks, an oil dispersant (Corexit 9527) was tested at the western end of the Galveston Seawall. To test for toxicity to marine life, cages containing adult blue crabs and white shrimp were placed in the splash zone at the test site and to each side. Although some of the shrimp did die during the experiment (all crabs survived), mortality could not be attributed to the dispersant. Death was more likely due to water turbulence. However, since the dispersant had little effect on the oil on the rocks, the cleanup contractor will probably not use it again.



Effects of oil spill on Galveston Island.

Estuarine Ecology

Utilization of Spartina alterniflora habitat in Galveston Bay by brown shrimp, white shrimp, blue crabs, and many estuarine fishes has been firmly established. Drop-sampler comparisons of vegetated and nonvegetated habitats continue to show high densities of natant fauna within the marsh at flood tide. Brown shrimp appear to be more attracted to marsh habitat than other commercial species, and annual abundances of brown shrimp correlate positively with seasonal high-water stands. Potential benthic food organisms, including certain algae, amphipods, tanaidaceans, and polychaetes, are also more dense in S. alterniflora habitat than nearby nonvegetated habitats. Other materials, such as organic detritus within sediments, and some benthic diatoms and blue-green algae, do not differ quantitatively between vegetated and nonvegetated habitats.

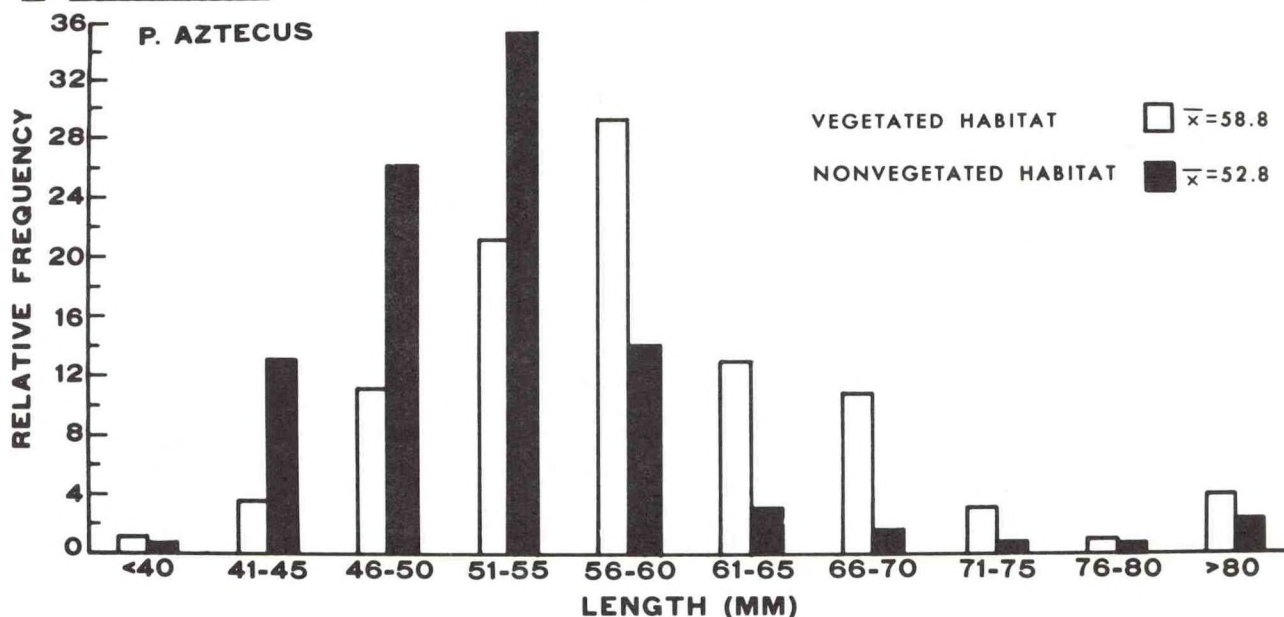


Comparison of vegetated and nonvegetated habitats.

Growth rates of brown shrimp given access to S. alterniflora habitat were higher than those of shrimp confined to nearby nonvegetated bottom, despite the limitations imposed in Spartina by tides. Under the same circumstances, white shrimp growth was not different between these habitats. Results of such

field experiments, differences in stable carbon isotopes, and laboratory feeding experiments imply dietary differences between white and brown shrimp. Postlarvae of both species survived well when given monotypic diets of Skeletonema costatum (a diatom) or epiphytic algae from Spartina detritus. However, white shrimp given Skeletonema and epiphytes had significantly higher growth rates than brown shrimp. Brown shrimp survived but did not grow well when given plant material alone (about an order of magnitude less than in nature), implying significant reliance on animal material for growth. In support, polychaetes and small crustaceans were greatly depleted in field enclosures containing shrimp.

Other studies are underway, using the drop-sampler, to compare shrimp habitats in several types of estuarine nurseries. In a Spartina patens marsh (Creole, Louisiana), brown shrimp were significantly more abundant in open-water habitat two miles from the marsh edge than 20 miles away. Shrimp and other natant organisms moved into marsh habitat during infrequent periods of flooding. In a Halodule wrightii seagrass bed (Christmas Bay, Texas), smallest sizes of brown shrimp and white shrimp were more dense than in nearby S. alterniflora or sand bottom habitats.



A sampling study of shrimp distribution and population size in the marsh system of Galveston Bay is being conducted at two sites. Quantitative and semi-quantitative samples of the macrofauna are taken once a month using a drop-sampler (a cylindrical device covering 2.8 m²) and a beam trawl (a six-foot hand-towed net), respectively. Preliminary results from the drop-sampler distribution study in March-May indicate there is no difference in brown shrimp abundance in flooded Spartina grass and nearby nonvegetated bottom in West Bay, but there is a significantly higher abundance of brown shrimp in the vegetated samples in East Bay. Comparisons show the drop-sampler (assuming nearly 100% efficiency) collects about 1.5 times as many shrimp per square meter as the beam trawl, indicating a catch efficiency of about 67% for brown shrimp by the beam trawl.

Shrimp aggregation studies with the beam trawl in nonvegetated areas of the marsh have found that brown shrimp tend to aggregate in clusters of about 5 meters during March-May. These clusters occur at varying distances per-

pendicular to the grass line and along the grass line. Shrimp sorting, measuring, counting, and identification are continuing, and these preliminary results could change as white shrimp become dominant in the marsh later in the year.

A series of laboratory predator-prey experiments has been recently completed to examine the effect of turbid water on predation. Juvenile brown shrimp, Penaeus aztecus, were used as prey and four species of predatory fishes were examined. A preliminary analysis of the data indicates that in turbid water, predation rates were reduced for pinfish, Lagodon rhomboides, and to a lesser extent Atlantic croaker, Micropogonias undulatus, while no effect was observed for red drum, Sciaenops ocellatus. Southern flounder, Paralichthys lethostigma, exhibited significantly higher predation rates in turbid water compared to clear water treatments. Data from these experiments also indicated that burrowing by shrimp decreased predation rates of all predators examined except Atlantic croaker. Since burrowing apparently protects shrimp from fish predators, studies of factors affecting burrowing by shrimp are also being conducted. Turbidity significantly reduced burrowing by brown shrimp but not white shrimp. Other factors to be examined include size, density, hunger, temperature, salinity, and the presence of predators.

Laboratory studies of fish predation on postlarval brown shrimp are continuing. The presence of Spartina alterniflora and the density of prey have both been shown to affect predation rates. Stomach contents of fish collected in vegetated and nonvegetated habitats in a Galveston Bay marsh are also being examined.

Shrimp and Bottomfish Surveys

Spring and fall shrimp and bottomfish surveys (SEAMAP) were conducted primarily in the north-central Gulf of Mexico in depths of 5 to 50 fathoms. Atlantic croaker was the dominant species caught and showed the same pattern of higher biomass in the fall and lower biomass (but higher density due to an early migration) in the spring as in previous cruises. Length frequencies of croaker were uniform throughout the area during the fall cruise, but were bimodal during the spring cruise as a result of large numbers of juveniles caught in the shallower depths off the west delta.

Declines in croaker and other finfish biomass and mean weight per individual continued through fall 1983; however, this decline appears to be stabilizing since 1977. Estimates for the annual total croaker mortality rate are 64.7% (1982), 53.8% (1981), 63.6% (1980), and 35.3% (1979). However, it is still unknown whether these declines are due to overfishing, environmental changes, or natural cyclic phenomena.

Age Structure and Croaker Stocks

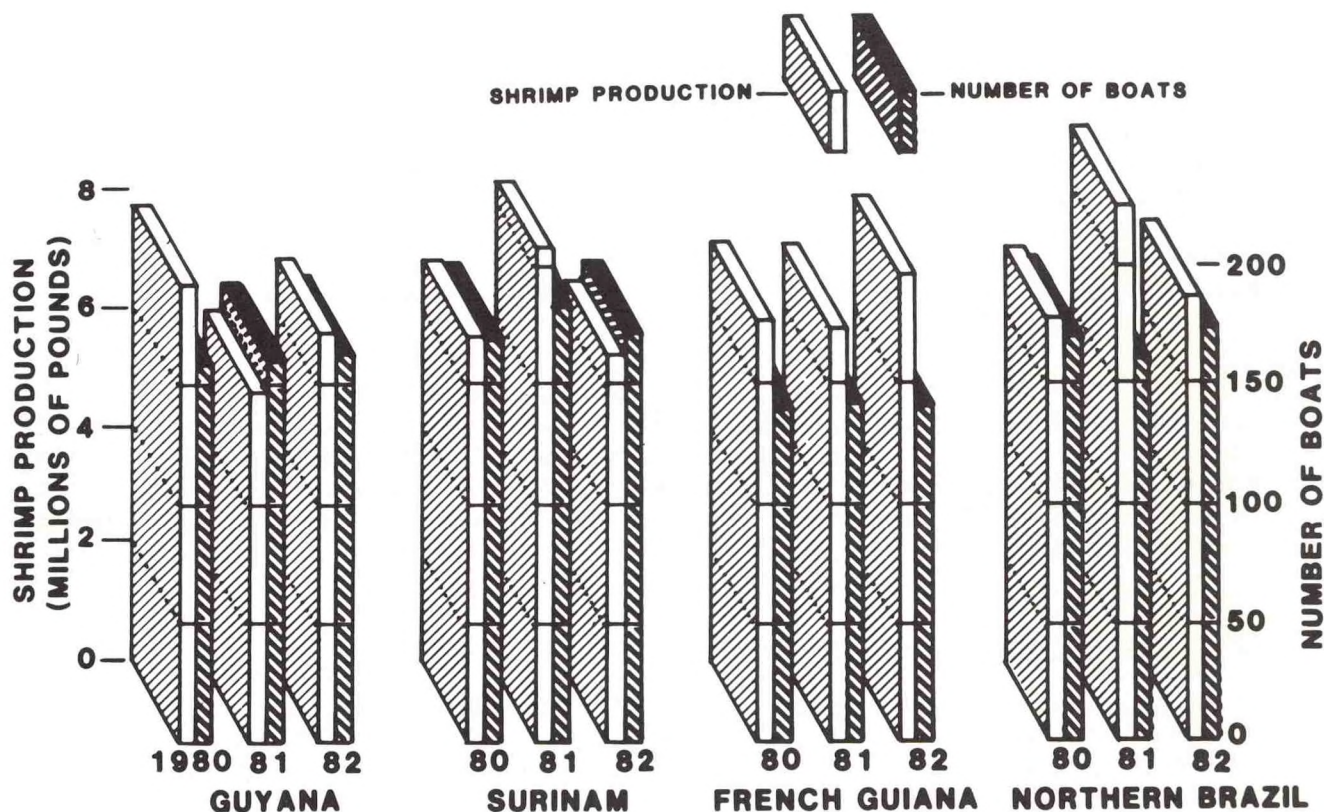
An age composition study of Atlantic croaker based on growth bands in otoliths started in 1983. Croaker ranging in size from 70 to 240 mm total length were collected in 1983 and 1984. Otoliths from croakers less than 180 mm (72% of the fish examined) had no recognizable growth bands and were labeled as zero age class, while 180-203 mm croaker were classified as one

