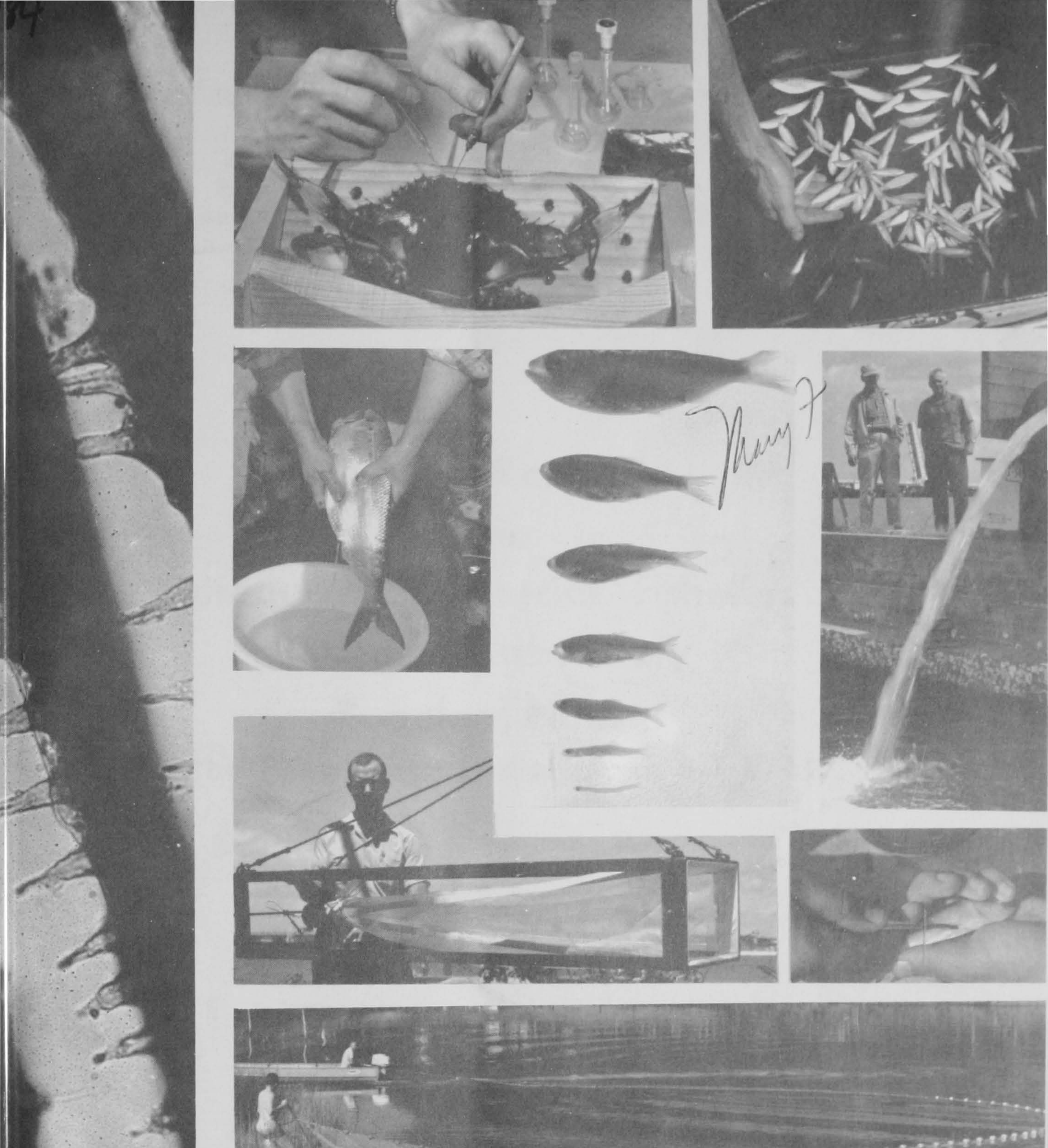

ANNUAL REPORT

FOR THE YEAR ENDING JUNE 30, 1962

BUREAU OF COMMERCIAL FISHERIES
BIOLOGICAL LABORATORY

BEAUFORT, NORTH CAROLINA

Circular 184

UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, *Secretary*
James K. Carr, *Under Secretary*
Frank P. Briggs, *Assistant Secretary for Fish and Wildlife*
FISH AND WILDLIFE SERVICE, Clarence F. Pautzke, *Commissioner*
BUREAU OF COMMERCIAL FISHERIES, Donald L. McKernan, *Director*

Annual Report of the Bureau of Commercial Fisheries Biological Laboratory Beaufort, N. C.

For the Fiscal Year Ending June 30, 1962

Circular 184

Washington, D.C.
September 1964

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Annual Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N. C.

REPORT OF THE DIRECTOR

G. B. Talbot

Research highlights: Research on the blue crab consisted of both field and laboratory studies oriented toward understanding the life cycle and environmental factors that affect the survival at different life history stages. One of the most important findings concerned the distribution of larvae. From an examination of plankton catches, it was shown that only the early-stage zoeae and megalops occurred in the estuaries and that the most productive waters for all larval stages were 20 to 40 miles offshore. Understanding larval distribution patterns is basic to our search for specific environmental factors which affect survival in the early stages of development.

Research on the biology of blue crabs in the St. Johns River was continued by biologists stationed at Green Cove Springs, Fla.

Two of the outstanding accomplishments of menhaden research were the artificial fertilization of eggs and the successful rearing of yolk sac larvae of the yellowfin menhaden, *Brevoortia smithi*. These accomplishments opened a new avenue of research on the genetics and physiology of these fishes. With completion of a 5-year study of the variation in body structure of juveniles in successive year broods, a major step forward also was made in understanding the composition of the Atlantic menhaden population. Results showed that juveniles inhabiting estuarine nurseries consisted of at least two groups or subpopulations--one occurring north and the other south of Long Island, N.Y.

A field station, located at Millville, Del., was established by the Menhaden Program in 1955 to investigate the relation between variations in environmental factors and the entry, distribution, and survival of young Atlantic menhaden in the estuarine nurseries. With the completion of programed studies, this field station was closed in September 1961, and personnel transferred to the laboratory at Beaufort.

Statistics on the fisheries for shad in the Connecticut, Hudson, York, Cape Fear, and St. Johns Rivers were collected; and population inventories on the runs were made available to management officials in the various States. In addition, methods were developed for successfully passing adult shad above dams, and information was obtained on the biology of the fish during their life in rivers; together, these will provide practical management tools for the protection and rehabilitation of runs.

Cooperative studies with North Carolina State College and the Chesapeake Biological Laboratory on the striped bass populations in Albemarle Sound, Roanoke River, Potomac River, and upper Chesapeake Bay provided estimates of population size, measures of the composition of the stocks (including growth rate), information on movements of adults, and predictions of age composition of the catch for the following year.

Radiobiological research was directed principally toward laboratory studies on the cycling of radionuclides, the uptake and accumulation of radionuclides, and the effects of radiation on marine organisms. A joint radioecological survey of the Savannah and Wilmington Rivers, S.C., also was conducted with the U.S. Public Health Service to develop methods of measuring radioactive contamination and predicting the effects of chronic low-level radioactivity in an estuarine environment.

In cooperation with the Woods Hole Oceanographic Institution and the U.S. Coast Guard, monthly releases of seabed drifters over the Continental Shelf, from Cape Hatteras to Cape Fear, N.C., were begun in January 1962. The pattern of currents in this area of the coast is of particular interest in connection with studies of the spawning of Atlantic menhaden and the distribution of blue crab larvae.

P. R. Nichols was appointed Acting Chief of the Blue Crab Program and Chief of the Shad and Striped Bass Programs, when C. H. Walburg, in December 1961, transferred to the Central Reservoir Investigation, Bureau of Sport Fisheries and Wildlife, and J. E. Sykes in March 1962 to East Gulf Estuarine Investigations.

Atlantic States Marine Fisheries Commission: Laboratory staff members participated in the South Atlantic and Chesapeake Bay Section meetings at which an outline of the section reports to be given at the 20th annual meeting of the Commission was completed. Two staff members attended the 20th annual meeting held in New York in October, and a report summarizing the accomplishments of the cooperative striped bass studies was given.

Work conferences: Numerous work conferences were held during the year for the purpose of coordinating research at this laboratory with that conducted by other Federal and State agencies and academic institutions, including the U.S. Army Corps of Engineers, Office of River Basin Studies, North Carolina Wildlife Resources Commission, North Carolina Department, of Water Resources, North Carolina State College Institute of Statistics, South Carolina Wildlife Resources Department, Atomic Energy Commission, Virginia Institute of Marine Science, Chesapeake Biological Laboratory, and Sandy Hook Marine Laboratory. The annual spring meeting of the Atlantic Estuarine Research Society was held at Morehead City, N.C., with the University of North Carolina Institute of Fisheries Research, the Duke University Marine Laboratory, and the Bureau of Commercial Fisheries Biological Laboratory acting as joint hosts. T. R. Rice was the Department of the Interior representative at an international symposium on "Agriculture and Public Health Aspects of Radioactive Contamination in Normal and Emergency Situations," held at Scheveningen, Netherlands. J. W. Reintjes attended the "International Symposium on Luminescence," held in New York. F. C. June and G. B. Talbot attended the Executive Committee meeting of the Industrial Products Division of the National Fisheries Institute, held in Morehead City, N.C. T. R. Rice, J. P. Baptist, T. J. Price, and G. H. Rees attended the first symposium on radioecology, held at Colorado State College. G. B. Talbot attended the Shallow Water Conference in Baltimore, Md.

Public relations: Staff members described their research and presented demonstrations to instructors and students from North Carolina State College, University of North Carolina at Chapel Hill, and Ohio State University. Talks also were given to faculty and students of the Morehead City High School and the Smyrna Grade School, and to members of the Queen Street School Faculty Science Club, Beaufort. Three staff members were invited to visit the AEC plant at Aiken, S.C., where they presented talks covering radiobiological research on marine organisms. G. H. Rees presented a lecture, "Low-Level Radioactive Contamination of the Aquatic Environment in its Introduction into Biological Cycles," at the School of Public Health, University of North Carolina, Chapel Hill. In collaboration with the University of North Carolina Institute of Fisheries Research, laboratory staff members prepared a brochure on fishery research which was used in connection with a fishery promotion display at the North Carolina State Fair held at Raleigh.

Training programs: F. C. June attended a 2-week short course, "Electronic Processing of Biological Data," at the University of Washington. J. P. Baptist attended a 2-week course, "Nuclear Methods Applied to Oceanography," at the Oak Ridge Institute of Nuclear Studies. T. R. Rice presented a lecture, "Uptake of Trace Elements by Marine Organisms," and instructed a laboratory session on the "Rate of Uptake and Release of Zn^{65} by Marine Organisms," during a 2-week course at the Oak Ridge Institute of Nuclear Studies. Po-wei Yuan, a trainee from Taiwan, visited the laboratory for 2 weeks to observe fishery research methods.

STAFF

Gerald B. Talbot, Director

Blue Crab Program

Paul R. Nichols	Acting Chief (Charles H. Walburg transferred 12-19-61)	Beaufort, N.C.
Kenneth J. Fischler	Fishery Biologist (resigned 9-8-61)	Beaufort, N.C.
Grady P. Frymire	Fishery Biologist (vice J. R. Musgrave resigned 8-18-61)	Green Cove Springs, Fla.
Mayo H. Judy	Fishery Biologist	Beaufort, N.C.
Peggy M. Keney	Fishery Biologist	Beaufort, N.C.
Marlin E. Tagatz	Fishery Biologist	Green Cove Springs, Fla.
Gordon M. Davis	Fishery Aid (military leave Oct. 1961; resigned)	Beaufort, N.C.
Donnie L. Dudley	Fishery Aid	Beaufort, N.C.
Ray G. Lewis	Temporary Aid (terminated 8-18-61)	Beaufort, N.C.
Gary C. Williams	Summer Aid	Green Cove Springs, Fla.

Menhaden Program

Fred C. June	Chief	Beaufort, N.C.
Frank T. Carlson	Fishery Biologist	Beaufort, N.C.
Joseph R. Higham	Fishery Biologist	Beaufort, N.C.
William R. Nicholson	Fishery Biologist	Beaufort, N.C.
Anthony L. Pacheco	Fishery Biologist	Beaufort, N.C.
John W. Reintjes	Fishery Biologist	Beaufort, N.C.
Doyle F. Sutherland	Fishery Biologist (transferred 7-13-61)	Beaufort, N.C.
James F. Guthrie	Fishery Biologist	Beaufort, N.C.
George N. Johnson	Fishery Aid	Beaufort, N.C.
Fronnie A. Jones	Airplane Pilot	Beaufort, N.C.
William G. Peele	Airplane Pilot (resigned 7-18-61)	Beaufort, N.C.
Mary K. Hancock	Clerk	Beaufort, N.C.
Martin A. Roessler	Summer Aid	Lewes, Del.
Wesley L. Rouse	Summer Aid	Reedville, Va.
Jack V. Guthrie	Summer Aid	Port Monmouth, N.J.
Robert K. Cissel	Summer Aid	Amagansett, N.Y.
Robert O. Fournier	Temporary Aid (October 1961-March 1962)	Gloucester Pt., Va.
William A. Dillon	Temporary Aid (October 1961-March 1962)	Gloucester Pt., Va.
Herbert F. Prytherch, Jr.	Temporary Aid (July-September 1961)	Gloucester Pt., Va.