plus age. The majority of croakers caught in the summer 1983 cruise were zero age class. The dominant age class needs to be identified for 1984.

South American Shrimp Studies

With the increased exploitation of the Guianas-Brazil shrimp fishery grounds off the coasts of Guyana, Surinam, French Guiana, and northern Brazil, the need for international cooperation in research to properly manage the fishery has been recognized. As part of this international cooperation to obtain information on shrimp distribution, movement, growth, and mortality rates, an inshore-offshore tagging effort began in 1981 and continued in 1982. Although approximately 29,000 shrimp were released in estuaries and 7,000 offshore, recoveries have been low, amounting to only 1.1% of releases. Data are very limited, but preliminary analysis suggests a generalized north-northwesterly movement by most of the shrimp off French Guiana, while others show a random pattern.

Catch and effort statistics gathered from plant managers and fleet operators in the Guianas-Brazil shrimp industry indicate only slight differences in the landing statistics from 1980 to 1982. Although catch-effort data are not available for all countries, effort can be implied by the number of boats working off each nation's coast. Of the four countries in the fishery, French Guiana has the highest production on a per boat basis. All the countries, except Surinam, had a fairly stable number of boats in the industry for 1980-1982.



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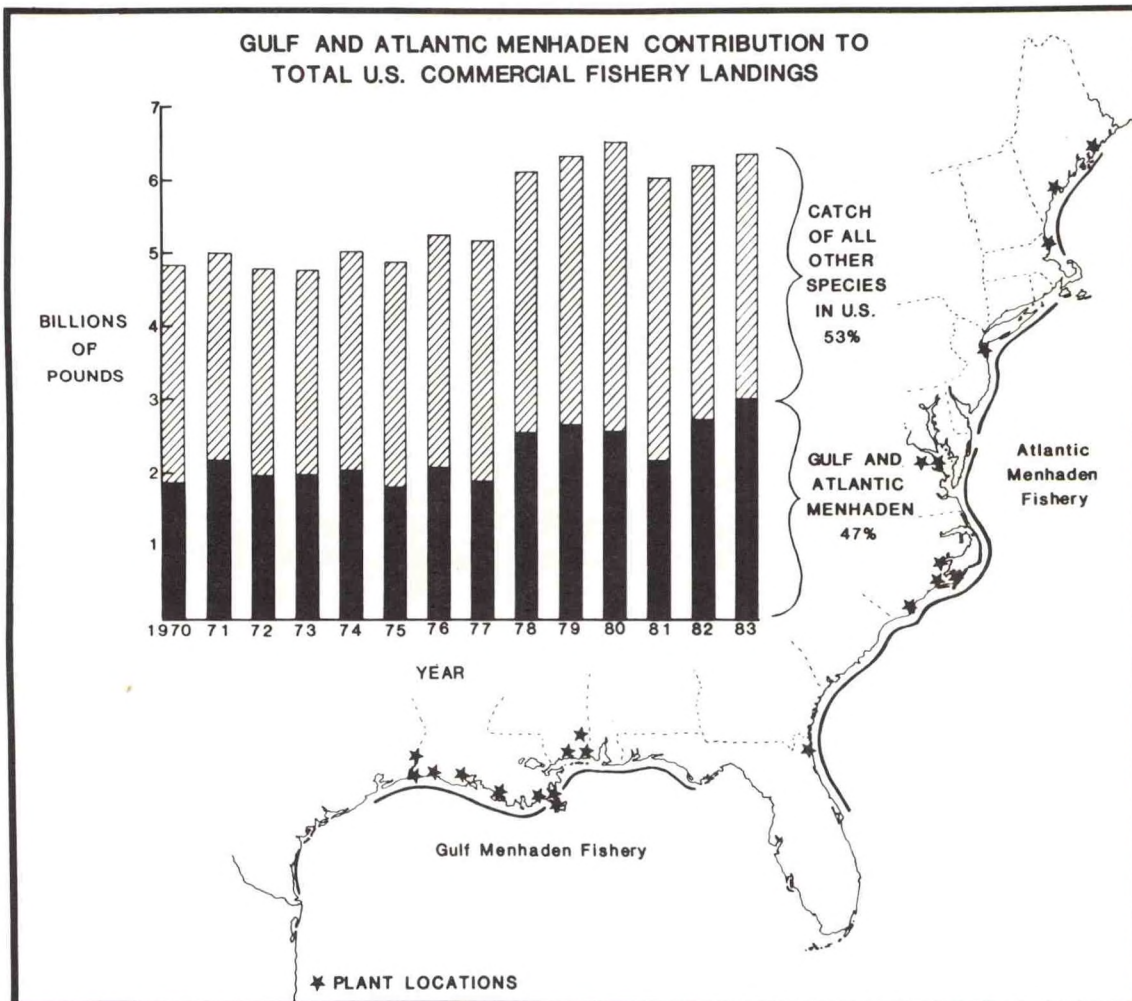
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FISHERY UTILIZATION

The Fishery Utilization Program provides scientific and technical information contributing to the stabilization and economic growth of the fishing industry of the southeast region. The specific areas of research are in post-harvest handling, process and product development, nutritional and quality evaluation, and the establishment of edibility and storage stability characteristics.

Menhaden for Human Food Use

In 1983, 47% of the commercial fishery landings in the United States were menhaden. They are easily caught in abundance commercially by purse seines and are mostly processed into fish meal and oil. Economic stresses on the menhaden fishing industry increased market demands for traditional food fish, and emphasis on optimal utilization of the fishery resources have directed attention to higher value utilization of the menhaden resource. The menhaden industry is taking action to upgrade the use of menhaden for human food and has requested assistance and cooperative efforts from both the private and public sectors. The Charleston Laboratory has been working on development of intermediate frozen products suitable for additional processing into a variety of consumer products such as sausages, fish cakes, luncheon meats, and fabricated or restructured products. This is the second year of a three-year program effort.



Fresh Menhaden Holding Studies

Atlantic menhaden were obtained from Fernandina Beach, Florida, in August and Weems, Virginia, in September. Gulf menhaden were obtained from Port St. Joe, Florida, in June and July. The fish were iced and chilled immediately after harvesting and transferred to refrigerated seawater (RSW) and chilled seawater (CSW) holding systems within 24 hours. Three hundred pounds of fish were held in each system for up to 14 days. Samples were taken periodically and subjected to sensory inspection, processed into washed and unwashed minced fish, frozen at -40°C , and tested or analyzed within a few days. The whole wet fish were evaluated for freshness by sensory examination (color, odor, eyes, gills, skin, scale, and viscera). Analyses for protein, ash, moisture, fat content, salt, pH, TBA, TVN, TMA-N, color, and fatty acid profiles were conducted on the raw flesh. Color, drip loss, and shear values were determined on the cooked mince. Results were compared over time for the three holding methods--RSW, CSW, and iced. While there were small differences in measured values as the fish deteriorated among the various catches and holding systems, there were no great differences among holding systems except in salt uptake by the fish. Salt uptake was, of course, highest in RSW systems but limited by the water ratios used in the system, the size of the fish, and time of holding. Salt was removed if the resulting minced fish was washed. Even though it was possible to hold the fish 4 to 6 days before they were rated of borderline quality as an edible fish, this is not recommended. The selection of a holding system depends upon the economics and operational effectiveness of the particular situation rather than upon the method of holding per se. RSW, CSW, or ice systems of holding menhaden can be equally effective for chilling and holding menhaden a limited time between harvest and processing. Each method has its advantages and disadvantages, depending upon the situation.

Whole Menhaden Frozen Storage Study

A previous study of the storage stability of frozen whole menhaden, carried out during 1983, indicated that freezer storage at -20°C maintains the quality of this species for at least 24 weeks. This year's study was undertaken to confirm this conclusion. Fresh menhaden, caught in late September 1983, were delivered to the Charleston Laboratory less than 24 hours after capture. Two 36-pound lots of fish were dipped in solutions of sodium erythorbate (NaE) plus sodium citrate (NaC) or NaE alone. After dipping, the treated fish were packaged in freezer cartons in three 12-pound lots per treatment. Six 12-pound lots of untreated fish were also packaged. After overnight blast-freezing, the treated fish were glazed with the appropriate antioxidant solutions. Three boxes of untreated fish were glazed with distilled water to serve as a positive control; the remaining three boxes of untreated fish, left unglazed, served as a negative control. After glazing, the boxes were stored at -20°C . At 8, 16, and 24 weeks, rancidity development was evaluated by measurement of peroxide values (POV), thiobarbituric acid (TBA) values, and losses of polyunsaturated fatty acids and polar lipids. At the end of each time period, a minced product was prepared and sensory evaluations of quality were also carried out.