Shad and Striped Bass Program

Paul R. Nichols	Chief (vice C. H. Walburg transferred 12-19-61 and J. E. Sykes transferred 3-2-62)	Beaufort, N.C.
Rupert R. Bonner, Jr.	Fishery Biologist	Beaufort, N.C.
Robert B. Chapoton	Fishery Biologist	Beaufort, N.C.
Randall P. Cheek	Fishery Biologist	Beaufort, N.C.
Robert M. Lewis	Fishery Biologist	Beaufort, N.C.
Louis E. Vogele	Fishery Biologist	Beaufort, N.C.
Erwin W. McIntosh	Fishery Biologist (resigned 1-26-62)	Beaufort, N.C.

Radiobiological Program

Theodore R. Rice	Chief	Beaufort, N.C.
John P. Baptist	Fishery Biologist	Beaufort, N.C.
Joyce S. Clarke	Fishery Biologist	Beaufort, N.C.
Thomas W. Duke	Fishery Biologist	Beaufort, N.C.
David W. Engel	Fishery Biologist	Beaufort, N.C.
Donald E. Hoss	Fishery Biologist (military leave October 1961)	Beaufort, N.C.
Thomas J. Price	Fishery Biologist	Beaufort, N.C.
George H. Rees	Fishery Biologist	Beaufort, N.C.
Claire L. Schelske	Fishery Biologist	Beaufort, N.C.
John C. White, Jr.	Fishery Biologist	Beaufort, N.C.
James N. Willis, III	Fishery Biologist	Beaufort, N.C.
Clarence M. Roberts	Vessel-Operator and Engineer	Beaufort, N.C.
James R. Wheatley, Jr.	Biological Technician	Beaufort, N.C.
Marianne B. Murdoch	Fishery Aid	Beaufort, N.C.
Thomas G. Roberts	Fishery Aid	Beaufort, N.C.
John A. Baker, Jr.	Summer Aid	Beaufort, N.C.
John H. Crowe	Summer Aid	Beaufort, N.C.
John S. Hinmon	Summer Aid	Beaufort, N.C.
Richard T. Sanders	Summer Aid	Beaufort, N.C.
Edna M. Davis	Biological Aid	Beaufort, N.C.
Edward Shaw	Biological Aid (Antioch Student)	Beaufort, N.C.
Mary Gaston	Biological Aid (Antioch Student)	Beaufort, N.C.
Judith Oplinger	Biological Aid (Antioch Student)	Beaufort, N.C.

Staff Services

Correna S. Gooding	Clerk-Typist (vice Mary L. Willis transferred 5-27-62)	Beaufort, N.C.
Margaret L. Rose	Clerk-Stenographer	Beaufort, N.C.
Elizabeth F. Talbot	Librarian	Beaufort, N.C.
David W. Windley	Fishery Aid	Beaufort, N.C.
Barbara A. Johnson	Temporary Clerk-Typist	Beaufort, N.C.

Administration and Maintenance

Thelma C. Nelson	Administrative Assistant	Beaufort, N.C.
Margaret M. Lynch	Clerk-Typist	Beaufort, N.C.
Claude R. Guthrie	Foreman-Repair and Maintenance	Beaufort, N.C.
Inez J. Nierling	Clerk-Stenographer (vice Olive L. Davis retired 2-7-62)	Beaufort, N.C.
Thomas R. Owens	Caretaker (vice John S. Mason resigned 11-17-61)	Beaufort, N.C.
Jack D. Lewis	Caretaker	Beaufort, N.C.
Willie S. Rainey	Laborer	Beaufort, N.C.
Donald R. Bell	Temporary Laborer	Beaufort, N.C.
Ronald E. McLaren	Temporary Laborer	Beaufort, N.C.

BLUE CRAB PROGRAM

Paul R. Nichols, Acting Chief

Research on the blue crab during 1962 can be divided into three large categories which correspond to phases in the life history of the species. These are (1) larval studies, (2) immature crab studies, and (3) adult crab studies. Each of these phases in the life history is different ecologically, physiologically, and morphologically; and what we know about them is relatively meager compared to the present interest in the fishery.

LARVAL STUDIES

John D. Costlow, Jr.
Duke University Marine Laboratory
and
Peggy M. Keney

The larval studies are basically of two types: (1) laboratory studies to determine the effects of environmental factors on larval survival and rate of development and (2) field studies to determine the distribution and abundance of larvae. The laboratory phase of the work is being conducted at the Duke University Marine Laboratory under contract.

<u>The effects of environmental factors on the development and survival of larvae of the blue crab (Contract: 14-17-0002-11)</u>: There is considerable variability in the survival of zoeae hatched from eggs of different female blue crabs. Survival has ranged from less than 1 percent to approximately 40 percent, even when all larvae of all series were maintained under almost identical environmental conditions. This variability has made it difficult to show any direct correlation between survival of the zoeae and conditions that would normally be encountered in nature, and suggests that physical conditions of the environment following hatching may not be the most important factor affecting larval survival. It is possible that variability in survival is associated with intrinsic factors such as diet of the female crab prior to egg laying, the environmental conditions at the time of egg laying, or genetic differences. Studies are underway to determine if variability of survival of larvae is associated with nitrogen content or other organic constituents of the eggs and larval stages. Additional work is needed to determine how the physiological condition of the female affects development of the eggs and larvae.

Recent work has established that mortality and rate cf development of the megalops stage, that stage just prior to the first crablike stage, are considerably affected by temperature and salinity. At a temperature of 30° C.

and at salinities of from 10 to 35 p.p.t., metamorphosis took place in 5 to 6 days; at 25° C., the time required was 8 to 9 days; at 20° C., it took 14 to 18 days; and at 15° C., the megalops rarely developed into a crab, but those that did required 60 days or more. At any one temperature, development was slower in the lower salinities, but the differences were less than those due to temperature.

Some work has been done this year on the effects of temperature and salinity on the growth rate of the early postlarval stages. The effects of low temperatures were to prolong the intermolt period and decrease the growth increment, but salinities of 5 to 35 p.p.t. did not affect the frequency of molting or the percentage increase at time of molting.

Analyses of plankton collections: In field studies, regular plankton collections were made in estuarine and offshore water in North Carolina and Florida. In addition, an analysis was completed of the plankton collections made available from the cruises of the research vessel Theodore N. Gill. This analysis revealed the following points concerning the distribution of Callinectes larvae:

1. Only early stage zoeae and megalops occur in the estuaries. There is a tremendous drop in numbers from first to second stage zoeae. This may be comparable to the heavy mortalities observed in laboratory rearing experiments.
2. All larval stages occur in the inlets, indicating that some complete development takes place in these waters.
3. Combined larval stages occur in greatest abundance 20 and 40 miles offshore. In Florida, Georgia, and South Carolina, large numbers of early stage zoeae occur near the beaches; with a progression to the advanced stages 20, 40, and 60 miles offshore (fig. 1). It was surprising to find relatively large numbers of late stage zoeae and megalops occurring 60 miles offshore and some as much as 80 miles offshore.

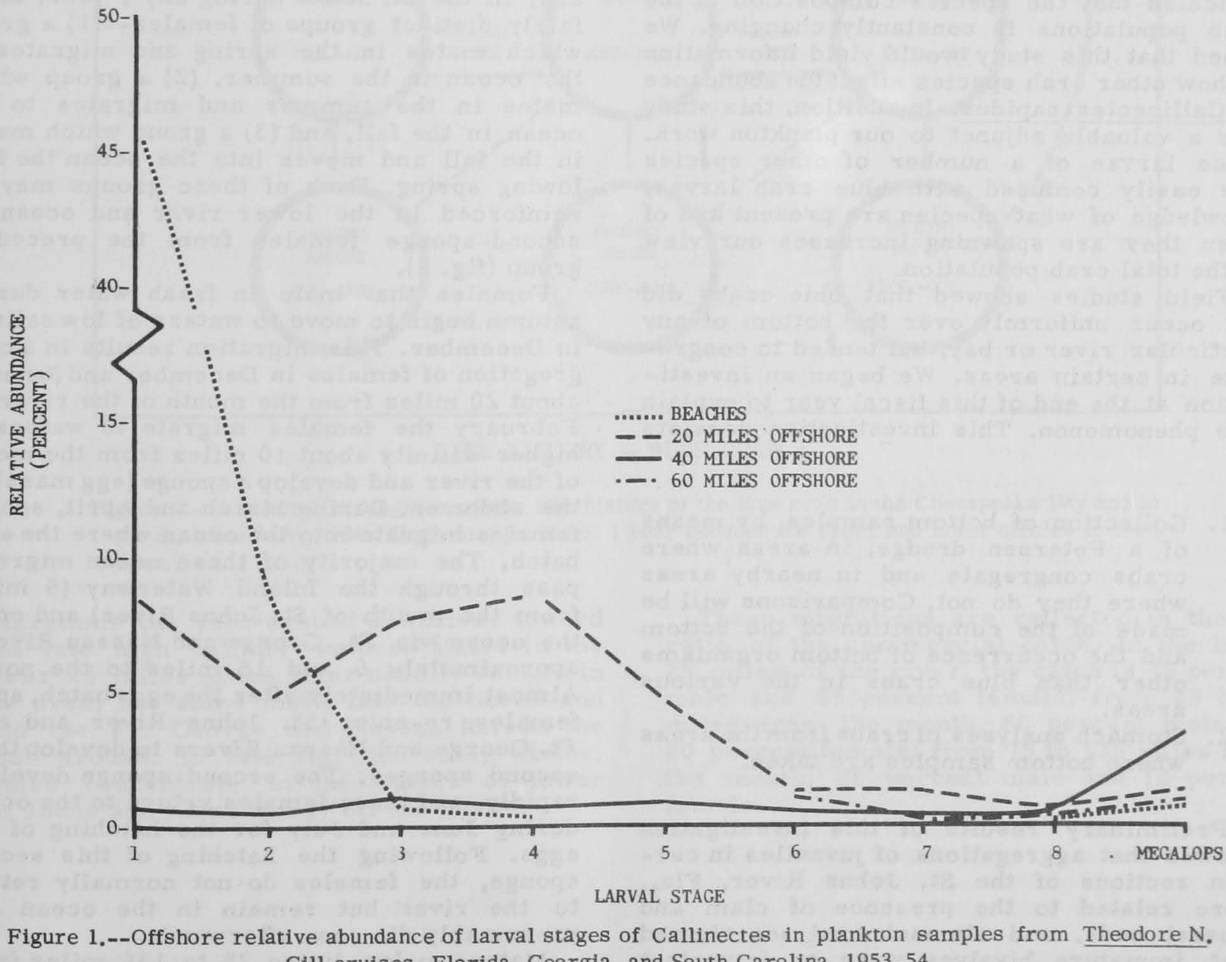


Figure 1.--Offshore relative abundance of larval stages of Callinectes in plankton samples from Theodore N. Gill cruises, Florida, Georgia, and South Carolina, 1953-54.

IMMATURE CRAB STUDIES

Mayo H. Judy
and
Donnie L. Dudley

We continued our attempts to locate the nursery grounds for immature crabs and determine their abundance, food, predators, and competition. Collecting very young crabs is difficult because they seem to prefer the shallow bays and creeks with soft, muddy bottoms, and spend considerable time buried, or partially buried, in this ooze. We worked on the design of a sled-type bottom skimmer that will permit us to take a sample at or slightly below the surface of the mud.

Also in our immature crab studies we made regular collections with a 30-foot shrimp trawl to determine the species composition of crab populations in our North Carolina study area. From these trawl collections we obtained data on the species present, their relative abundance, size, sex, and the maturity of the females. This new phase of our work indicated that the species composition of the crab populations is constantly changing. We hoped that this study would yield information on how other crab species affect the abundance of Callinectes sapidus. In addition, this study was a valuable adjunct to our plankton work. Since larvae of a number of other species are easily confused with blue crab larvae, knowledge of what species are present and of when they are spawning increases our view of the total crab population.

Field studies showed that blue crabs did not occur uniformly over the bottom of any particular river or bay, but tended to congregate in certain areas. We began an investigation at the end of this fiscal year to explain this phenomenon. This investigation consists of:

1. Collection of bottom samples, by means of a Petersen dredge, in areas where crabs congregate and in nearby areas where they do not. Comparisons will be made of the composition of the bottom and the occurrence of bottom organisms other than blue crabs in the various areas.
2. Stomach analyses of crabs from the areas where bottom samples are taken.

Preliminary results of this investigation showed that aggregations of juveniles in certain sections of the St. Johns River, Fla., were related to the presence of clam and mussel beds, and stomach analyses showed that immature bivalves were an important item in the blue crab's diet.

ADULT CRAB STUDIES

Marlin E. Tagatz
and
Grady P. Frymire

Studies of adult crabs consisted of a tagging and recovery program to follow their movements, examination of our own trawl catches to determine the stage of sexual maturation as related to season and to various portions of the estuary, examination of the commercial catch for size and sex ratio, and collection of catch and effort statistics. These studies were conducted in the Newport River estuary in North Carolina and the St. Johns River, Fla.

Our study of the St. Johns blue crab covers an area from the mouth of the river to Astor, Fla., a distance of 135 miles. Thirty miles above the mouth of the river the salinity is zero; about two-thirds of the St. Johns River blue crab fishery takes place in fresh water.