The fish utilized were smaller than those of the previous study (mean weights of 0.16 kg and 0.25 kg, respectively) and their lipid content was

somewhat less (3.9% vs. 7.7%). Consequently, their lipids contained smaller percentages of triacylglycerols and greater percentages of polar lipids than those of fish used in the previous study. Free fatty acids were undetectable in baseline samples but increased in stored samples to a high of about 2% in lipids of fish stored for 24 weeks.

The highest TBA values measured (0.6 gm/kg tissue) were obtained on unglazed controls after 16 and 24 weeks of frozen storage. For all other treatments and storage times, TBA values ranged from 0.2 to 0.3 mg/kg tissue. These values were very similar to those obtained in the previous study and confirmed the conclusion that, under these experimental conditions, TBA values were treatment-dependent rather than time-dependent. As in the earlier study, POVs were highly variable, with no apparent pattern. No losses of polyunsaturated fatty acids were detected, nor were there any significant losses of polar lipids in any of the stored samples over the duration of the study. Flavor scores decreased slightly from 4.8-5.0 (five-point scale) for samples stored for 8 weeks, to 4.1-4.3 after 24 weeks, with no significant differences between treatments.

Although the POVs were almost three times higher than those of the previous study, TBA values did not differ significantly from those of the earlier study and sensory scores indicated satisfactory quality after 24 weeks storage. Thus, freezer storage at -20°C appears to satisfactorily preserve the quality of menhaden.

Washed Minced Menhaden

Numerous experiments and studies were conducted this year to define a "reasonable" process to produce a washed, minced menhaden intermediate product. Water ratios, number of washes, degree of soluble protein removal, degree of fat removal, pH of wash water, settling time, use of counter-current washes, use of frozen and fresh fish, use of fish of varied fat content (different catches from the Gulf and Atlantic), and several equipment choices were studied. Deboning, straining, screening, pressing, and centrifuging were also studied. A dewatering press was selected in preference to a centrifugal decanter for both economy and performance. Scaling of the fish was eliminated as unnecessary and detrimental to mechanical gutting and deboning. Commercial heading and gutting machines were tested on menhaden by manufacturers whom we supplied with fish. A deboner drum with 3 mm perforations was selected in preference to larger 5 mm perforations because of more effective bone and scale removal. A temperature of 45°F (7°C) had been selected previously over ambient or higher temperature because of changes in color and increased chemical and microbiological reactions at higher temperatures. Tap water with 0.1% salt added was used for washing. Intra-stage use of a rotating screen was added to increase washing efficiency by increasing free water removal. Counter-current use of the wash water appears feasible from bench-scale studies. A strainer drum with 1.2 mm perforations was used. Methods of analysis for residual bone and scale were investigated. The present pilot plant process consists of dressing the fresh fish, deboning, washing the minced fish, straining, packaging, and freezing. Washing consists of stirring the minced fish for 3 minutes with 5 parts of 7°C (45°F) tap water containing 0.1% salt; settling for 10 to 20 minutes, gravity decanting the floating materials and free water, and screening the settled solids to reduce excess

free water. After washing and screening three times the solids are additionally dewatered to 80% moisture in a screw press. The washed minced fish is strained to remove residual bone, scale and defects, then packaged and frozen at -40°C . Fractional straining can be used to alter properties such as color. Cooperative pilot plant runs have been made with investigators from Virginia Polytechnic Institute to prepare samples for consumer product processing and formulation. Next year's effort will be directed toward critical frozen storage studies, intermediate product evaluation, and necessary iterative process modifications. Samples will be prepared for use and evaluation by interested cooperating investigators.

Minced Fish Products

Preliminary experimental sausage products were prepared from minced menhaden. Unwashed mince, with and without straining, was used. The second set of samples contained sodium nitrite at 150 ppm and was prepared from deboned (3 mm drum) but unstrained menhaden. Color was improved with nitrite added, but texture was somewhat softer. The stronger, more spicy of two sausage seasoning mixes was preferred by the sensory panel. It tended to mask "fishy" flavors in the sausage (97% menhaden).

A 6-month frozen storage study was conducted with 1-pound blocks of unwashed, minced menhaden. The effects of incorporation of sodium erythorbate and Lem-o-Fos in the mince on storage stability at -20°C and -30°C were tested. The sodium erythorbate treated samples had lower TBA numbers after 6 months, but were rated no better than control samples by the sensory panel. The addition of Lem-o-Fos (primarily phosphates) increased water retention by cooked samples and resulted in a softer texture as measured with the Instron unit.

Both washed and unwashed minced menhaden were used in some initial studies on methods for measuring the gel-forming capacities of the minces. This is important for surimi based products and also to some extent for sausage products.

Menhaden Minced Fish Bacterial Analyses

Work in this area consisted of familiarization with the processes and literature reviews for preparation of bacterial analytical protocols for various aspects of the production of minced products from menhaden. Studies show no organisms of sanitary or public health significance. Studies on microbiological profile of minced fish will be expanded in 1985.

Menhaden Oil Petition Development Effort

Work continued on developing an information base on marine oils that will be used by the menhaden reduction industry in their food additive petition submission to the Food and Drug Administration. An important part of this data base is the results being generated from three long-term toxicological studies in which partially hydrogenated menhaden oil (PHMO) was fed to experimental animals. The in-life phase of the third and final long-term study was

successfully completed in June 1984. During this 12-month dog study, PHMO was incorporated in a diet of supplemented special Certified Diet #5007 at concentration levels of 8% and 16%. The diet of the low-dose animals (8% PHMO) also contained 8% partially hydrogenated soybean oil (PHSO). Each experimental and the two control groups contained six male and six female beagles. One of the control groups was offered the special Certified Diet and the other received the Certified Diet containing 16% PHSO.

Detailed observations indicated that the dogs developed normally and there was no evidence of adverse effects from consumption of the test diets. Twelve-month hematologic and clinical chemistry values were considered within the normal range of historical control values and without toxicological significance. The rapid early growth of the dogs in the experimental and PHSO control groups resulted in a larger increase in mean body weight of those groups compared to that of the untreated control group. The evaluation of this study is proceeding as planned, with no unexpected or unusual findings. A draft final report of the dog study is scheduled to be completed in December 1984.

As to the status of the other two long-term studies, a rat multi-generation study with a teratology phase and a rat life-span study, the former is undergoing final draft revision. A final draft report of the latter study is scheduled for delivery on October 26.

A meeting between menhaden industry representatives and NMFS officials was held August 17 to review progress and determine future actions necessary to allow for submission of a petition at the earliest possible date. One consensus reached was that the scientific aspects of developing the petition were essentially complete, and that the Special Menhaden Task Force would now function only in an advisory capacity. In addition, the National Fish Meal and Oil Association assigned to its Executive Director the role of Project Manager with full authority to take the necessary steps to complete the petition as soon as possible. As part of the petition development effort, the Charleston Laboratory has created a comprehensive literature file on fish oil. There are currently 4,700 articles on file, of which 1,867 are related in some way to the petition.

In the near future, the Charleston Laboratory will publish a "A Selected Fish Oil Bibliography." To make the information from the articles contained in the bibliography more accessible to interested persons, a computer program (ORALS) for entering, collating, searching, and retrieving these references has been developed.

Tissue Lipids from Rats Fed Experimental Diets Containing Partially Hydrogenated Menhaden Oil

Lipids were extracted from perirenal fats and liver tissues of 21 male and 24 female rats fed a stock control diet, a control diet containing 16% PHSO, an experimental diet containing 16% PHMO, or a second experimental diet containing 8% PHSO and 8% PHMO. The compounded diets were also supplemented with 4% corn oil as an essential fatty acid (EFA) source. The rats were exposed in utero to the diets and were maintained on the diets for their entire life-span.

No trans fatty acids were detected by infra-red (IR) spectrophotometry in depot fats or liver lipids of rats fed the stock control diet. In depot fats of rats fed the other three diets, trans unsaturation was greatest in rats fed the PHSO diet (16.7% in males, 19.4% in females), lowest in rats fed the PHMO diet (15.4% in males, 16.1% in females), and intermediate in rats fed the mixed diet, but these differences are probably not statistically significant. In the liver lipids, there was no significant difference in trans unsaturation (mean $12.8 \pm 0.3\%$) in males and females fed any of the compounded diets.

Analysis of fatty acid methyl esters by gas-liquid chromatography (GLC) showed that individual fatty acids containing trans unsaturation were present in very low concentration, except for trans 18:1 (position of ethylenic bond uncertain). This fatty acid was present at appreciable levels in depot fats of rats fed the PHSO diet (11%), lowest in that of rats fed the PHMO diet (4%), and intermediate in rats fed the mixed diet (8%). In the liver lipids, trans 18:1 was about one-third greater in rats fed the PHSO diet as compared with rats fed the PHMO and mixed diets.

While some differences in the percentage of 20:4 ω 6 were detected in liver lipids of the treated animals, these differences were not statistically significant nor were they significantly different from 20:4 ω 6 percentages in liver lipids of rats fed the stock control diet. Similar percentages of 20:4 ω 6 and the absence of 20:3 ω 9 (an EFA deficiency indicator in rats) in the liver lipids suggest that none of the dietary groups were suffering an EFA deficiency at the time of sacrifice.

None of our experimental results suggest that PHSO is better than PHMO as a dietary fat for rats. In fact, the presence of greater percentages of trans fatty acids in the liver lipids of rats receiving dietary PHSO suggests that it may not be as good a dietary fat as PHMO for rats.

Tissue Lipids from Dogs Fed Experimental Diets Containing Partially Hydrogenated Menhaden Oil

Samples of perirenal fat and liver tissues from 24 male and 24 female beagles were shipped on dry ice to the Charleston Laboratory from the International Research and Development Corporation Laboratory where the feeding study was carried out. Because of anticipated high activity of hydrolytic and lipolytic enzymes in the liver tissues, the liver lipids were extracted as rapidly as possible, the tissues remaining on dry ice until extracted. All extractions of liver tissue were completed within three days. The depot fat samples have been stored at -40°C while the liver lipids are being analyzed by qualitative and quantitative thin-layer chromatography, GLC and IR spectrophotometry.

Fatty Acid Composition of Commercial Menhaden Oils

Investigations of the fatty acid composition of commercial menhaden oils were continued. Fatty acids of 63 oils, composited monthly during the 1983 fishing season at participating plants on the Atlantic and Gulf coasts, were analyzed in duplicate by high-resolution, wall-coated open-tubular GLC. From a total of more than 60 components in each sample, 36 fatty acids were

selected for calculation of annual mean values, standard deviations, and ranges of percentages found. Then of these fatty acids of nutritional or biochemical importance were selected for sophisticated statistical analysis of annual, seasonal, and geographical differences.

In the Atlantic oils, there were no significant differences between 1982 and 1983 annual mean percentages of these 10 fatty acids, though statistically significant annual differences ($p \leq 0.001$) in several were observed in gulf oils. For most of the 10, geographic and seasonal differences were prominent. In both 1982 and 1983, the mean percentages of 16:0 and 18:1 ω 9 were significantly greater while those of 20:5 ω 3 and 22:6 ω 3 were significantly lower in gulf oils than in Atlantic oils. Even though the ω 3 polyunsaturates were lower in the gulf oils, the yield of these potentially valuable nutritional supplements or therapeutic agents is much greater from the gulf oils because of the much larger catch of fattier menhaden on the gulf coast.

Among the gulf oils, there were significant seasonal and geographic differences in the percentages of 18:1 ω 9, 20:5 ω 3, and 22:6 ω 3. As in the 1982 gulf oils, 18:1 ω 9 percentages were significantly lower in oils produced by plants east of the Mississippi River than in those from western plants during the early months of the fishing season, but the difference became much less as the season progressed. Since menhaden are planktivorous, it seems likely that this seasonal difference is probably due to differences in phytoplankton populations of the east and west gulf or in waters of the menhaden's winter residence.

A manuscript describing fatty acid compositions of 1982 and 1983 menhaden oils has been prepared and submitted to SEFC for publications in Marine Fisheries Review.

Minced Mixed Species Studies

A study was conducted on the characterization and frozen storage quality of washed and unwashed minced croaker, spot, and weakfish. These species were selected as the dominant species in shrimp bycatches. Samples of the three species plus 1:1:1 and 2:1:1 mixtures, respectively, were prepared and stored at 0°F for 6 months. The 10 samples were each tested at 0, 6, 12, 18, and 24 weeks of storage. Physical, chemical, and sensory testing consisted of measuring protein, moisture, ash, fat, salt, total volatile nitrogen (TVN), thiobarbituric acid (TBA) values, pH, raw and cooked color, cook drip, peak shear values of cooked mince, flavor and texture sensory profiles, and fatty acid profiles. The data from this study have not been completely analyzed. The study generally indicated good storage stability for all samples and proportional results for the mixed species samples. Washing of the minced fish resulted in significant alteration of most factors.

Dried, Salted Fish Studies

Studies were directed toward modernizing and adapting traditional salting and drying methods to southeast species of fish to make competitive products and supplement current world markets. Most of the effort this year consisted of evaluating example products collected from several foreign markets. There

is a continuing effort to define and test specific methods and applications to specific fish. In addition, sample products were prepared for foreign trade shows and other marketing opportunities as examples of commercially producible products. This is a cooperative effort with the University of Georgia Marine Extension Service and the NMFS Southeast Regional Office.

Coastal Herrings Products

The coastal herrings classification includes primarily herring (clupeid) species and the smaller jacks (carangids). These species are generally small, bony and oily, although the oil content can vary greatly between species and seasons. They are abundant in the Gulf of Mexico, but are not suited for current domestic fresh or frozen markets. Studies of processed products from coastal herrings, primarily canned and/or smoked fish were continued. Menhaden fillets were naturally smoked and then canned in brine. The yield of smoked fillets was 20.3% of the initial round weight, and the overall yield was equivalent to 1,025 cans (307 x 113) per ton of menhaden. From another lot of menhaden, canned in oil after hot smoking, it was determined that precooking and draining of the cans of smoked menhaden is required to prevent the esthetically unattractive protein precipitation during sterilization. Dressed (58.4% yield) small chub mackerel were canned without smoking, yielding the equivalent of 2,250 cans (211 x 304) per ton of raw fish.

Further development work was done on a smoked and steamed coastal herring product. Gulf menhaden and chub mackerel, as well as buck (male) shad, were processed. Herrings such as shad and menhaden develop an excellent smoked flavor due to their high oil content, but the many small bones throughout the flesh present an edibility problem. If the naturally smoked fish are steamed in a retort to mild sterilization conditions (e.g., internal temperature equivalent to 2-4 minutes at 250°F), the bones are softened and present no problem. We have found that if the smoked fillets are steamed on open racks, processing is accelerated and simplified and the product can be vacuum packaged after it is removed and chilled. The appearance of the product was good but rated lower than the smoked, not steamed product. The color was darker and the surface not as glossy. The overall acceptability by a small taste panel was higher for the steamed product, however, due to the elimination of the bone problem.

Microwave Pasteurization Studies

The pasteurization of packed blue crab meat in hot water baths is an established industry procedure. Microwave processing could provide a means for more rapid and efficient pasteurization of crab, fish flakes, or other seafood products. Last year, we received on loan a prototype, conveyor-fed microwave processing unit. We have been looking at equipment operating capabilities and product packaging requirements. Tests show that size, configuration, number, and capacity of containers, as well as product characteristics exert a strong influence on the absorption of microwave energy. Plastic containers and covers were tested for flaked fish pasteurization studies. A pasteurization temperature of 185°F is required, but plastic containers and covers tended to separate at 180°F and 1.5 psi internal pressure. A more compatible cover material has been obtained for testing.

Grouping Seafoods by Edibility Characteristics

The average seafood consumer has preferences and some knowledge of edibility characteristics, but is unfamiliar with the vast majority of potentially available finfish species. An aim of the National Nomenclature Project is to group species by edibility characteristics, thereby increasing the number of seafood options for processors and consumers and improving the utilization of unfamiliar species. We are evaluating the edibility characteristics of southeastern species of finfish. This includes the rating of nine flavor and seven texture attributes for each species by a trained sensory panel and the instrumental measurement of texture and color. Proximate chemical compositions and fatty acid profiles are also being determined, for both raw and cooked samples of each species.

To date we have made more than 100 evaluations including 45 different southeastern species. A minimum of three seasonal evaluations are required for the description of each species. Thus far we have evaluated 20 different species at least three times. Sensory data are being entered into computer storage for later inclusion in a national edibility data bank.

This year, samples of seven different species of sharks, obtained from South Carolina Marine Resources Division survey cruises, were compared and grouped by cluster analysis according to edibility characteristics. The textural hardness and chewiness of several species was found to cover a very wide range and was directly related to the maturity of individual sharks tested.

Calico Scallop Investigations

Calico scallop landings traditionally fluctuate from year to year. In 1981, however, landings were nearly five-fold greater than for any previous year. This greater availability of calico scallops magnified pre-existing quality considerations of 1) the presence of a naturally-occurring, non-pathogenic nematode in these scallops, and 2) the concern that poor quality off-odor products could reach markets distant from harvest areas.

In 1983, the FDA suggested a temporary action level based not on the significance of the parasite, but rather on the aesthetics of nematodes in lake fish. The Charleston Laboratory conducted literature surveys and contacted and identified groups/agencies that have pertinent information bases regarding the nematode question to provide a realistic evaluation of the meaning of the nematodes in calico scallops. These actions were followed up during 1984 with meetings with FDA parasitologists, who reaffirmed that the calico scallop nematode was not known to be a human pathogen, and with Sea Grant researchers investigating interaction of the biological cycles of the nematodes and calico scallops.

To assure that only high-quality calico scallops are commercially available, microbiological and organoleptic characteristics of calico scallops during storage, transportation, and marketing were investigated. This work, completed in 1984, was carried out in conjunction with the University of Florida investigations on the effects of harvesting and processing on scallop quality. A draft procedural manual for processors and distributors of calico

scallops is being prepared by Florida Sea Grant and they are soliciting input by NMFS and FDA.

A seminar of calico scallop process managers, NMFS, and the Gulf and South Atlantic Fisheries Development Foundation was held October 24, at Cocoa, Florida, for presentation of data, suggestions, and for discussions.

We have shown that calico scallops have a shelf life of 3 weeks when maintained at 1°C in ice. Bacterial activity is minimal during the first week of storage but progresses rapidly from 2 to 3 weeks. Odor intensity increases proportionately to levels of spoilage bacteria.

If shellstock must be trucked to processors distant from the primary harvest landing area in Port Canaveral, Florida, it should be done in refrigerated trucks to avoid the loss in shelflife as shown in Table 1.

Table 1: Shelflife of calico scallop meats at 0°C after transportation of shellstock with and without ice.

Month	Condition	Shelflife (days)	Transport Temperature Changes (12 h)
October 1983	Iced	21	25°C → 14°C
	Non-Iced	12	25°C → 26°C
February 1984	Iced	21	16°C → 3°C
	Non-Iced	18	19°C → 11°C
April 1984	Iced	18	21°C → 6°C
	Non-Iced	12	23°C → 10°C
June 1984	Iced	18	26°C → 6°C
	Non-Iced	6	28°C → 36°C

Shrimp Quality Changes Related to the Use of Sulfites

Shrimpers have used sulfiting agents on shrimp for several decades. Sodium bisulfite and related compounds are effective in reducing black spot in shrimp through non-enzymatic interference of quinones formed during melanosis and by direct oxidation with tyrosinase. Additionally, sulfites are effective against spoilage, bacteria, particularly those belonging to the genus Pseudomonas.

The implications of recent negative publicity regarding the use of sulfites has led NMFS to support in-house studies and monitor S-K grants on alternatives to bisulfite use on shrimp and methodology to determine the fate of bisulfite added to shrimp. Our research has shown that 1) less than 1.25% sodium bisulfite can be used when shrimp are adequately washed; 2) alternatives such as erythorbate and EDTA can be substituted for bisulfite--especially EDTA since it can retard spoilage flora; and 3) combinations of low

concentrations of bisulfite combined with chelating agents (e.g., EDTA) can retard black spot formation and may retard spoilage to some degree.

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NATIONAL MICROCONSTITUENTS

The National Microconstituents Program continued to undertake and promote research on critical seafood safety issues stemming from chemical and microbiological contamination of fish and shellfish. This year's research was responsive to specific problems affecting both the fishing industry and the seafood consumer. Cooperative research and communication interfaces, initiated previously with state and federal regulatory and environmental agencies, were further strengthened throughout the year.

Program Management

Several important changes in program direction were made during 1984. Increased emphasis was placed on methods development for detecting and/or measuring enteric viruses in molluscan shellfish. Similarly, in recognition of the pressing need to develop a practical screening test to prevent fish containing ciguatoxin, the naturally occurring marine biotoxin, from reaching the marketplace, an in-house research project was initiated to address specific informational needs related to transfer of the toxin through the marine food web. A decision was also made to defer further research on the physiological aspects of organic contaminants. This was done in light of previous in-house research showing that, under conditions simulating a moderately polluted environment, several priority organic contaminants failed to elicit either mutagenic or toxic effects in a selected laboratory test system (in vitro mammalian cells).