Mating of the St. Johns River blue crab takes place throughout the 135 miles of the river under study. The period of mating is primarily March through November. There are, in the St. Johns during any 1 year, three fairly distinct groups of females--(1) a group which mates in the spring and migrates to the ocean in the summer, (2) a group which mates in the summer and migrates to the ocean in the fall, and (3) a group which mates in the fall and moves into the ocean the following spring. Each of these groups may be reinforced in the lower river and ocean by second-sponge females from the preceding group (fig. 2).

Females that mate in fresh water during autumn begin to move to waters of low salinity in December. This migration results in a congregation of females in December and January about 20 miles from the mouth of the river. In February the females migrate to waters of higher salinity about 10 miles from the mouth of the river and develop a sponge (egg mass) on the abdomen. During March and April, sponge females migrate into the ocean where the eggs hatch. The majority of these ocean migrants pass through the Inland Waterway (5 miles from the mouth of St. Johns River) and enter the ocean via Ft. George and Nassau Rivers, approximately 6 and 15 miles to the north. Almost immediately after the eggs hatch, spent females re-enter St. Johns River and also Ft. George and Nassau Rivers to develop their second sponges. The second sponge develops rapidly, and these females return to the ocean during June and July for the hatching of the eggs. Following the hatching of this second sponge, the females do not normally return to the river but remain in the ocean and presumably die soon afterwards.

Mature males, living 25 to 135 miles from the mouth of the river, also make intensive

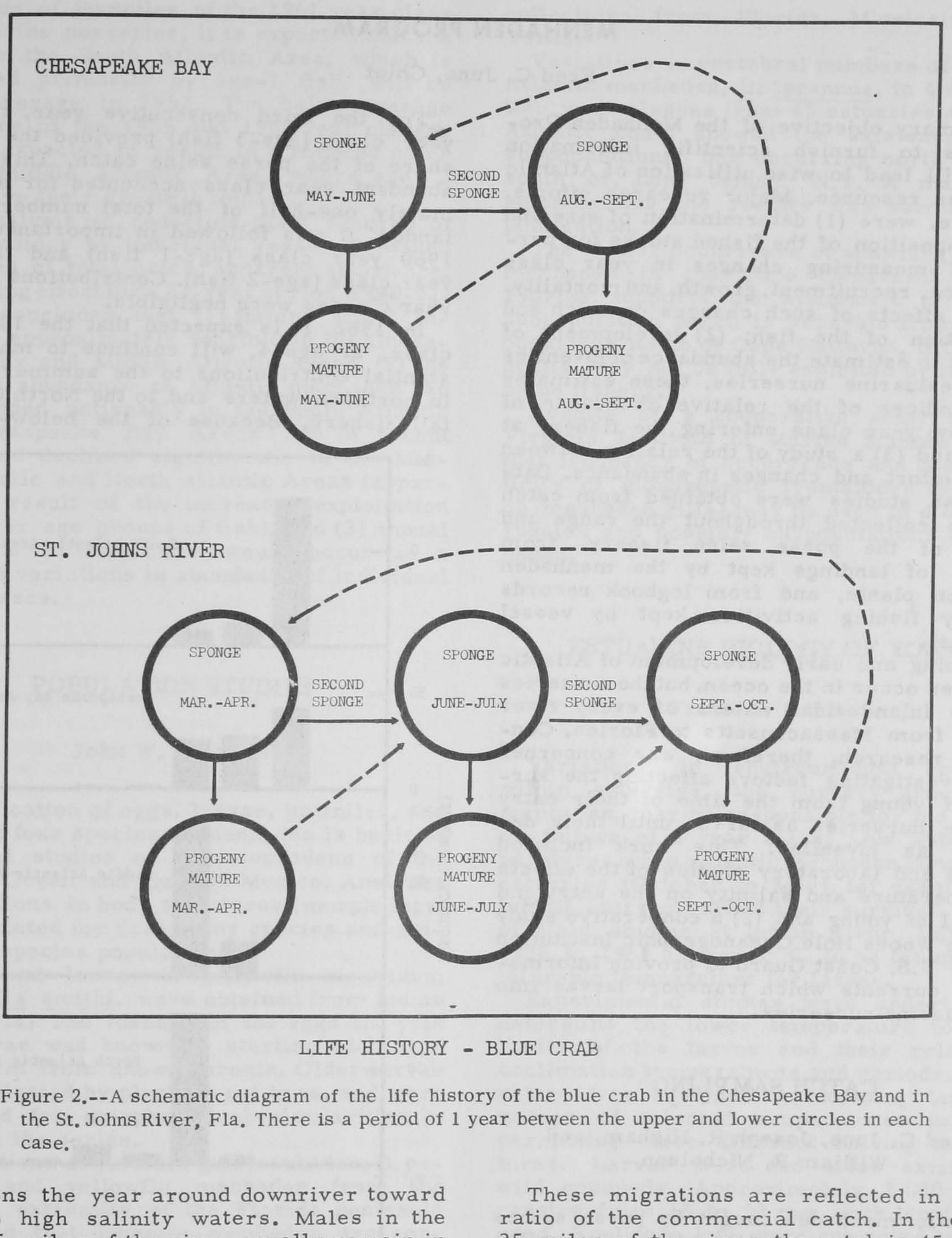


Figure 2.--A schematic diagram of the life history of the blue crab in the Chesapeake Bay and in the St. Johns River, Fla. There is a period of 1 year between the upper and lower circles in each case.

migrations the year around downriver toward and into high salinity waters. Males in the lower 25 miles of the river usually remain in the area, but some move into the ocean and into the Ft. George and Nassau Rivers the year around. In late fall and early winter, males concentrate in the waters of lower St. Johns and immediately off the mouth.

These migrations are reflected in the sex ratio of the commercial catch. In the lower 25 miles of the river, the catch is 45 percent male and 55 percent female; from 25 to 75 miles from the mouth, 80 percent male and 20 percent female; from 75 to 135 miles from the mouth, 88 percent male and 12 percent female.

MENHADEN PROGRAM

Fred C. June, Chief

A primary objective of the Menhaden Program is to furnish scientific information which will lead to wise utilization of Atlantic menhaden resource. Major research efforts, therefore, were (1) determination of size and age composition of the fished stocks for purpose of measuring changes in year class abundance, recruitment, growth, and mortality, and the effects of such changes on catch and distribution of the fish; (2) development of methods to estimate the abundance of juveniles in the estuarine nurseries, these estimates being indices of the relative abundance of each new year class entering the fishery at age 1; and (3) a study of the relation between fishing effort and changes in abundance. Data for these studies were obtained from catch samples collected throughout the range and season of the purse seine fishery, from records of landings kept by the menhaden reduction plants, and from logbook records of daily fishing activities kept by vessel personnel.

Spawning and early development of Atlantic menhaden occur in the ocean, but the nurseries are the inland tidal waters of every river system from Massachusetts to Florida. Continuing research, therefore, was concerned with investigating factors affecting the survival of young from the time of their entry into the nurseries as larvae until their departure as juveniles. This work included (1) field and laboratory studies of the effects of temperature and salinity on the entry and survival of young and (2) a cooperative study with the Woods Hole Oceanographic Institution and the U.S. Coast Guard to provide information on currents which transport larvae into the estuarine nurseries.

CATCH SAMPLING

Fred C. June, Joseph R. Higham, and William R. Nicholson

Atlantic menhaden caught by purse seines were sampled at reduction plants during the 1961 "summer" fishery (May to October) and during the North Carolina "fall" fishery (November to January) for age, size, and sex composition. Analyses of these data, along with records of catch and logbook information on the amount and location of fishing, as well as estimates of juvenile abundance in estuarine nurseries, provided a measure of the current condition of the fishery.

The average 1961 catch per purse seine set increased over that of 1960 but was below the 1955-60 annual average.

For the third consecutive year, the 1958 year class (age-3 fish) provided the largest share of the purse seine catch. This superabundant year class accounted for approximately one-half of the total number of fish landed. It was followed in importance by the 1960 year class (age-1 fish) and the 1959 year class (age-2 fish). Contributions by other year classes were negligible.

In 1962, it is expected that the 1958 year class, at age 4, will continue to make substantial contributions to the summer fishery in northern waters and to the North Carolina fall fishery. Because of the below-average

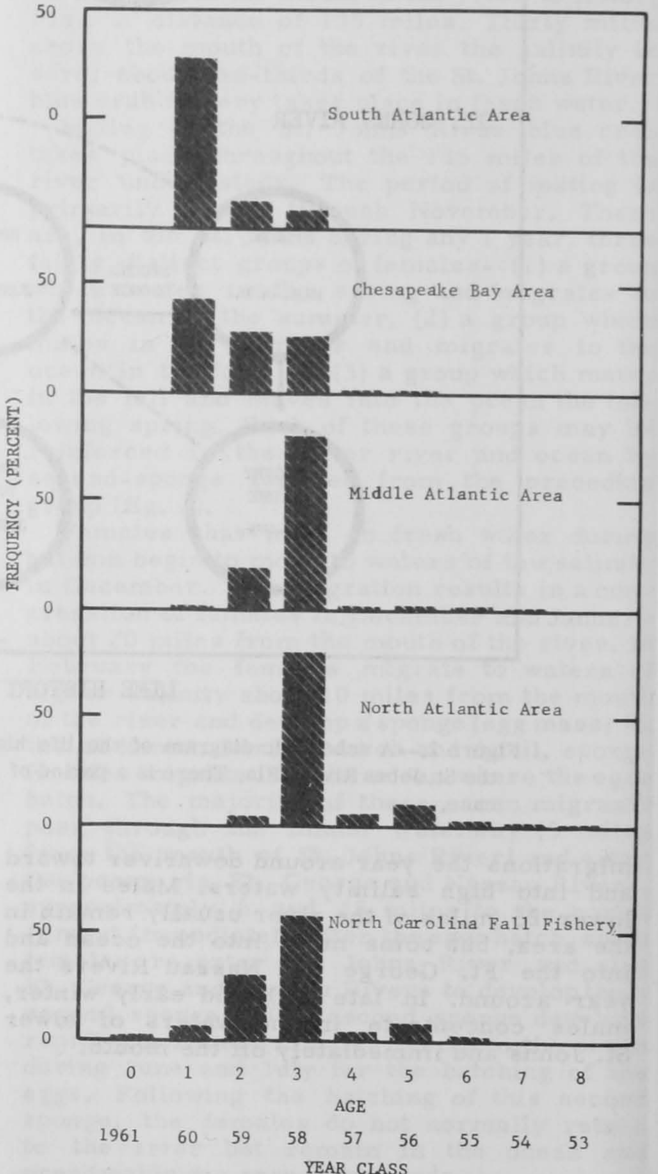


Figure 3.--Age composition of purse seine caught Atlantic menhaden, by area, 1961.

abundance of juveniles of the 1961 year class in estuarine nurseries, it is expected that the catch in the South Atlantic Area, which is supported primarily by age-1 fish, will be below average in 1962. The below-average abundance of the 1959 and 1960 year classes also is expected to result in a reduced catch in the Middle Atlantic Area, where ages 2 and 3 have their greatest impact.

An analysis of reduction plant records of daily landings by individual vessels provided measures of total catch, apparent abundance, and fishing effort for a 22-year period, 1940-61. It was concluded that (1) fishing effort increased approximately fourfold in the Chesapeake Bay and Middle Atlantic Areas, (2) the apparent abundance of Atlantic menhaden had not changed noticeably in the South Atlantic and Chesapeake Bay Areas but in recent years had declined significantly in the Middle Atlantic and North Atlantic Areas (apparently a result of the increased exploitation of younger age groups of fish), and (3) annual variations in the catch would occur as a result of variations in abundance of individual year classes.

POPULATION STUDIES

John W. Reintjes

Identification of eggs, larvae, juveniles, and adults of four species of menhaden is basic to biological studies of the menhadens of the Atlantic Ocean and Gulf of Mexico. Analyses of variations in body structures (morphology) were initiated for describing species and divisions of species populations.

Eggs and larvae of yellowfin menhaden, Brevoortia smithi, were obtained from Indian River, Fla. The identity of the eggs and yolk sac larvae was known by starting with eggs and sperm from known parents. Older larvae were collected by plankton net tows, and were compared for morphological similarities to complete the series.

Collections of juvenile gulf menhaden, B. patronus, and yellowfin menhaden from the southern extremity of the Florida peninsula confirmed that juvenile menhaden are continuously distributed from the Atlantic Ocean to the Gulf of Mexico.

Adult gulf menhaden, collected over the known geographical range, Florida to Mexico, were examined for morphological variations. One purpose of the study was to describe the species and distinguish it from other menhadens occurring in the region. Another purpose was to determine if meristic variations within the species might be used to identify subpopulations. Analysis of vertebral counts showed significant differences between collections from Florida, Mississippi, and Texas.

Variations in vertebral numbers of juvenile Atlantic menhaden, B. tyrannus, in 4 consecutive year classes from 45 estuaries along the Atlantic coast showed the existence of two subpopulations, one occurring north and one south of Long Island, N.Y. A manuscript summarizing the results was submitted for publication.

The winter occurrence of spawning Atlantic menhaden in the Cape Canaveral area of Florida supports the hypothesis of a third subpopulation which is separate from the two occurring north of Cape Hatteras, N.C. These adults may not be fully exploited by the purse seine fishery.

Results of a cooperative study with the Virginia Institute of Marine Science showed that frequency of occurrence and host specificity of monogenetic trematodes (parasites on menhaden gills) may be used to distinguish species and possibly subpopulations of menhaden.