Program staff were also assigned to two new major initiatives relating to quality of the marine environment and seafood safety. The first, an element of NOAA's Status and Trends Program, the Benthic Surveillance Project, is the initial phase of a monitoring activity designed to detect changes in concentrations of critical toxic organic chemicals and trace metals in coastal and estuarine areas around the United States. The Charleston Laboratory is responsible for organic contaminant analyses for all samples collected from the southeast region. The second comprises an intensive survey of PCB's in east coast bluefish in response to congressional questions being raised about the potential public health risk associated with consumption of this important recreational and commercial species.

Work statements on four seafood safety topics of mutual interest to NMFS and FDA were prepared within the framework for research collaboration provided by a FDA/NMFS Memorandum of Understanding. The proposals recommend that collaborative studies be conducted in the areas of marine biotoxins, cadmium toxicity, enteric viruses, and contaminant exposure assessment. The projects have been approved by the managements of both agencies and may be expected to develop into significant work activities for the involved researchers.

The data file on the NMFS 1981 Seafood Consumption Survey was made available for integration into existing contaminant risk assessment models. Major discrepancies in the data file are currently preventing its use in planned simulation modeling of U.S. dietary intake of seafood contaminants.

Computer software for a comprehensive retrieval and reporting system was developed for in-house organic contaminant data transmitted to the NMFS

mainframe computer at Seattle, Washington. A user's guide is being prepared to facilitate operation of the system by research investigators.

Metabolism and Toxicity of Cadmium in Oysters

Cadmium (Cd) accumulates to relatively high levels in commercially important shellfish compared to most foods. Oysters, therefore, may be a significant dietary source of Cd to some consumers. Questions about the safety of long-term exposure to Cd through oyster consumption have been raised. In addition, if an action level were implemented by the FDA or any of the various state agencies for a maximal tolerable level of Cd in shellfish, it may impose severe economic hardships on fishermen.

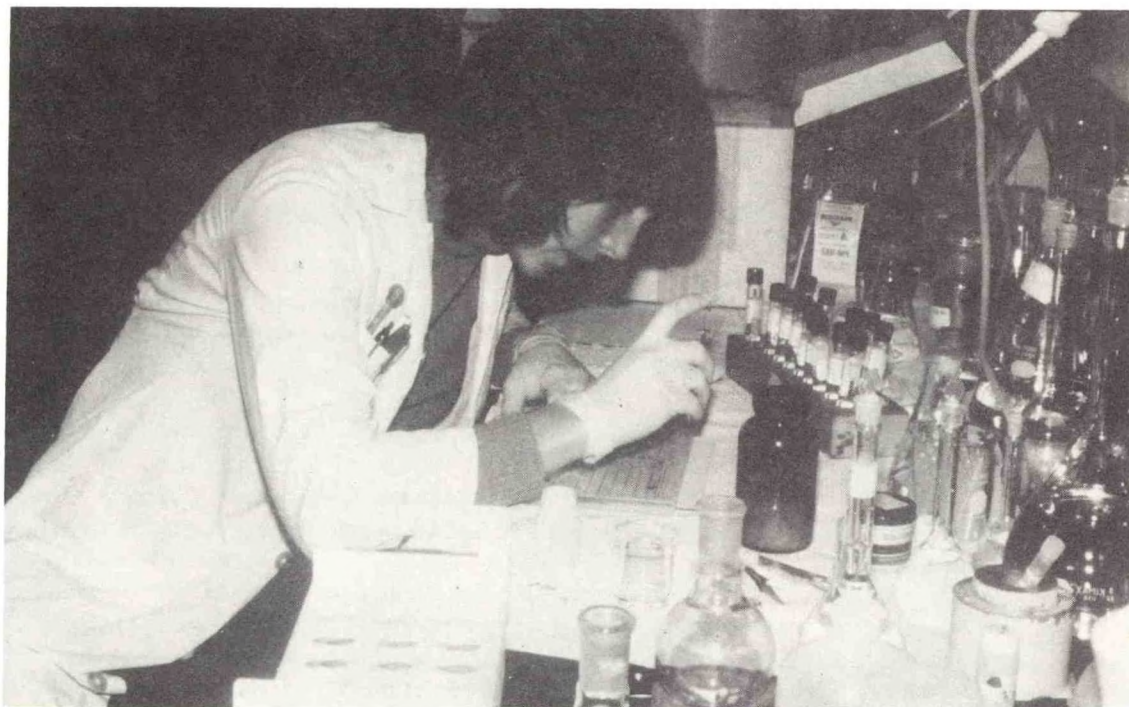
Our research this year included evaluating the influence of certain natural constituents of the oyster on Cd toxicity elicited in consumers of shellfish. For example, zinc is generally considered to have an inhibitory effect on Cd absorption and consequently may have an ameliorating effect on Cd toxicity. Animal feeding studies conducted in our laboratory suggest, however, that the normally high levels of zinc in oyster tissue alters the toxic effect of Cd on iron bioavailability.

Metallothionein is a small, inducible protein implicated as a detoxification mechanism for Cd and other metals. We have adapted a procedure to measure metallothionein and have used this procedure in preliminary studies to evaluate the differing tissue distributions and toxic effects of oyster-Cd compared to other food sources of Cd.

Transferrin is an iron-binding protein important for the absorption and transport of iron. Recent evidence indicate transferrin may be a critical interactive site for iron and xenobiotics such as Cd. We have quantified total transferrin and examined the relative binding of iron to transferrin blood. Further research may suggest transferrin as an important biological index of exposure to food sources of Cd.

Ferritin is a protein essential to the absorption of available iron in specific tissues, but has also been shown to bind Cd. Results of preliminary studies with laboratory animals indicate the levels of ferritin in certain tissues are not affected by dietary oyster-Cd at levels likely to occur in the human diet.

Cadmium complexes isolated from oyster tissue have been compared to the combined complexes of intact oyster in terms of bioavailability and tissue distribution in mice. The major soluble form of Cd occurring in oyster tissue was partially purified. When this material was gavaged into mice, Cd was retained at levels four times higher in liver and three times higher in kidneys than was the case for CdCl₂-dosed mice. This material was characterized as having significant concentrations of metals zinc, magnesium, iron, calcium, phosphorous, and arsenic and the amino acids homarine, taurine, glycine, valine, leucine, threonine, lysine, and proline.



Preparation of a TLC plate to characterize cadmium complexes on puster tissue.

We now have a significant data base on the metabolism and toxicity of Cd following consumption of eastern osysters, but have not yet obtained corresponding data for other commercially important shellfish species. Emphasis in this future research will be focused on samples obtained from commercially important areas.

Inter-species comparison studies on mice and quail have been conducted via collaborative studies with FDA researchers. Results suggest mice and quail metabolize oyster-Cd similarly, thus supporting extrapolation of our results to humans. Additional collaboration with the FDA is planned.

The results suggest that Cd occurring in shellfish may be metabolized differently by the consumer than Cd in other food sources. This difference may be significant enough to warrant special consideration of the toxicological implications of consuming Cd contaminated shellfish. Additional research is needed to further define the public health significance of shellfish sources of Cd.

Biochemical Characterization of the Interactions of Methylmercury and Selenium

Selenium, a required nutrient often found in high concentration in seafood, is known to reduce the toxic effects of methylmercury. Furthermore, it appears that predatory marine fish that accumulate mercury (in the form of methylmercury) via the food chain also accumulate relatively high concentrations of selenium. When the current mercury regulatory guideline of 1 part per million was formulated, no consideration was given to concomitantly occurring selenium in seafood. Therefore, we are investigating the metabolic

interactions of selenium with mercury for the purpose of increasing our knowledge of the mechanism by which selenium ameliorates methylmercury toxicity. Such knowledge will enable us to better assess the risk to consumers from methylmercury occurring in marine fish.

A laboratory mammalian model (mouse) is being used to study the effects of selenium upon consumers of mercury. Glutathione, a thiol-containing tripeptide, has been implicated in the normal detoxification of several toxicants, including methylmercury. Therefore, we have investigated the enzymes and metabolites of what is known as the "glutathione metabolic cycle" in tissues of experimental animals following their exposure to varying amounts of selenium and/or methylmercury.

Mercury exerts its toxic effect primarily on two organs, the brain and kidney. Our biochemical and histological studies of the effects of mercury in the kidney suggest a selenium-mercury interaction involving glutathione transpeptidase, an important enzyme associated with transport of amino acids across membranes.

The effects of toxicants, including heavy metals, are likely to be exhibited more dramatically in the unborn and rapidly developing infant. Therefore, we have begun a series of investigations to determine how selenium interacts with methylmercury during fetal and neonatal development. Experiments have shown that in adult mice, methylmercury is first metabolized in the liver where methylmercury produces a sharp drop in the level of glutathione and a slow rise in the activity of a methylmercury detoxifying enzyme, glutathione-S-transferase. However, neonatal studies suggest that glutathione and glutathione-S-transferase are not involved in the detoxification of methylmercury in livers of neonates undergoing in utero exposure to mercury.

Organic Contaminants Baseline Data

Analysis of several species of reef fish taken from the northern coast of Puerto Rico and the vicinity of the U.S. Virgin Islands for the presence of petroleum hydrocarbons was completed this year. The survey indicated a relatively low level of petroleum contamination in this area of the Caribbean compared to that of some U.S. coastal waters. These same fishes are also being screened for synthetic organic chemicals such as PCB's and pesticides, but the results are not yet available. Similar analyses have begun on a new collection of groundfishes from the northern Gulf of Mexico. Results so far confirm only the chronic level of petroleum contamination in the Gulf, with no "hot spots" yet identified.

Other highlights of this year's work include contributions to the planning and preparation for a nationwide survey to establish the current status of environmental contamination in selected coastal and estuarine locations and thus lay the groundwork for future assessment of changes in contaminant levels over time. The Charleston Laboratory is responsible for analyzing sediment and selected groundfish samples from the Gulf and south Atlantic for a suite of critical organic contaminants. Staff chemists have been participating in sampling cruises for this project (Benthic Surveillance Project, NOAA Status and Trends Program) since August. The Charleston Laboratory will also be responsible for analysis of the edible tissues from a larger number of

bluefish, collected at several east coast sites, for PCB's and pesticides. This congressionally mandated study was triggered by the closure of certain waters in New Jersey and New York due to high levels of PCB's found in several species of recreationally and commercially valuable finfish. The National Marine Fisheries Service is taking a lead role in this study which also involves elements of FDA and EPA.

Enteric Virus Coordination/Research

Recent outbreaks of shellfish-induced enteric virus illness among consumers have given added momentum to this study. Research has been directed towards development of virus extraction and assay procedures for shellfish. Two categories of viruses are of concern, the Norwalk virus and enteroviruses, which include polio and hepatitis A viruses. The results of in-house research on improved poliovirus extraction and assay procedures for shellfish has been published. We have also contracted with the University of North Carolina to develop a hepatitis A virus assay procedure for shellfish extracts. Virus infectivity in cell cultures has been increased by the use of several chemical additives during the first phase of this contract work. We are also monitoring Saltonstall-Kennedy funded research at Baylor College of Medicine, Houston, Texas, where an amplified enzyme-linked immunosorbent assay is under development for hepatitis A virus detection in environmental samples.

A report on Norwalk virus, a virus incriminated in thousands of cases of shellfish-associated gastroenteritis in the past few years, was prepared as part of an overall effort to devise a strategy for Norwalk virus detection in shellfish. This report provides a plan for producing the virus and its antibody in sufficient quantities to permit developmental work on a practical assay for Norwalk virus in shellfish and harvest waters.

Prompted by requests from northeast area state health department officials and by recent clam-associated outbreaks of viral gastroenteritis, the Charleston Laboratory provided a training course on enteric virus extraction and assay procedures for clams, oysters, and marine waters in December 1983. This course was presented at the Northeast Technical Services Unit, U.S. Food and Drug Administration facility in Davisville, Rhode Island. Sponsors of the course were the National Marine Fisheries Service, U.S. Food and Drug Administration, New Jersey Marine Science Consortium, State University of New York/Cornell Sea Grant College Program, and the Rhode Island Sea Grant College. Twenty-one individuals, representing state and federal agencies, Canada, and Italy participated in this course. Health department microbiologists from Connecticut, Massachusetts, New Jersey, New York, and Rhode Island were in attendance.

Several weeks after the course, the Connecticut, Massachusetts, and New Jersey Health Departments requested that we provide them with cell cultures and virus pools as they develop virus monitoring programs. We recently learned that Connecticut is actively involved in evaluating the sensitivity of the Buffalo green monkey kidney cell culture that we sent them. A wide variety of enteroviruses obtained from clinical specimens have been successfully propagated on these cells. Connecticut is awaiting approval of a funding request before initiating a program to extract and assay enteric viruses from shellfish. Massachusetts has evaluated several virus extraction

procedures for clams, and report the successful assay of clam extracts using a new U.S. Food and Drug Administration extraction procedure that was designed for use with oysters. Massachusetts is also gearing up for a study to correlate fecal coliform and enterovirus levels of clams taken from approved and closed harvesting areas. New Jersey, pressured by constraints, was unable to initiate an enterovirus monitoring program for shellfish. However, their virology laboratory now has the capability to develop such a program should the need arise.

This and two previous training courses offered last year were considered a success in transferring laboratory developed techniques into the hands of potential users. The courses demonstrated the ease with which enteric virus assays may be conducted and the relative simplicity of growing and maintaining cell cultures.

Ciguatera Research and Coordination

Ciguatera is an illness that can result from the consumption of contaminated seafoods. Of the several hundred incidents of illnesses attributed to eating seafood between 1970 and 1978, 38% were attributed to ciguatoxic fish. Although most cases of illness occur in the Caribbean Islands, Florida, and Hawaii, the incidence of ciguatera elsewhere in the continental United States is increasing, due in part to successful efforts to increase the geographic market distribution of high value reef fish. Yet, there is presently no reliable or practical method for screening seafood for ciguatoxin. Among several tests that could be developed to protect both the health of the consumer and the economic well being of the U.S. fisheries industry, some form of immunological assay, adaptable to marketplace testing, is considered to be the most accurate and practical.

In order to accelerate the development of a promising immunological assay currently being attempted at other institutions, an in-house ciguatera research project was initiated in 1984. The objectives are to establish clones of toxin-producing marine algae; to determine physical and nutrient conditions that stimulate maximum toxin production by specific species of marine algae; and to determine physiological conditions governing the conversion or transfer of algal-produced toxin to ciguatoxin found in edible portions of fish tissue. To date, several clones of the toxin-producing dinoflagellate, Gambierdiscus toxicus, have been established and toxin production has been compared among clones from Puerto Rico, Florida, and Hawaii. Fish have been exposed to toxic algal cells by both feeding and interperitoneal injection. Subsequently, toxin has been detected in the flesh of these animals. In addition, an HPLC-fluorometric method was developed for rapidly and accurately detecting algal and fish-produced toxins.

Coordination and interfaces with other institutions focused on the identification of marine areas likely to harbor fish that could provide a source of incurred toxin. Within the Caribbean, the waters around St. Kitts-Nevis have yielded such ciguatoxic fish. The livers from suspect fish are currently being shipped to the University of Puerto Rico where potentially toxic residues are extracted and partially purified. The residuals are then sent to the Medical University of South Carolina where they are tested for ciguatoxicity using a standard mouse bioassay. To expedite the screening

process, negotiations are underway to set up the necessary laboratory facilities at St. Kitts to prepare fish liver extracts locally.

Three conferences covering issues of interest to ciguatera researchers are being held in the near future. The International Coral Reef Symposium is scheduled for May 1985 in Tahiti and the Toxic Dinoflagellate Conference will be held in New Brunswick, Canada, in June 1985. We are directly assisting in agenda planning for the Second Conference on Ciguatera, scheduled for April 1985 in Puerto Rico.

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FISHERY HABITAT

Research during 1984 focused on both natural environmental processes controlling fishery production in coastal and estuarine waters and on the effects of man-induced environmental changes on fishery production and effective fishery management. The program's goals are to 1) develop a sound scientific basis for predicting the effects of habitat loss and modification on fishery production, 2) determine the biological and chemical processes involved in trace metal toxicity and detoxification to selected components of estuarine and marine food webs that support fishery organisms, and 3) determine the relationship between fishery and ecosystem productivity in estuarine and coastal waters.

Estuarine Research

Research centered on four primary areas: 1) importance of detritus to food webs of fishery organisms; 2) predator-prey interactions; 3) distribution of fishery organisms as a function of freshwater inflow and habitat type; and 4) transplantation of seagrasses as a means of sediment stabilization and fishery habitat loss mitigation. Rates of decomposition of plant material control the availability of detritus to fishery organisms and bacterial and environmental factors influence its nutritional quality. Decomposition rates of roots and rhizomes of submerged seagrasses indicate that detritus from these sources can be an important resource for benthic invertebrates and bacteria in sediments of temperate and tropical seagrass areas. Dissolved organic matter released during decomposition is readily utilized by bacteria, but sediment fauna also appear to graze on this detritus directly. Microbial studies conducted at a sludge dump site indicated that bacteria apparently were removing material that leached from the sludge during settling. Interactions between bacteria and algae were evaluated during the spring bloom in a southeastern estuary. The bloom may serve as an energy source for coastal planktonic communities when it is flushed offshore during heavy spring rains. Laboratory experiments were carried out to evaluate the influence of turbidity, light level and prey species on predatory feeding success. Spotted hake feeding success was influenced by both levels of turbidity and prey species utilized.

Two studies were made on fishery organisms distribution. One, funded by the U.S. Army Corps of Engineers, evaluated the influence of excessive freshwater inflow in a south Florida estuarine system in the Ten Thousand Islands area of Florida. Due to drainage flow modifications, the majority of surface water flow enters a single bay rather than flowing over land to a wide area. Salinities in the bay are reduced during the rainy season relative to adjacent bays. Sampling during the rainy season showed that, although the species composition of the fishery community in the impacted estuary was similar to that in adjacent unimpacted areas, the total number of organisms collected was severely depressed in the estuary receiving excessive freshwater. Research funded by the National Park Service was also begun in Florida Bay and adjacent bays to evaluate the utilization of seagrass and mangrove habitats by fishery species. This study is designed to evaluate the major areas of entrance of larval fishes into the system and to evaluate juvenile fish nursery areas. Research was continued under funding by the Corps of Engineers to transplant seagrasses to stabilize dredge material. Three tropical species were

transplanted both in the Florida Keys and along the Florida panhandle. The transplants are highly successful, attaining growth rates similar to natural communities within a 90-120 day period.

Oceanic Research

The oceanic research phase of the Fishery Habitat Program provides information used in evaluating the nature and probable importance of specific pollutant or environmental changes that may impact fisheries. Our efforts included laboratory experiments, field surveys, and synthesization of scientific information. The major issues addressed this year were defining the structure of larval fish food webs and determining impacts of offshore thermal energy conversion (OTEC) operations on Caribbean fisheries.

Larval fish surveys were conducted in both the Gulf of Mexico and the Caribbean Sea. Data on abundance and distribution in the northern Gulf of Mexico indicate that the area adjacent to the mouth of the Mississippi River has a higher abundance of gulf menhaden and Atlantic croaker larvae than other study sites. High primary productivity in this area results in abundant larval fish food, possibly reducing mortality from starvation and predation. The location of this larval concentration indicates the need for concern about the impact of river borne pollutants on larval survival. The survey in the Caribbean was conducted to aid in evaluating and possibly reducing undesirable impacts associated with potential OTEC operations. Data on vertical distribution of fish larvae was collected to determine if changes in intake and discharge location and design could reduce mortality of early life stages of fish.

Experiments were conducted to evaluate the importance of larval fish mortality caused by pollutant induced changes in the food web and to determine if OTEC induced thermal regimes cause larval mortality. The food web of larvae is typically phytoplankton to zooplankton to fish larvae. Our experiments indicate that the larvae are very selective in the zooplankton they eat but the zooplankton are omnivorous. Thus, it appears that studies of pollutant induced food web changes can concentrate on relatively few zooplankton species. However, some pollutant caused changes in the phytoplankton may impact the very young larvae of some fishes. The thermal impacts of OTEC operation on larval fish are not known, in part because no methodology has been developed. Procedures used to simulate temperate power plant heat shock were modified to simulate "OTEC cold shock." Initial measurements were conducted on larvae of French grunt. While additional information and analysis are needed, initial results indicate that the impact of cold shock during the summer will be minimal.