ESTUARINE BIOLOGY OF YOUNG

Frank T. Carlson

Variations in environmental conditions within estuaries, the nursery grounds for menhaden, may be responsible for the success or failure of a year class. Low water temperatures when Atlantic menhaden larvae enter estuaries (October to May), for example, can inhibit entry or affect their survival. Results of field studies at Indian River, Del., from 1956 to 1961 showed 3° C. to be the minimum tolerable temperature for larvae.

Experimental studies were undertaken to determine the lower temperature tolerance limits of the larvae and their relation to acclimation temperatures and periods. A laboratory was equipped for keeping larvae in waters of selected temperatures in a unit permitting three different holding temperatures. Larvae were fed brine shrimp and wild copepods. Approximately 2,000 larvae, ranging from 15 to 32 mm. fork length, were used. Replicate lots were subjected to abrupt chilling in 0.5° increments from acclimation temperatures that ranged from 21.0° to 8.3° C. to experimental temperatures ranging from 7.0° to -0.5° C. The results of the laboratory trials supported the field observations that 3° C. was approximately the threshold for survival. Larvae accustomed to temperatures below 11.5° C. survived in significantly greater numbers than those accustomed to water above 11.5° C.; therefore, the lesser the amount of cooling, the greater the survival to temperatures near the lethal limit.

ESTIMATION OF JUVENILE ABUNDANCE

Anthony L. Pacheco

Studies were continued on several methods of estimating the abundance of juvenile Atlantic menhaden in estuarine nurseries. Reliable estimates of the relative abundance of each new year class are important since age-1 fish support the commercial purse seine fishery in the South Atlantic and Chesapeake Bay Areas.

We conducted Petersen-type mark and recovery experiments in six tributaries from North Carolina to Massachusetts to provide estimates of absolute abundance. We obtained estimates of relative abundance concurrently at each location from catch per haul by haul seines and surface trawls. We also examined the variation in the availability of juveniles to haul seines.

The major findings were: (1) a positive relation existed between estimates of relative and absolute abundance at each location, (2) surface trawling was a reliable method for estimating relative abundance in areas inaccessible to haul seines, and (3) night seining resulted in higher average catches than day seining. Also, there were fewer zero catches and less variation in numbers of fish caught per haul at night.

Annual estimates of absolute abundance by mark and recovery methods, and relative abundance estimates by catch per haul in White Creek, Del., (a tributary of Indian River) are shown in figure 4. Studies over the past 3 years have shown a high positive correlation between the indices of relative abundance of juveniles in estuaries and of age-1 fish in the purse seine fishery the following year. Variability of absolute estimates was examined from replicate surveys conducted in four tributaries. Based on a mathematical analysis (triple-catch trellis), estimates of juvenile survival and recruitment rates in four estuaries indicated a progressive decline in abundance at rates varying from -0.045 to -0.090 per day from June to September. A progressive decline in haul seine and trawl catches, as well as decline in school counts, and tag recovery ratios, provided supporting evidence.

Aerial counts were made during replicate flights over 40 estuaries from South Carolina to Massachusetts. In general, we encountered optimal conditions for aerial scouting in mid-morning at altitudes of 500-800 feet. Except in turbid areas, schools were clearly distinguishable and counts easily made. Estimating relative abundance by aerial spotting appears satisfactory for most estuaries, and it offers the observer broad geographic coverage and the opportunity to compare regional differences in the occurrence of the fish.

Compared to 1959, a below average year class and the base year, the relative abundance of juveniles in 1961 appeared unchanged from South Carolina to Long Island, and slightly higher north of Long Island. Compared to 1960, relative abundance in 1961 generally was lower.

METHODS OF MARKING AND RECOVERY

Frank T. Carlson

We experimented with internal ferromagnetic tags on juvenile menhaden, 115-165 mm. fork length, in tanks at the laboratory. Four different tags were tested--three were iron or iron-nickel toroids of different sizes and finishes, and one was a plastic cylinder with an iron core. Tags were inserted into the body cavity through a slit made with a scalpel. Controls of (1) incised but untagged fish and (2) nonmutilated fish were kept in the same tanks. The most suitable tag was the smoothest and smallest toroid. The other tags damaged the viscera, and many tags were shed. The only significant mortality was among fish tagged with the larger and rougher toroids.

Recovery or detection of fish tags from fish meal and oil requires a mechanical or electronic device. Magnetic recovery of tags has been successful in the herring, sardine, and anchoveta fisheries. Results indicate that this method would be satisfactory for the menhaden industry.

A possible method for recovering marked fish is the photoelectric detection of fish marked with luminescent pigments. An initial inquiry showed that luminescent pigments were not detectable by intensity alone and that discrimination by color could not be done with our present detection device. Although the method may have laboratory applications, it seems impractical for plant installation. To date, the inquiry has concerned only the development of a detection instrument, and no application of luminescent pigments to live fish has been tried.

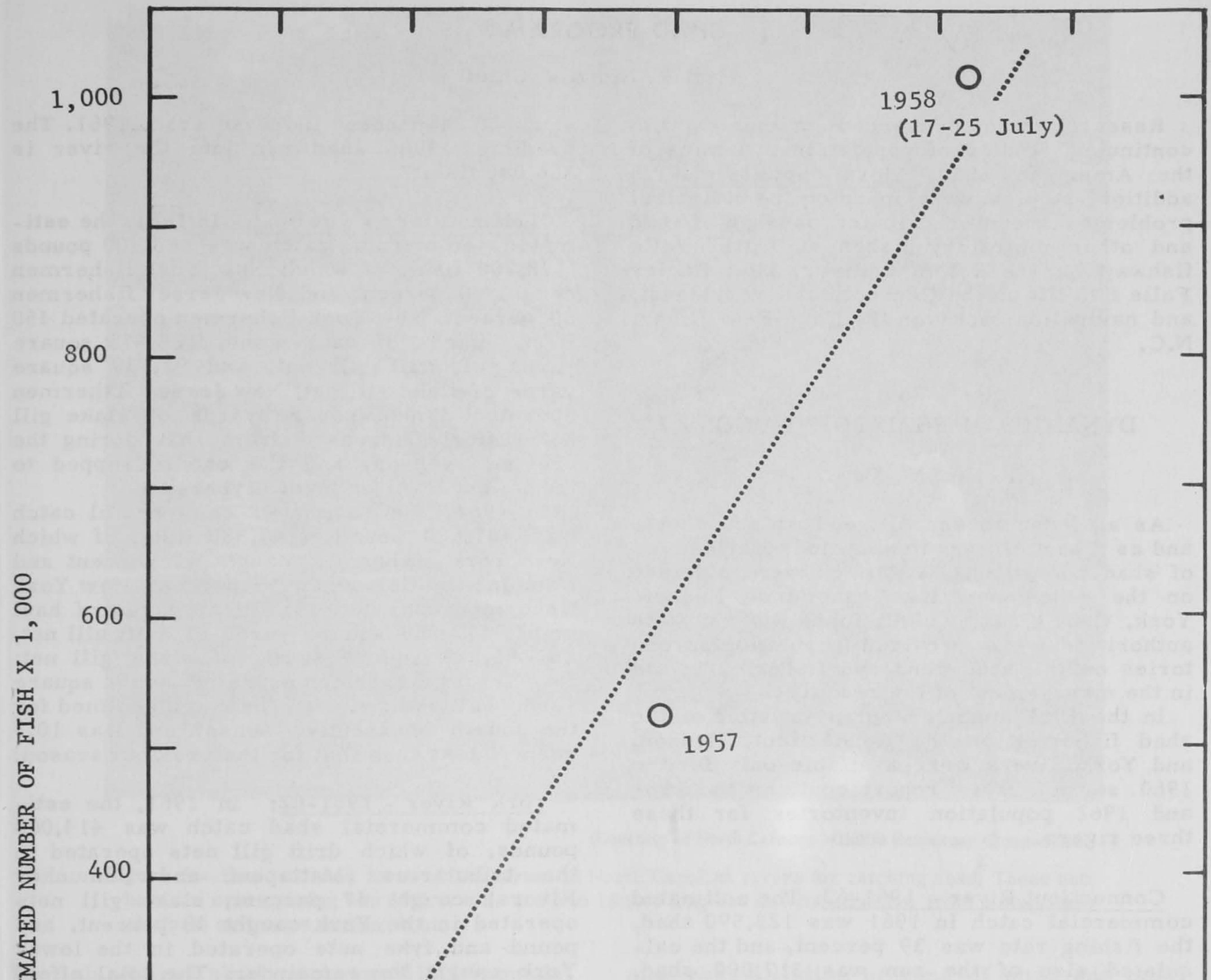


Figure 4.--Relation of population estimates and availability of juvenile menhaden during 4 consecutive years at White Creek, Del.

SHAD PROGRAM

Paul R. Nichols, Chief

Research was concerned primarily with continuing studies of population dynamics of the American shad, Alosa sapidissima. In addition, studies were made on the biological problems encountered in the passage of shad and other migratory fishes at Little Falls fishway on the Potomac River, Md.; Hadley Falls fish lift on the Connecticut River, Mass.; and navigation locks on the Cape Fear River, N.C.

DYNAMICS OF SHAD POPULATIONS

Robert M. Lewis

As an index to annual trends in abundance, and as a part of a continuing study of dynamics of shad populations, statistics were obtained on the fisheries of the Connecticut, Hudson, York, Cape Fear, and St. Johns Rivers. State authorities were provided population inventories on the shad runs and fisheries to aid in the management of the resource.

In the 1961 annual report, statistics on the shad fisheries on the Connecticut, Hudson, and York Rivers were available only for the 1960 season. This report contains the 1961 and 1962 population inventories for these three rivers.

Connecticut River - 1961-62: The estimated commercial catch in 1961 was 123,590 shad, the fishing rate was 39 percent, and the calculated size of the run was 317,000 shad. From a regression equation calculated from escapement and size of run data, the predicted size of the 1961 run was 378,000 shad. The 19-percent difference between the calculated and predicted size of run may have resulted from some of the fishermen discarding a portion of the male catch. Also, purse seiners fishing out of Gloucester, Mass., during the summer and fall of 1960 landed approximately 630,000 pounds of shad, which could have affected the size of run into the river because fish that spawn in rivers from Chesapeake Bay to the Connecticut River migrate northward after spawning and spend the summer and fall in the Gulf of Maine. The estimated sport catch by both Connecticut and Massachusetts fishermen was 25,000 shad--the same yield as for the previous season.

In 1962, the estimated commercial shad catch was 121,206 fish, fishing rate 39 percent, and calculated size of run 311,000 shad. The predicted size of the 1962 population entering the Connecticut River was 386,000 shad. The estimated sport catch by both Connecticut and Massachusetts was 31,000 shad--a 24-percent increase from 1961. The predicted 1963 shad run into the river is 386,000 fish.

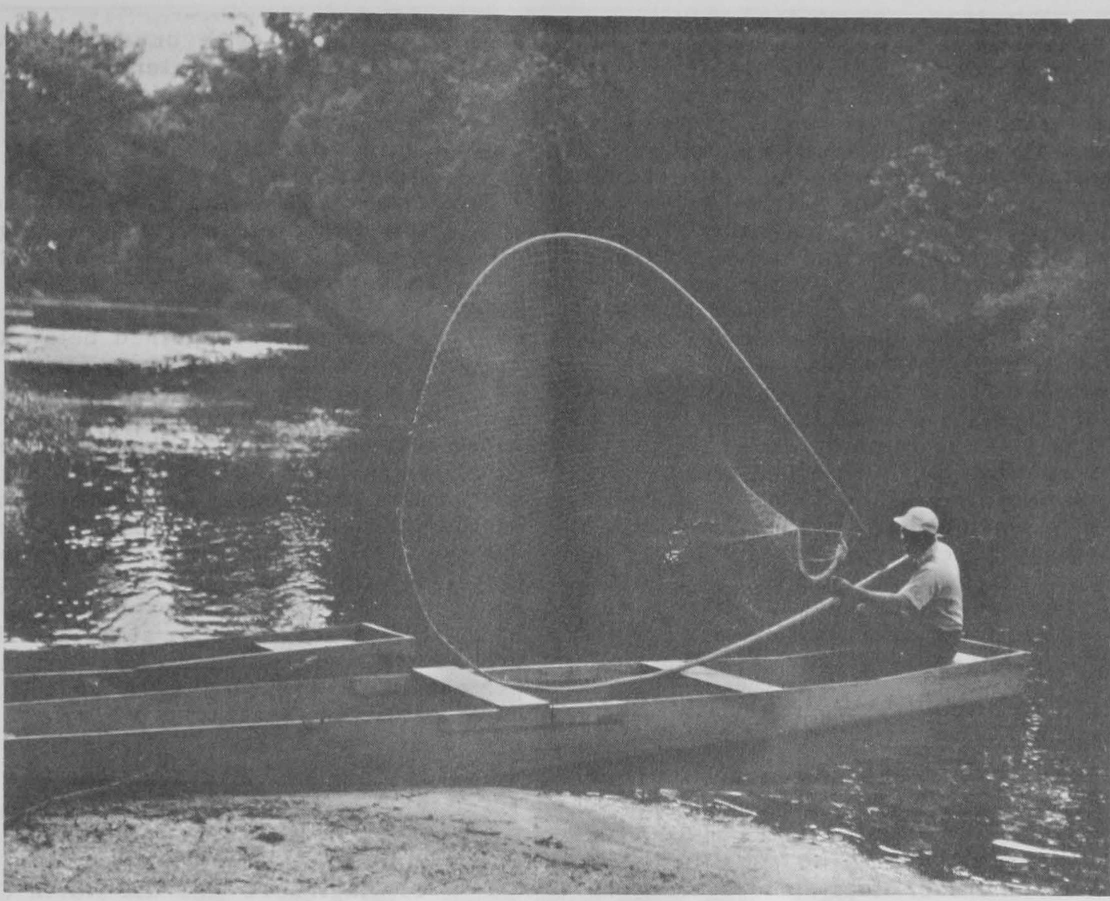
Hudson River - 1961-62: In 1961, the estimated commercial catch was 588,900 pounds (178,700 fish), of which New York fishermen caught 40 percent and New Jersey fishermen 60 percent. New York fishermen operated 450 linear yards of haul seine, 125,873 square yards of drift gill net, and 92,639 square yards of stake gill net; New Jersey fishermen operated 30,022 square yards of stake gill net. Effort decreased from that during the previous season, and the catch dropped to the lowest level in several years.

In 1962, the estimated commercial catch was 527,680 pounds (149,380 fish), of which New York fishermen caught 41 percent and New Jersey fishermen 59 percent. New York fishermen operated 457 linear yards of haul seine, 113,059 square yards of drift gill net, and 96,329 square yards of stake gill net; New Jersey fishermen operated 30,952 square yards of stake gill net. The catch declined for the fourth consecutive season and was 10.3 percent less than that for the previous season.

York River - 1961-62: In 1961, the estimated commercial shad catch was 414,068 pounds, of which drift gill nets operated in the tributaries (Mattaponi and Pamunkey Rivers) caught 47 percent, stake gill nets operated in the York caught 48 percent, and pound and fyke nets operated in the lower York caught the remainder. The total effort was 16,275 standard-fishing-unit-days (100 yards of drift gill net fished for 1 day - 1 s.f.u. day), of which drift gill nets accounted for 62 percent, stake gill nets 35 percent, and pound and fyke nets the remainder. The estimated population size was 749,000 pounds, and the fishing rate 55 percent.

In 1962, the estimated commercial catch was 589,377 pounds, of which drift gill nets caught 37 percent, stake gill nets 58 percent, and pound and fyke nets the remainder. The total effort was 13,414 standard-fishing-unit-days, of which drift gill nets accounted for 56 percent, stake gill nets 39 percent, and pound and fyke nets the remainder. The estimated population size was 1,146,000 pounds, and the fishing rate 51 percent.

Cape Fear River System - 1962: The estimated commercial area shad catch was 121,525 pounds. The Cape Fear River produced 64 percent, the North East Cape Fear River 29 percent, and the Black River 7 percent. Drift gill nets produced 96 percent of the catch, and anchor gill nets and haul seines the remainder.



(Courtesy of North Carolina Wildlife Resources Commission.)

Figure 5.--Bow net used in the inland areas in North Carolina rivers for catching shad. These nets have an oval opening 4 to 10 feet wide and 6 to 18 feet long and are fished either from a stationary platform or from a drifting boat.

The inland area shad catch was 61,500 pounds, of which the North East Cape Fear produced 75 percent and the Black the remainder. Of the inland area catch, gill nets took 72 percent and bow nets the remainder. The total catch of 183,025 pounds was 4 percent less than that in 1961; however, the catch per unit of effort was 33 percent greater than that in the previous season.

St. Johns River - 1962: The estimated shad catch was 795,000 pounds; the commercial fishery caught 621,000 pounds and the sport fishery 174,000 pounds. The calculated size of the run was 3,362,000 pounds, and the total fishing rate 24 percent. The production increase of 30 percent over the previous season, probably resulted from the large spawning escapement of more than 2 million pounds in 1957-58.

FISHWAY STUDIES

Paul R. Nichols

The Bureau of Commercial Fisheries continually receives requests to help solve biological problems associated with the protection and rehabilitation of runs of shad and other migratory fishes at existing impoundments. Studies were made (1) at the Little Falls Dam Fishway on the Potomac River to study the passage of migrating fishes, especially anadromous species, to spawning grounds and nursery areas above the dam; (2) at the Hadley Falls Dam fish lift on the Connecticut River to observe the passage of adult shad and to make comparable growth and racial studies on the young hatched above and below the dam; and (3) at Lock and Dam No. 1 on the Cape Fear River on the practicability of using navigation locks in lieu of fishways for the upstream passage of shad and related species.

Little Falls Dam Fishway, Potomac River - 1962: The fishway was operated and observed from May 5 to May 31. No shad or related species ascended the fishway, but local river fishes used the fishway successfully during experiments with various combinations of attraction flow. Since the resident fish did negotiate the fishway, anadromous species should do so if present.

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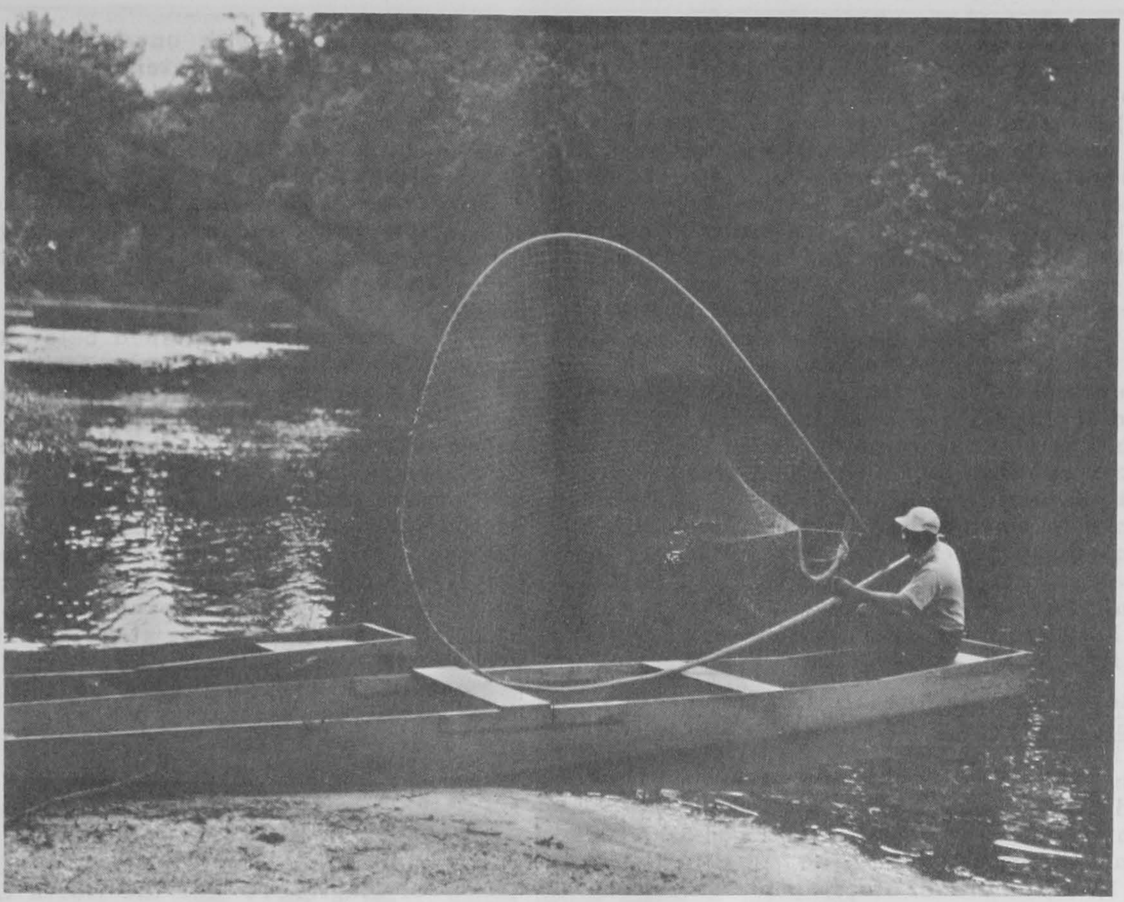

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The reasons why shad and other anadromous fishes do not ascend the river to the fishway are not readily apparent. It is quite possible that (1) the runs are now so small that the fish do not need the spawning areas above the dam and therefore have no urge to push further upstream; (2) the upriver stocks may have been blocked from their spawning grounds when the dam was repaired after the 1942 flood, and therefore lost their migratory instinct, at least as far as ascending the river above the dam; and (3) rapids about 0.8 mile below the fishway may act as a deterrent to their upstream progress, at least at some river discharges, and therefore only few fish pass this partial obstruction.

Fertilized shad eggs obtained from commercial fishermen in the lower river were held in experimental hatching boxes above the impoundment to determine the suitability of the waters above the dam for successful hatching. Survival from four experiments was poor; however, with some changes in technique, it probably could be increased.

Hadley Falls Dam Fish Lift on the Connecticut River - 1961-62: Passage of shad in 1961 totaled 22,601 fish--50 percent more than in 1960. From 1952 to 1961 the number of shad passed annually has increased steadily. The catch and size of run into the river have remained relatively high in the last six seasons (table 1). Numbers of other species using the fishway were 1,158 alewife, Alosa pseudoharengus; 267 bass, Micropterus sp.; 35 trout, Salmo sp.; 2 walleye, Stizostedion vitreum; 13 perch, Perca flavescens; 13 bullhead, Ictalurus sp.; 37 catfish, Ictalurus sp.; 11 carp, Cyprinus carpio; and 42 lamprey, Petromyzon marinus.

Passage of shad in 1962 totaled 21,346 fish--somewhat below 1961. However, in 1962 the fish lift operated with unusually low water levels in the river. By extensive changes, the lift was made more efficient. The trap now rises to a flume to the forebay of the dam, thus eliminating the bucket system used in previous seasons.

Studies on the young shad hatched above and below the dam showed some significant differences. In samples taken on October 1, 1962, those hatched above the dam ranged from 104 to 142 mm. fork length with a mean of 118.2 mm.; those hatched below the dam ranged from 81 to 130 mm., with a mean of 105.8 mm. (fig. 6). This difference in size indicates that the area above the dam was superior for growth to the area below the dam, at least for the hatch from the present number of adult shad passed. The young shad hatched above the dam consistently had higher fin ray counts than those hatched below the dam, with the difference in the left pectoral fin ray count being significant at the 1-percent level. Differences in body structures between the young from each area may enable us to project these differences to the commercial catch, and thus evaluate the effect of shad passage on the fishery.

Experimental lockage of fish at Lock and Dam No. 1, Cape Fear River - 1962: Studies were made in cooperation with the U.S. Army Corps of Engineers and the North Carolina Wildlife Resources Commission to determine the practicability of using locks, instead of fishways, to pass anadromous fishes during their spawning migrations. A lock was operated 108 hours for the passage of fish from April 2 to June 4. Based on the number of fish netted in the lock chamber during periodic sampling with haul seine, an estimated 1,030 American shad, Alosa sapidissima, 1,140 glut herring,

Table 1.--Numbers of American shad passed at Hadley Falls Dam (Holyoke, Mass.) and dynamics of the Connecticut River population, 1955-62

Year	Fish lifted	Catch	Fishing rate	Size of run
	Number	Number	Percent	Number
1952	35	134,856	54	249,272
1953	262	114,695	50	229,850
1954	124	78,506	41	191,478
1955	4,900	60,449	35	172,711
1956	7,731	53,500	24	223,000
1957	8,847	81,368	26	313,000
1958	5,705	126,463	34	372,000
1959	14,972	107,902	31	348,000
1960	15,076	115,706	34	340,000
1961	22,601	123,593	39	317,000
1962	21,346	120,230	40	304,000