Trace Metal Research

Investigations concerning the effects of trace metals on food chain organisms that support the production of important fishery organisms is a combined laboratory/field investigation. The laboratory phase of the research was devoted to demonstrating the chemical and biological mechanisms of trace metal availability and accumulation that affect the survival and growth of larval fish and the food organisms supporting them. Studies were conducted to

develop ion-exchange techniques for determining the free ion concentrations of copper, zinc, and manganese in natural waters. Since our previous data show that the free ion concentration, not total dissolved metal, controls both toxicity and accumulation of trace metals, it is important to be able to quantify ionic metal concentrations, both to assess current environmental conditions and determine if environmental quality is decreasing. Such a technique would be a true breakthrough in environmental monitoring and impact assessment. Additionally, investigations are underway to determine the combined effects of copper and zinc ion concentrations on the survival and growth of copepods and larval fish. The results indicate that the egg and larvae of the Atlantic menhaden are less sensitive to copper and zinc than those of the copepod, *Acartia tonsa*. For example, the 96-hour survival of *A. nauplii* was reduced by at least 60% at an ionic copper concentration of 2.5×10^{-5} $\mu\text{g/l}$ and a similar reduction in survival of menhaden larvae required 10 times this concentration of copper. Interestingly, both of these copper ion concentrations are within the range predicted for polluted environments.

The field portion of this investigation was conducted in conjunction with NOAA's Atlantic Oceanographic and Meteorological Laboratories and was concerned with the effects of copper and sewage sludge on microbial activity. The research was done at sea at the sewage sludge dump site in the New York Bight. The results indicated that microbes from surface oceanic waters were more sensitive to added copper than those sampled from productive coastal waters. In general, the 50% inhibition copper concentration for surface water microbes ranged from 0.3 to 2×10^{-7} M added copper and did not show substantial differences between impacted and unimpacted areas.

Our investigations with the Duke University Marine Biomedical Center on the mechanisms of trace metal accumulation, metabolism, and detoxification in marine fishery organisms have demonstrated some of the pathways blue crabs, lobsters, and oysters use to sequester trace metals. Through the use of both laboratory and environmentally exposed organisms, we have shown that our laboratory derived models of trace metal detoxification are valid. In addition, we have demonstrated that the season of the year and different stages in the life cycle affect both the body-burden of metals and their pathways of metabolism. Both of these observations are of importance in interpreting monitoring data on trace metal levels in sentinel organisms (i.e., oysters). We also have demonstrated that low molecular weight copper-binding proteins in the digestive gland of blue crabs and lobsters are involved in the synthesis of the copper-containing respiratory protein, hemocyanin.

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INFORMATION MANAGEMENT

The Information Management Program is responsible for providing a fishery information management system and ADP services to NMFS southeast region and its cooperators. The Program processes fishery and environmental data, maintains and protects the confidentiality of fishery data, provides ADP services to managers and scientists, develops new information systems, and operates the regional computer facility. These functions are essential to the efficient operation of a modern fishery management agency.

During 1984, computer services were provided through the NMFS computer facility located at the Northwest and Alaska Fishery Center, Seattle, Washington. This facility operates a Burroughs 7800 computer. All SEFC laboratories, the Southeast Regional Office, the Southeast Fishery Management Councils, and State cooperators have access and are linked to this computer by terminals or microcomputers and telecommunication systems. In January 1984 the SEFC acquired and installed a Burroughs 6800 computer at the Miami Laboratory. This computer provides an additional computational capability required to meet the requirements of the southeast region and national headquarters for the next few years. The two computers presently operate independently, but in the future will be networked to behave as a single computer and will provide users with a combined and expanded computing capability. A major activity during 1984 was review of ADP operations with the intent of establishing future management procedures. A cost analysis review is being conducted which will be the basis of determining how data services will be provided and organized.

Systems support was provided for fishery research projects, including major programming jobs and additions to bluefin tuna, swordfish, and shrimp data bases. State cooperators were provided software to access regional statistical data files and to enter and edit fishery data which they collect.

Fishery data files maintained on the computer are a basic information source for NMFS managers and researchers and were actively used during the year. A new group of users was added to the data management system during the year; Council staff members were approved access to confidential landings information, as required for completing their work.

Information Management participated in the NMFS post-86 ADP study to outline long-term ADP requirements of NMFS and to plan for southeast implementation of the study that will provide for future computing requirements of the region.

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NATIONAL FISHERIES ENGINEERING

The National Fisheries Engineering Program (NFEP) satisfies and/or coordinates the engineering needs of NMFS organizational elements; promotes technological advancements in fisheries research, management and utilization; and applies engineering expertise to fishery problems where technology is a major constraint to attainment of NMFS goals. Requirements for fishery engineering stem primarily from legislative mandates delegated to NMFS, such as the: Magnuson Fishery Conservation and Management Act (MFCMA) of 1976; the Marine Mammal Protection Act of 1972; and the Endangered Species Act of 1973. Specific NMFS program and constituency requirements also influence NFEP project activities.

Program emphasis during 1984 was placed on development and refinement of hardware and software systems to meet the operational needs of SEAMAP, NMFS vessel support, and new/improved management techniques aimed primarily at resource surveys. All NMFS organizational elements, as well as other government and state living marine resource management agencies and research organizations, benefited by results.

SEAMAP Remote Sensing

Satellite color data were obtained from NOAA/NESDIS and NASA/Goddard for each available cloud-free day that occurred during 1982 SEAMAP cruises. These data were used to develop synoptic chlorophyll maps which were calibrated with available vessel measurements. Also, available satellite-derived sea surface temperature maps for the same period were obtained from NOAA/NESDIS/SFSS. The chlorophyll and temperature maps were included in the 1982 SEAMAP Environmental Data Atlas.

A hypoxic bottom water condition was discovered from samples taken on a SEAMAP cruise in late June 1982. The affected area was off the southwest coast of Louisiana. Coastal Zone Color Scanner (CZCS) data were obtained subsequently for a June 14, 1982, overpass of that area. After application of several processing techniques, the combined satellite chlorophyll and temperature data indicated a correlation with in-situ measurements of bottom water hypoxia. CZCS digital tapes were acquired and processed within 24 hours of a satellite overpass on June 9, 1983, during a SEAMAP survey. Potentially hypoxic areas were identified and research vessels sampled the area during June 13-20. The vessels confirmed the prediction since no hypoxia was found along the entire coast until approaching the predicted area -- about seven days after the overpass. It therefore appears that CZCS-type data may be a valuable tool for predicting areas of potential hypoxic bottom water. The bioenvironmental relationships of this condition and its affect on living marine resources are not fully understood; however, trawl catch rates for shrimp and finfish were virtually zero in hypoxic areas.

Vessel Support

A conductivity-temperature-depth (CTD) system is used aboard the NOAA Ship OREGON II as the primary data acquisition source for environmental data. The system produced by Biospherical Instruments, Inc., also includes a

spectroradiometer and a rosette bottle array. The unit was originally installed aboard the vessel early in FY-1983. Support provided during 1984 included removal and disassembly for return to the vendor for periodic maintenance, calibration, and repair. A splash shield was developed to protect the slip rings on the wench after two incidences occurred. A failure of the spectroradiometer and/or associated ship-board mini-computer is unresolved and the unit has been returned to the vendor for trouble-shooting and repair.

Maintenance and calibration of the XBT unit occurs each time the vessel is in port. Data required by the CTD and XBT units provided related bio-environmental information for all cruises conducted during 1984 in support of assessment activities.

The data recording and communication system, installed aboard the OREGON II, and the corresponding receiving and processing system at NSTL were upgraded and refined during the year. The system was used primarily during SEAMAP cruises to provide daily updates of weekly summaries of assessment results. The current system operates through the ATS-3 satellite. An operating instruction manual was prepared to provide ship-board guidance for the system's use.

NOS installed a color sounder hydroacoustic system aboard the OREGON II to test its capabilities as an assessment tool. Initial trials were conducted during the late spring and were centered on attempts to locate and quantify schools of herring in the northern Gulf of Mexico. Targets were located and the system increases the assessment capabilities of the vessel. Other systems are being investigated for possible future installation to enhance or replace the present one.

Mini-Mach

This continuing project was initiated by NMFS to determine the feasibility of using Landsat multispectral scanner (MSS) digital data and computer-assisted processing techniques to detect and quantify land cover and land use changes in the Barataria Basin, Louisiana. Historical changes in the area between 1956-78 have been related primarily to man's activities--agricultural expansion, dredging of oil and gas canals, urbanization, and industrial development. Freshwater wetland loss during the 22-year period in the study area was nearly 66,000 ha. Nonsite-specific changes in land areas were tabulated for each of 20 U.S. Geological Survey 7.5-minute topographic quadrangles that cover the study area using unsupervised classifications of Landsat MSS images made in 1974, 1979, and 1982. Problems with scene noise in the 1974 and 1982 imagery had a tendency to bias estimates of land change in the study area during the 1974-82 period.

Data Management

A primary objective for data management this year was to refine the functions designed to provide a smooth flow of SEAMAP data from acquisition to users, and to provide storage in archival files for future utilizations. Data formats, collection techniques, and other requirements were carefully coordinated to ensure compatibility and effective interchange. Currently, the

Land and water areas and total land area changed for each of 20 U.S. Coast Guard 7.5-minute topographic quadrangle estimates from unsupervised classifications of Landsat MSS imagery, 1974-82, Barataria Basin, Louisiana.