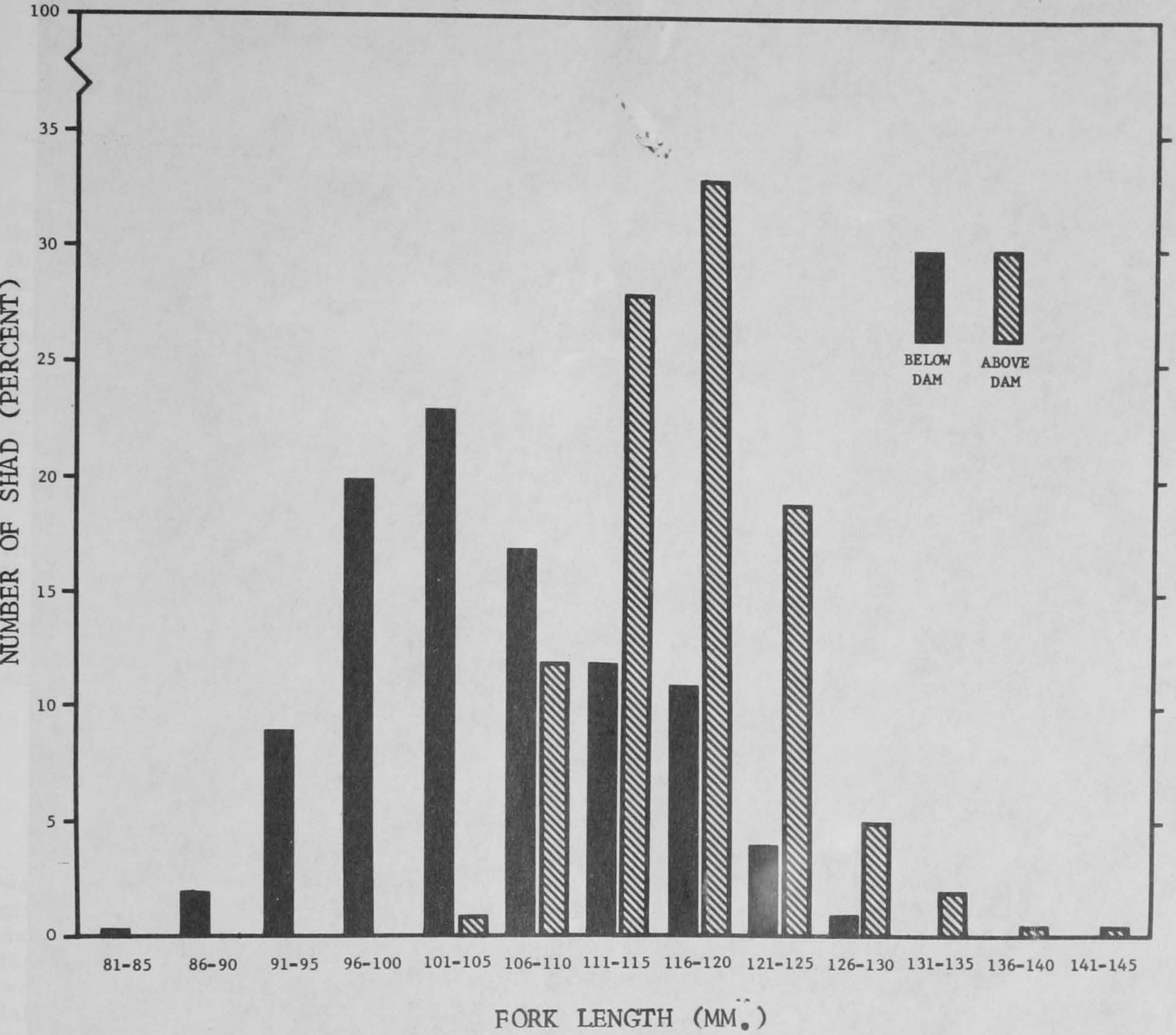

Figure 6.--Length frequency of young shad hatched above and below the Hadley Falls Dam on the Connecticut River, October 1, 1962.

A. aestivalis, and 1 striped bass, Roccus saxatilis, were passed (fig. 7).

Some difficulties encountered were (1) the lock could be operated for passage of fish upstream only when there was light boat traffic, (2) most fish were attracted to the base of the dam approximately 160 feet upstream from the lower lock opening, and (3) there was not enough water to operate the lock for passage of fish upstream during most of the scheduled period. This experiment, however, offered evidence that anadromous species can be passed upstream with navigation lock and that a secondary use can be made of the lock to restore the spawning runs above such barriers. (A report on techniques used for locking fish upstream, and on sampling the lock chamber, is available from the laboratory.)

COMPARATIVE STUDY OF JUVENILE FIN RAY AND SCUTE COUNTS

Paul R. Nichols

Forty-five collections of juvenile shad, from 10 major shad producing rivers along the Atlantic coast, were examined to determine if differences in fin ray and scute counts gave evidence of discrete river populations. In each river except the Susquehanna, Rappahannock, and Edisto, collections were made at two or more locations, and in each river except the Susquehanna during two or more seasons. Counts were made of pectoral fin rays, dorsal fin rays, anal fin rays, and scutes (table 2). The variations in the counts between locations and years within rivers were small compared to those between rivers.

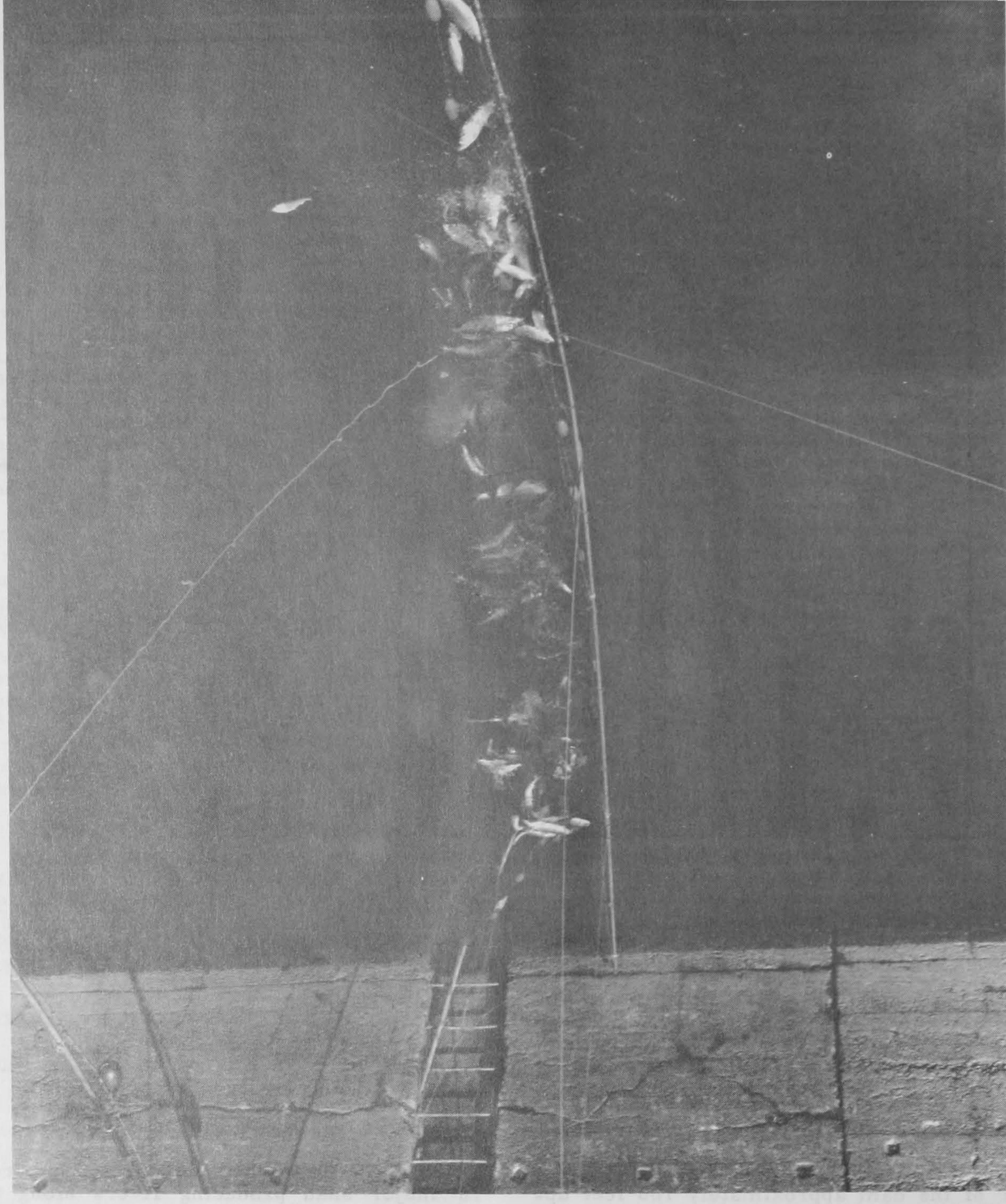

Figure 7.--Sampling the lock chamber at Lock and Dam No. 1 on the Cape Fear River to determine the efficiency of the lock as a fish passing device.

Significant differences were found between neighboring streams and among streams within large geographical areas. Significance at the 1-percent level was considered as biologically different.

Connecticut-Hudson Rivers: The average counts for Hudson River juveniles were higher than those for Connecticut River fish. Except for anal fin ray counts, differences were significant between rivers.

Susquehanna-Rappahannock - York-James Rivers: The average counts between rivers were quite variable. Differences were significant in each count between the York and James Rivers, in pectoral fin ray and scute counts between the York and Rappahannock

Table 2.--Average number of fin rays and scutes of juvenile American shad

River	Pectoral ray	Dorsal ray	Anal ray	Scute
Connecticut...	15.22	18.13	21.23	36.59
Hudson........	15.78	18.44	21.26	37.42
Susquehanna...	16.12	18.34	21.28	37.22
Rappahannock..	15.39	18.54	21.51	36.25
York..........	16.32	18.58	21.27	36.95
James.........	15.69	18.27	20.77	36.29
Neuse.........	15.98	18.72	21.55	36.23
Edisto........	16.29	18.56	20.74	36.44
Ogeechee......	16.22	18.91	21.12	36.50
St. Johns.....	16.19	18.98	21.70	36.68

Rivers, in pectoral fin ray and scute counts between the Rappahannock and Susquehanna Rivers, in pectoral fin ray and dorsal fin ray counts between the York and Susquehanna Rivers, and in scute counts between the James and Susquehanna Rivers.

Neuse-Edisto-Ogeechee-St. Johns Rivers: There were no differences in the counts between locations and years within rivers. Differences were significant in pectoral fin ray and anal fin ray counts between the Neuse and Edisto Rivers, in pectoral fin ray counts between the Neuse and Ogeechee Rivers, in anal fin ray counts between the Edisto and Ogeechee Rivers, in dorsal fin ray and anal fin ray counts between the Edisto and St. Johns Rivers, and in anal fin ray counts between the Ogeechee and St. Johns Rivers.

The significant differences in the fin ray and scute counts contributed evidence that different shad populations exist in the rivers, as was previously noted by other workers who studied homing behavior, life history characteristics, and various anatomical structures in the adults. Whether the cause of differences in the fin ray and scute counts was primarily genetic or resulted from environmental variation under which the young developed, or a combination of both, makes relatively little difference as long as the variation between the collections was consistent from year to year.

ATLANTIC COAST STRIPED BASS PROGRAM

Paul R. Nichols, Chief

Research on striped bass, Roccus saxatilis, was concerned primarily with continuing tagging studies, collecting of catch and effort data, and sampling the commercial catches in the major production areas. The objectives were to develop methods to (1) estimate population sizes, determine exploitation and escapement rates, and predict the age and size composition of the catch prior to harvest, and (2) obtain information on age, growth, and migration. The findings will aid state authorities in their independent or cooperative management plans.

The chief areas of research were in Albemarle Sound and Chesapeake Bay, where the combined annual commercial catch has been approximately 5 million pounds.

ALBEMARLE SOUND COOPERATIVE STUDY

Robert M. Lewis and Randall P. Cheek

Studies on the striped bass population of Albemarle Sound and tributaries consisted of trawling for young-of-the-year fish as an index of abundance, sampling the commercial catches for determination of age and size composition of the catch, and tagging for population estimates.

The work was a joint effort with the Zoology Department of North Carolina State College, Raleigh.

Albemarle Sound - 1962: Population estimates and determinations of age group composition were continued during the commercial season. The estimated fishable population was 1,143,000 pounds, fishing rate 23.6 percent, and catch 270,000 pounds. Age composition of the commercial catch was 96 percent in ages 2 and 3, and only 4 percent in age 4 or older. The estimated population size and catch were the lowest values for any of the previous study years (table 3).

Trawling for young striped bass, sampling of commercial catches, and tagging results made it possible to predict relative year class

Table 3.--Dynamics of Albemarle Sound striped bass populations, 1956-57 through 1961-62 seasons (September through April)

Fishing season	Commercial catch	Fishing rate	Population size
	Thousand pounds	Percent	Thousand pounds
1956-57......	562	26.4	1,544
1957-58......	467	31.4	1,489
1958-59......	1,080	44.7	2,415
1959-60......	352	22.4	1,573
1960-61......	424	21.6	1,967
1961-62......	269	23.6	1,143

strength and population size 1 year in advance of the fishery. Prediction techniques were designed to determine (1) the combined percentage of fish in ages 2 and 3, (2) the percentage of fish in ages 2 and 3 separately, and (3) the pounds of fish in ages 2 and 3 occurring in the fishable population. Predictions were based upon mathematical analyses (multiple regression), of commercial-catch-sampling data and trawl catch-per-unit-effort of young-of-the-year fish from a series of years.

Predicted age composition derived from these analyses showed that the catch should consist of 98.2 percent in ages 2 and 3 combined. The observed percentage of these ages was 93.6 percent.

Regressions designed to yield separate estimates of fish in ages 2 and 3 showed that age-2 fish should comprise 33.8 percent of the catch. The observed percentage was 50.1. The estimated percentage composition of age-3 fish was 69.4, and the observed percentage was 45.9. Age-3 fish were from a dominant year class in 1959; however, this age fish did not appear in the predicted magnitude. This could be due to a change in behavior and in catchability of the fish, or a combination of both. These fish will be available to the fishery at age 4 in 1963.

Regressions designed to yield estimates of the weight of ages 2 and 3 in the catch resulted in a prediction of 2,024,000 pounds in the population, compared to 1,097,000 pounds estimated from tagging and catch-effort data. A smaller poundage would be expected in view of the larger than expected percentage of age-2 fish in the catch. After commercial-catch-sampling data and trawl catch-per-unit-effort of the young-of-the-year fish have been obtained for an additional number of years, hypotheses may be formulated to account for differences in observed and predicted year class strength and population size.

Using regression analyses, the following predictions were made for the 1962-63 fishing season: (1) the percentage in the population of age-2 and -3 fish combined should be 86.6; of age 2, 53.3 percent; and of age 3, 33.3 percent; and (2) the total fishable population should consist of 1,534,600 pounds of striped bass.

Roanoke River - 1961: There is a delay in obtaining final data from the Roanoke River study. Because of this delay, the 1961 annual report concerned the 1960 season and this report concerns the population inventory for 1961.

The Roanoke River in North Carolina produces young striped bass that grow to maturity in Albemarle Sound. In the river in recent years, the sport and commercial fisheries for the adults on their spawning migration have made annual catches of 15,000 to 44,000 striped bass. On the basis of catch-effort data, the estimated size of the 1961 spawning run was 290,151 striped bass--a decrease of 33 percent from 1960 and an increase of approximately 45 percent over that of the 1956-57-58 seasons. The catch was 20,618 striped bass--a decrease of 31 percent from 1960 and an increase of approximately 16 percent over that of the 1956-57-58 seasons. The fishing rate was 7.1 percent--a decrease of approximately 3.0 percent from 1960.

During April and May, 482 striped bass were tagged and released during their spawning run to provide a check on the accuracy of the catch-effort estimate. The population estimate based on tag recaptures was 301,078 striped bass compared to an estimated population of 290,151 striped bass from the catch-effort data.

CHESAPEAKE BAY COOPERATIVE STUDY

Robert M. Lewis and Robert M. Chapoton

Striped bass research in Chesapeake Bay was directed primarily to studies on abundance and exploitation. The work was a joint study with the Chesapeake Biological Laboratory at Solomons, Md.

Potomac River - 1962: Tagging studies were conducted on the striped bass fishery during 3 study years 1959-60-61, and tentative population estimates were made. The study was continued in 1962, and on the basis of catch-effort data the tentative population estimate was 2,398,000 pounds available to the commercial fishery at the beginning of the spring season. The commercial catch was approximately 761,675 pounds, and the fishing rate 30.5 percent. Stake gill nets took 84 percent of the catch, and pound nets and haul seines took the remainder. Fish in ages 2 and 3, and less than 6 pounds, made up most of the catch. During the study years, there has been little change in the size of the fishery.

Upper Chesapeake Bay - 1962: During early January, we tagged and released 1,573 striped bass in upper Chesapeake Bay between Annapolis and Solomons, Md., to observe the movements of these fish, to estimate their utilization, and to estimate the population available to the winter gill net fishery. Preliminary analyses of the tag recovery data by the Petersen method and by the catch-effort statistics gave a population estimate of about 2,107,000 pounds. The minimum and maximum unrefined population estimates by the modified DeLury method were 2,600,000 pounds and 2,925,000 pounds, respectively. The estimated rate of exploitation was 24 percent. The principal harvestable portion of the population was composed of fish in ages 2, 3, and 4.

Figure 8.--Sampling the striped bass winter gill net catch in upper Chesapeake Bay.

Information obtained from the tag returns showed considerable winter movement by striped bass in the upper Bay. This is a significant finding, because this movement was previously unknown.

LIFE HISTORY STUDIES

Robert B. Chapoton and
Rupert R. Bonner, Jr.

Homing behavior: Recapture of adult striped bass tagged and released on the spawning grounds in the Potomac River indicated that fish returned to the same stream to spawn again. Cooperating fishermen captured 326 (29 percent) of the 1,110 striped bass that were tagged. During the spring of tagging, 221 of the recaptures were made within the river. In the spring following tagging, 36 tagged fish were recaptured within the river--15 on the spawning grounds where the fish had been tagged the previous spring and 21 downstream from the tagging site. In the second spring following tagging, three tagged fish were recaptured within the river--one on the spawning grounds and two downstream from the tagging site. Sixty-six of the recaptures were made outside the river during summer and fall. No tagged fish were recaptured on the spawning grounds in any other river during the spawning season.

Tag mortality: Experiments were completed on striped bass held in fresh-water and salt-water ponds to determine tag loss and tagging mortality. Each fish was marked with an Atkins-type tag (fig. 9) attached by sewing a 7-inch nylon loop through the back of the fish below the second dorsal, allowing the tag to trail over the caudal peduncle. To inhibit fungus infections, fish were treated with 1:10,000 malachite green solution for 2-1/2 minutes. A total of 106 fish, 53 tagged and 53 controls, were held in the fresh-water pond. All died within 4 weeks. Severe infestation by the copepod Ergasilus labracis was a contributing factor. Eighty-six fish, 43 fish and 43 controls, were held in the salt-water pond. No mortality occurred until the 8th week, when 22 percent of the tagged fish and 38 percent of the controls died. Total tag loss was 27 percent, all of which occurred during the 7th and 8th weeks. The experiment was terminated at the end of the 8th week.

Growth rate: Preliminary analyses of age and growth rate data for striped bass from Albemarle Sound showed that the growth rates of males and females were similar for the first 3 years of life. After striped bass reached age 4, the increase in length and weight of females was significantly greater than that of males. The most growth in length was made by both male and female fish in the second year of life, when the annual growth increment was approximately 7 inches (fig. 10).

Compensatory growth: The scale growth increments of 2,511 striped bass, representing the 1953-56 year classes in Albemarle Sound, N.C., were studied mathematically (linear regression analyses) to determine if compensatory growth occurred and if the amount of growth differed among the year classes. For each year class, compensatory growth occurred in years 2 and 3 but not thereafter. There was no significant difference in the amount of compensatory growth, as measured by the regression coefficients, among the year classes.

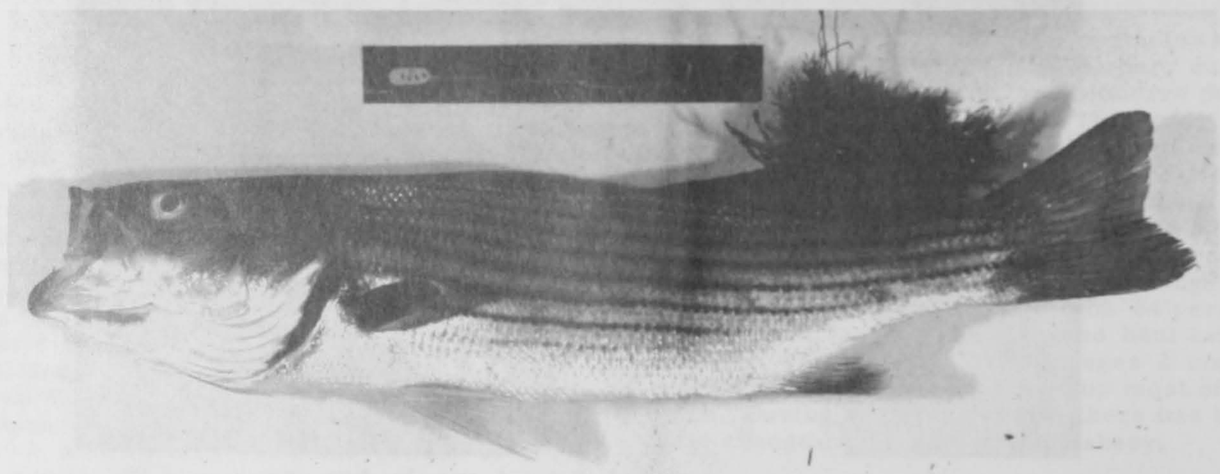

Figure 9.--Atkins-type nylon streamer tag used for marking striped bass (A), and algal growth on tag after the fish had been released for 8 weeks in fresh-water pond.

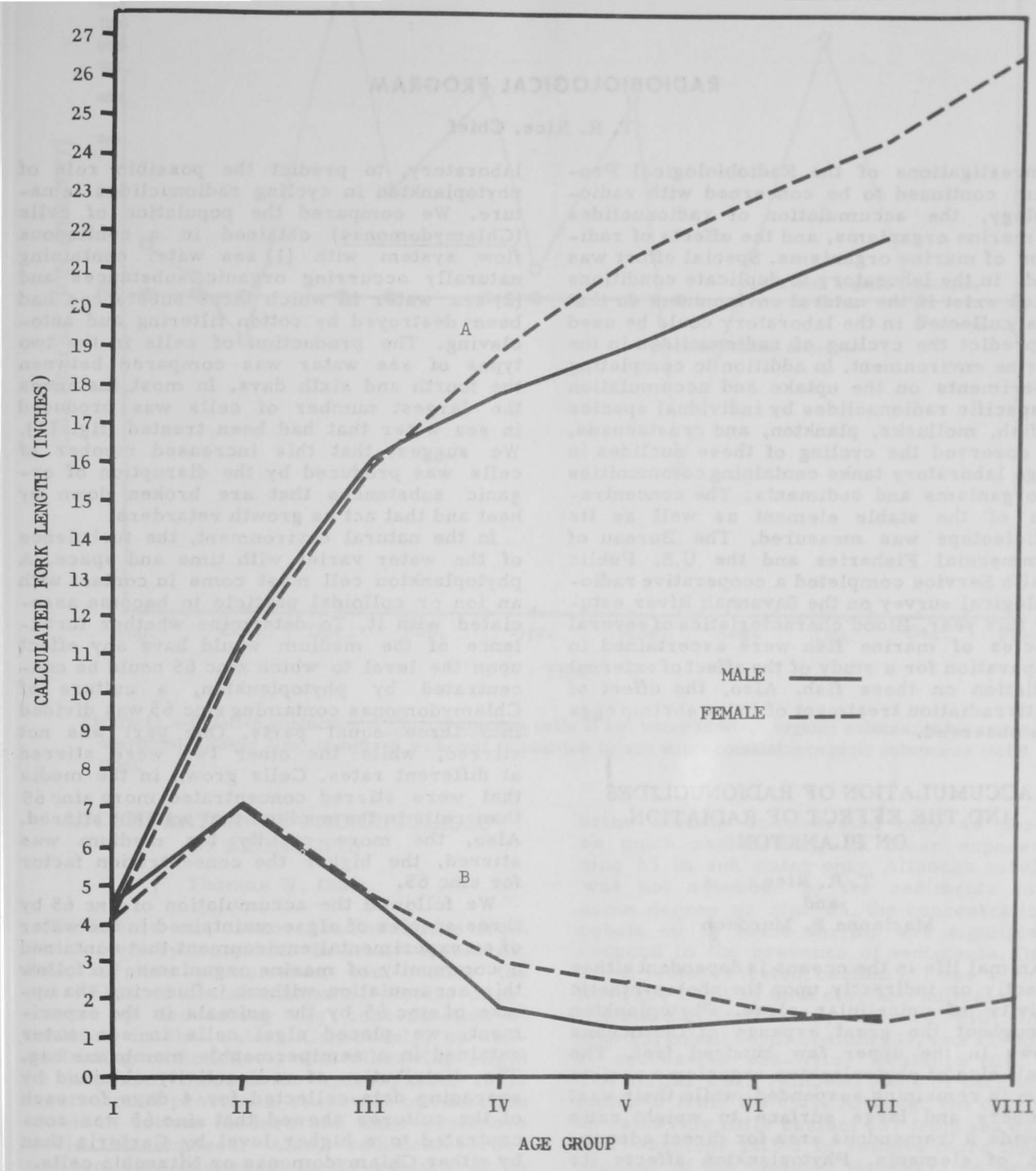

Figure 10.--Growth curve (A) and annual growth increment (B) for striped bass in Albemarle Sound.

RADIOBIOLOGICAL PROGRAM

T. R. Rice, Chief

Investigations of the Radiobiological Program continued to be concerned with radioecology, the accumulation of radionuclides by marine organisms, and the effects of radiation of marine organisms. Special effort was made in the laboratory to duplicate conditions which exist in the natural environment so that data collected in the laboratory could be used to predict the cycling of radionuclides in the marine environment. In addition to completing experiments on the uptake and accumulation of specific radionuclides by individual species of fish, mollusks, plankton, and crustaceans, we observed the cycling of these nuclides in large laboratory tanks containing communities of organisms and sediments. The concentration of the stable element as well as its radioisotope was measured. The Bureau of Commercial Fisheries and the U.S. Public Health Service completed a cooperative radioecological survey on the Savannah River estuary this year. Blood characteristics of several species of marine fish were ascertained in preparation for a study of the effect of external radiation on these fish. Also, the effect of postirradiation treatment of brine shrimp eggs was observed.

ACCUMULATION OF RADIONUCLIDES AND THE EFFECT OF RADIATION ON PLANKTON

T. R. Rice
and
Marianne B. Murdoch

Animal life in the oceans is dependent either directly or indirectly upon the photosynthetic activity of unicellular algae. Phytoplankton throughout the great expanse of the oceans grows in the upper few hundred feet. The small size of phytoplankton organisms assists them in remaining suspended, while their vast numbers and large surface to weight ratio provide a tremendous area for direct adsorption of elements. Phytoplankton affects its environment by removing nutrient elements and their radionuclides, by changing the pH, and by excreting biologically active substances. Not only does it serve as food for filter-feeding organisms while alive and in suspension, but after death it settles to the bottom where it either becomes food for detritus-feeders or decomposes and returns to the environment nutrient elements used in the synthesis of organic substances.

Efforts are being continued, in the laboratory, to duplicate conditions under which phytoplankton grow in the natural environment, and, on the basis of data collected in the laboratory, to predict the possible role of phytoplankton in cycling radionuclides in nature. We compared the population of cells (Chlamydomonas) obtained in a continuous flow system with (1) sea water containing naturally occurring organic substances and (2) sea water in which these substances had been destroyed by cotton filtering and autoclaving. The production of cells in the two types of sea water was compared between the fourth and sixth days. In most instances the largest number of cells was produced in sea water that had been treated (fig. 11). We suggest that this increased number of cells was produced by the disruption of organic substances that are broken down by heat and that act as growth retarders.