Quadrangle Name	1974 Area (ha)		1979 Area (ha)		1982 Area (ha)		Land Area Changed (%)		
	Land	Water	Land	Water	Land	Water	1974-79	1979-82	1974-82
Cut off	14,886	2,045	14,953	1,978	15,131	1,800	0.45	1.19	1.65
Golden Meadow	14,868	2,092	15,372	1,588	14,846	2,114	3.39	-3.42	-0.15
Bay Courant	10,222	6,745	11,005	5,962	10,266	6,701	7.66	-6.72	0.43
Bay L'Ours	9,797	7,137	9,716	7,218	9,237	7,697	-0.83	-4.93	-5.72
Golden Meadow Farms	10,784	6,149	11,080	5,853	10,082	6,851	2.74	-9.01	-6.51
Mink Bayou	11,810	5,124	13,272	3,662	12,203	4,731	12.38	-8.05	3.33
Leeville	9,722	7,246	11,252	5,716	8,884	8,084	15.74	-21.05	-8.62
Belle Pass	2,247	14,721	2,214	14,754	2,040	14,928	-1.47	-7.86	-9.21
Three Bayou Bay	11,880	5,019	12,078	4,821	10,845	6,054	1.67	-10.21	-8.71
Bay Tambour	4,868	12,101	4,808	12,161	4,130	12,839	-1.23	-14.10	-15.16
Caminda Pass	4,127	12,842	4,015	12,954	3,249	13,720	-2.71	-19.08	-21.27
Lake Laurier	12,974	3,964	13,164	3,774	12,303	4,635	1.46	-6.54	-5.17
Wilkinson Bay	4,342	12,654	4,324	12,672	3,833	13,163	-0.41	-11.36	-11.72
Point a la Hache	13,038	3,863	13,270	3,631	12,484	4,417	1.78	-5.92	-4.25
Bay Batiste	8,975	7,996	8,900	8,071	8,103	8,868	-0.84	-8.96	-9.72
Bay Ronquille	3,131	13,841	2,449	14,523	1,962	15,010	-21.78	-19.89	-37.34
Pelican Pass	1,628	15,345	(1)	(1)	1,490	15,483	(1)	(1)	-8.48
Barataria Pass	2,006	14,938	1,852	15,092	1,541	15,403	-7.68	-16.79	-23.18
Grand Isle	392	16,586	338	16,590	388	16,590	-1.02	0	-1.02
Bay Dogris	8,975	7,959	8,885	8,049	8,093	8,841	-1.00	-8.91	-9.83
TOTALS:	160,672	178,367	162,997 ²	159,069 ²	151,110	187,929	2.46 ²	-7.29 ²	-5.95

¹ Data not tabulated because of cloud cover during the 1979 Landsat overpass.

² Excludes 1979 area estimates for Pelican Pass quadrangle.

SEAMAP data management system is limited to the Gulf of Mexico; however, planning is underway to include Atlantic coast data collection and use.

All data flow through various field collectors to the NMFS data management/processing center located in the Mississippi Laboratories. Data types include near-real-time and comprehensive environmental, meteorological, and biological measurements. Data from each source are keyed into the local system and transmitted to the NMFS computer system in Seattle for editing, calibration, and storage in user files. Current year data files by data type are merged with previous year's files after verification to create composite archival files on tape and/or disk. Thermal, color, and chlorophyll data obtained from satellites are archived at NSTL.

Six subsystems currently comprise the SEAMAP Data System: environmental data, groundfish data, ichthyoplankton data, shrimp data, satellite data, and near-real-time survey data. During 1984, seven reports of near-real-time data from SEAMAP cruises were issued. The system also provided graphics for the FY-1982 SEAMAP Atlas and FY-1983 station data plots, completed six user requests for SEAMAP data maintained FY-1982 data, and edited FY-1983 data for NMFS and five states, and contributed data support for nine cruise reports.

Menhaden Data Base

A special cooperative project was initiated between NMFS and Texas A&M Sea Grant to correlate menhaden catch data with CZCS data in the Gulf of Mexico. A total 632 selected daily vessel logs for four selected periods in 1979 that overlapped a NIMBUS overpass were provided by the SEFC Beaufort Laboratory. These logs represented 2,284 menhaden sets. Each set was transformed to a data line entry and the resulting information was keypunched and verified. The completed data base was forwarded to Texas A&M where cooperative correlation studies are in progress.

Year-of-the-Ocean

NSTL's NOAA Data Buoy Center hosted an Ocean Science Day as a kick-off for "The Year of the Ocean." Planned activities were geared toward participation by junior and senior high school students from the surrounding area. The agenda included movies, presentations, and a facility tour. A one-hour presentation of fisheries engineering activities was included.

In a related public affairs activity, NASA/NSTL significantly expanded its Visitor Information Center. Fisheries engineering accomplishments and activities are displayed along a 12-foot wall using back-lighted photographs, text, and models. A one-third scale Trawl Excluder Device (TED) and shrimp trawl was located in front of the building.

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LEMING, T. D. and W. E. STUNTZ

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REGIONAL FISHERY STATISTICS

The Regional Fishery Statistics Program is responsible for designing, operating, coordinating, and monitoring fishery data collection and reporting systems in the southeast region. Fishermen, seafood dealers, and processors submit reports or provide data to fishery reporters on amounts and values of catches and landings, fishing effort, vessel activity, and fishery products. These data are used to monitor fisheries, answer information requests from the public, and provide decision makers with the material needed to formulate regulations necessary to conserve southeast regional fishery stocks and to ensure their profitable utilization.

During 1984, fishery reporters located at the major southeast fishing ports and working in cooperation with state agencies, conducted monthly surveys of amounts and prices of commercial fishery landings, interviewed fishermen to obtain data on species composition of the catch, fishing area and fishing effort, and provided quarterly and annual summaries of processed fishery product production and fishing fleet operations. In addition, project personnel provided statistical and marketing data for publication in NMFS Market News reports and responded to numerous requests for information.

New or special data collection activities in 1984 included recording landings of shrimp according to a greater number of size categories, recording the numbers of fishing trips for the inshore shrimp fleet operating in Texas and certain areas of Louisiana, and conducting a survey of the frequency of use of "salt boxes" by shrimp vessels. Another major new activity undertaken in 1984 was the development and testing of a creel survey and biological sampling program (CSBSP) to provide catch per effort and size frequency data for fishery resources that are under FMP management. The CSBSP provides a sample survey design, using the fishing trip as the sampling unit, to collect statistically reliable data for regional fisheries. In most areas, CSBSP achieved a 10% sample coverage of fishing trips of commercial vessels fishing for fish and met its target quotas for size frequency samples of selected species of mackerels, snappers, groupers, and other species under federal or state management programs. For the U.S. Caribbean area, a spiny lobster and reef fish biostatistical sampling program provided similar essential data.

Data for monitoring fisheries under FCMA management were also provided by the Fishery Statistical Program. Mandatory reporting requirements for gulf shrimp became effective in May 1984 and the required data were collected, information in king mackerel catches were provided on a weekly basis to monitor the quotas set by regulation, and reports were received from stone crab fishermen and dealers.

The Southeast Cooperative Fishery Statistics Program is a joint effort of federal and state marine fishery management agencies to meet fishery statistics information needs. These agencies have developed cooperative programs using their agency funds and federal grant funds to develop a uniform fishery statistics data collection and management system throughout the southeastern United States. During 1984, cooperative agreements were in effect with North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Puerto Rico, and the U.S. Virgin Islands. A state/federal statistics workshop was held in Miami during October 1984, during which 1984 data collection activities of the cooperative program were reviewed

and plans made for 1985 programs. Workshop participants also considered adoption of a unified regional approach to collecting recreational fishery data for the southeast, which up to now has been accomplished by separate surveys.

The commercial landings by species for 1983 for the South Atlantic and Gulf of Mexico areas are given in Tables 1 and 2.

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Table 1: Fishery landings for the U.S. South Atlantic region during 1983 (preliminary).

Species	Total		Species	Total	
	Thousand pounds	Thousand dollars		Thousand pounds	Thousand dollars
Alewives	5,887	466	Crabs, Blue	57,739	14,644
Bluefish	8,308	1,107	Crab, Other	44	58
Bonito	46	5	Lobster, Spiny	675	1,708
Butterfish	107	32	Shrimp	26,615	69,755
Cod, True	2	0	Clam, Hard	1,799	7,007
Croaker	7,339	2,879	Clam, Other	0	0
Flounder, Black	2	0	Oyster Meat	2,529	2,139
Flounder, Fluke	9,999	5,777	Scallop, Bay	205	509
Flounder, Yell.	0	0	Scallop, Calico	9,581	11,940
Flounder, Atl.	296	193	Scallop, Sea	26	151
Groupers	2,820	2,969	Squid, Short Fin	0	0
Hake, Red	2	0	Squid, Long Fin	92	27
Mackerel, King	4,089	3,824	Shellfish, Other	1,252	679
Mackerel, Atl.	0	0			
Menhaden	185,143	6,455	Total Shellfish:	100,557	108,617
Mullet	3,193	638			
Scup of Porgy	2,016	1,246	Grand Total:	397,324	172,587
Sea Bass, Black	823	658			
Sea Trout, Gray	10,356	4,364			
Sea Trout, Spot	630	521			
Shark, Dogfish	0	0			
Sharks, Unclass.	576	219			
Snapper, Red	316	724			
Snapper, Other	1,016	1,567			
Mackerel, Span.	5,987	1,743			
Striped Bass	361	491			
Swordfish	4,145	11,002			
Tilefish	2,086	2,014			
Tuna, Albacore	0	0			
Tuna, Bluefin	1	1			
Tuna, Little	56	6			
Tuna, Yellowfin	97	85			
Tuna, Unclass.	253	332			
Whiting	353	142			
Fish, Other	40,462	14,510			
Total Fish:	296,767	63,970			

Table 2: Fishery landings for the U.S. Gulf of Mexico region during 1983 (preliminary).

Species	Total		Species	Total	
	Thousand pounds	Thousand dollars		Thousand pounds	Thousand dollars
Alewives	141	22	Crabs, Blue	36,153	11,607
Bluefish	630	112	Crabs, Other	4,664	7,089
Bonito	315	27	Lobster, Spiny	3,850	9,548
Croaker	885	324	Shrimp	198,457	416,911
Flounder, Fluke	525	502	Clam, Hard	15	38
Flounder, Atl.	1,061	592	Oyster Meat	27,687	33,156
Groupers	9,422	11,186	Scallop, Bay	22	74
Mackerel, King	2,592	2,349	Squid, Short Fin	0	0
Menhaden	2,036,122	82,445	Squid, Long Fin	74	21
Mullet	22,267	5,271	Shellfish, Other	293	899
Scup or Porgy	203	99			
Sea Bass, Black	11	4	Total Shellfish:	271,215	479,343
Sea Trout, Spot	3,045	2,815			
Sea Trout, White	609	176	Grand Total:	<u>2,442,991</u>	<u>615,574</u>
Sharks, Unclass.	789	358			
Snapper, Red	6,610	11,504			
Snapper, Other	2,334	2,845			
Mackerel, Span.	1,773	646			
Swordfish	716	2,055			
Tilefish	260	205			
Tuna, Little	53	8			
Tuna, Yellowfin	5	7			
Tuna, Unclass.	358	609			
Tuna, Blackfin	0	0			
Fish, Other	81,050	12,070			
Total Fish:	2,171,776	136,231			

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
SOUTHEAST FISHERIES CENTER
75 VIRGINIA BEACH DRIVE
MIAMI, FL 33149

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