In the natural environment, the turbulence of the water varies with time and space. A phytoplankton cell must come in contact with an ion or colloidal particle to become associated with it. To determine whether turbulence of the medium would have any effect upon the level to which zinc 65 could be concentrated by phytoplankton, a culture of Chlamydomonas containing zinc 65 was divided into three equal parts. One part was not stirred, while the other two were stirred at different rates. Cells grown in the media that were stirred concentrated more zinc 65 than cells in the medium that was not stirred. Also, the more rapidly the medium was stirred, the higher the concentration factor for zinc 65.

We followed the accumulation of zinc 65 by three species of algae maintained in the water of an experimental environment that contained a community of marine organisms. To follow this accumulation without influencing the uptake of zinc 65 by the animals in the experiment, we placed algal cells in sea water retained in a semipermeable membrane bag. The distribution of radioactivity obtained by averaging data collected for 4 days for each of the cultures showed that zinc 65 was concentrated to a higher level by Carteria than by either Chlamydomonas or Nitzschia cells.

We followed the concentration of zinc 65 from sea water by the brine shrimp, Artemia salina, a laboratory animal that satisfied many of the requirements of a planktonic link in the food web (fig. 12). The Artemia were maintained in 1,200 l. of sea water in a plastic container. Daily measurements of the radioactive content of these animals showed that zinc 65 was taken up for the first 4 days. After this time, there appeared to be no further uptake of zinc 65. The concentration factor, however, continued to increase due to a decrease of radioactivity in the water.

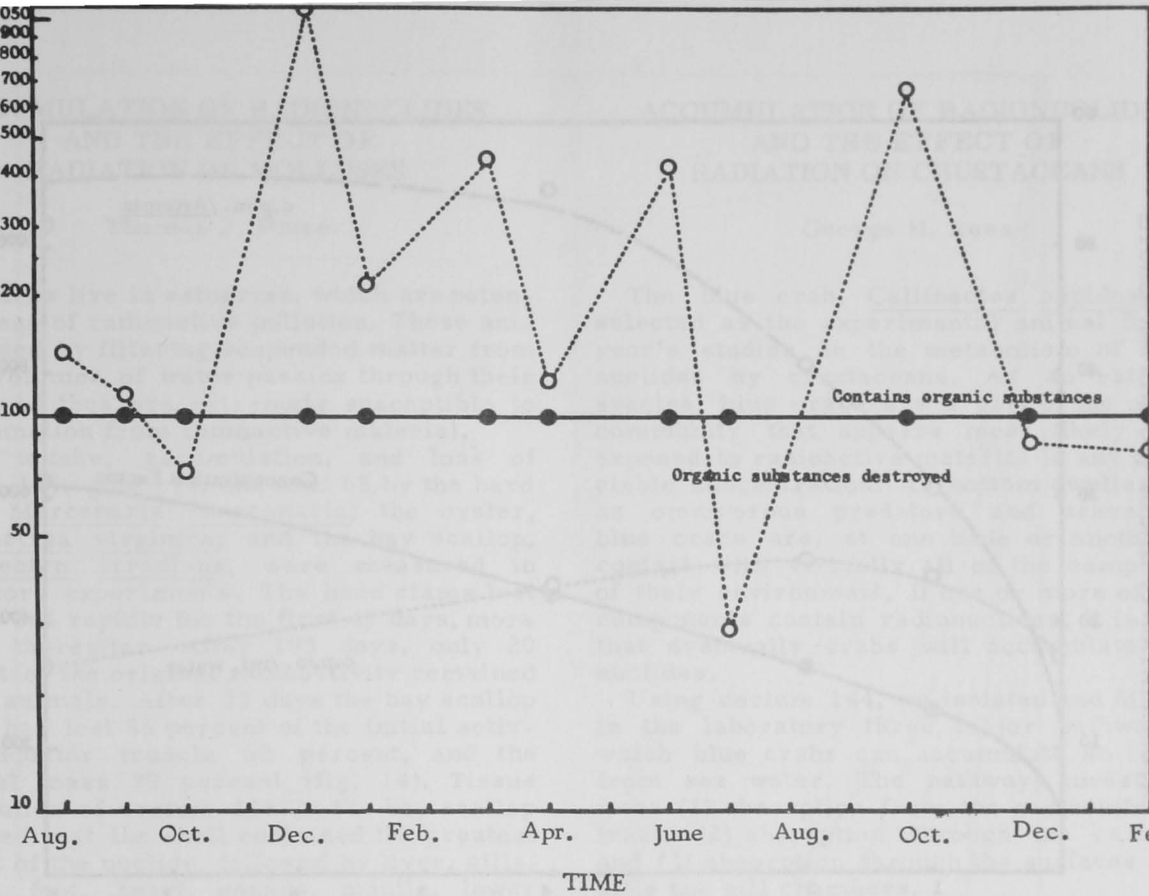

Figure 11.--Relative production of Chlamydomonas cells in sea water in which organic substances have been destroyed (broken line) compared with cell production in sea water containing organic substances (solid line).

ACCUMULATION OF RADIONUCLIDES BY SEDIMENTS

Thomas W. Duke

Sediments can remove radionuclides from sea water by sorption. In many instances, this sorption phenomenon can reduce the possibility of contamination of marine organisms by decreasing the concentration of nuclides in the water. Conversely, by concentrating radioactivity that otherwise might be dispersed through the hydrosphere, sediments could provide a reservoir of radiation to which bottom feeders and their predators would be exposed. Also, sediment-sorbed radioactivity deposited in an estuary or in littoral waters could be subject to continual sea water "washing" through turbulence and tidal action. Animals could become radioactive by exposure to leaching activity even though they did not actively feed on the sediments.

We exposed brine shrimp to either zinc 65, cesium 137, or cobalt 60 in sea water with and without sediments. The radioactive content of each component in the system was compared on a counts per minute per gram (c.p.m./g.) wet weight basis. When exposed to sea water containing zinc 65 and sediment, brine shrimp concentrated only 44 percent as much radioactivity as those exposed to zinc 65 in sea water only. Although cobalt 60 was not adsorbed by the sediments to the same degree as zinc 65, the concentration of cobalt 60 by brine shrimp was significantly reduced in the presence of sediments. Of the three isotopes tested, cesium 137 was accumulated the least by both clay and animals.

Montmorillonite clay, labeled with either zinc 65, cobalt 60, or cesium 137, was submitted to successive sea-water washings (fig. 13). The initial wash removed some of each of the isotopes from the clay. Although the clay took up relatively little cesium 137 from sea water, four washings failed to remove more than 22 percent of the isotope. However, 84 percent of the cobalt 60 was removed after washing.

We observed the accumulation of two radioactive metals, zinc 65 and gold 199, by sediments maintained in large volumes (1,000 l. or more) of sea water. Although the chemical form of the two isotopes in sea water is different (zinc 65 is ionic, gold 199 is colloidal), their rates of sediment-sorption were similar. An apparent steady state between the concentration of each isotope in the water and their concentration in the sediments was reached in approximately 240 hours.

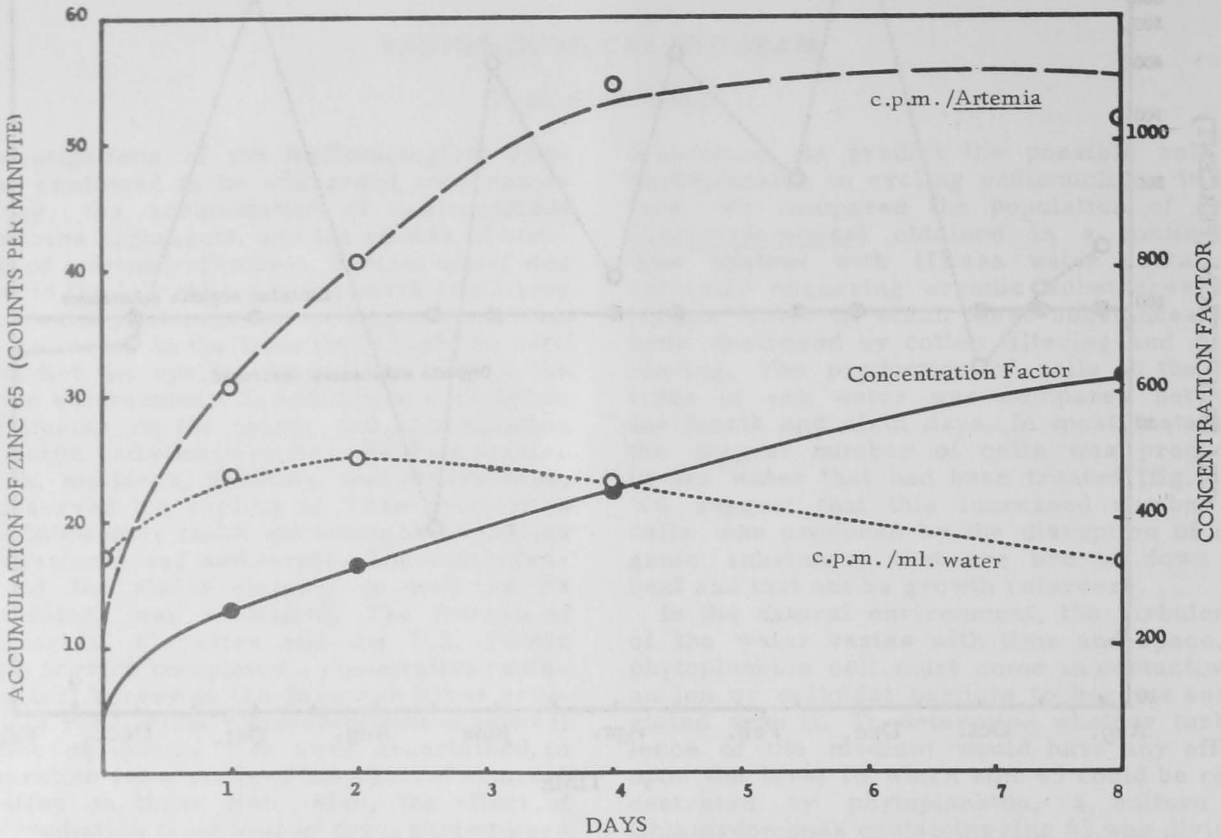

Figure 12.--Accumulation and concentration of zinc 65 by Artemia salina.

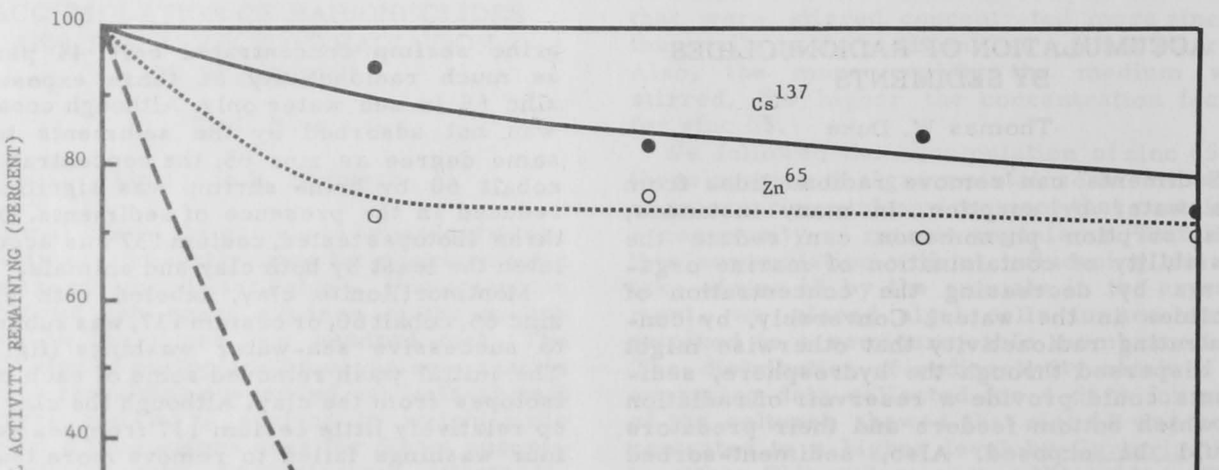

Figure 13.--Effect of sea-water washings on labeled clay.

ACCUMULATION OF RADIONUCLIDES AND THE EFFECT OF RADIATION ON MOLLUSKS

Thomas J. Price

Mollusks live in estuaries, which are potential areas of radioactive pollution. These animals feed by filtering suspended matter from large volumes of water passing through their gills, and thus are extremely susceptible to contamination from radioactive material.

The uptake, accumulation, and loss of cerium 144, gold 199, and zinc 65 by the hard clam, Mercenaria mercenaria; the oyster, Crassostrea virginica; and the bay scallop, Aequipecten irradians, were measured in laboratory experiments. The hard clams lost cerium 144 rapidly for the first 45 days, more slowly thereafter. After 195 days, only 20 percent of the original radioactivity remained in the animals. After 35 days the bay scallop shells had lost 55 percent of the initial activity, adductor muscle 62 percent, and the visceral mass 89 percent (fig. 14). Tissue distribution of cerium 144 in the bay scallop indicated that the shell contained the greatest amount of the nuclide, followed by liver, gills, kidney, foot, heart, gonads, mantle, lower intestinal tract, and adductor muscle.

The uptake of gold 199 by both the clams and their separated shells was rapid during the first 8 days and then diminished for the remaining 15 days of the experiment (fig. 15). At the completion of the experiment, the clams contained 3.6 times the amount of activity found on the shells. Clams placed in montmorillonite clay contained 38 percent less of the gold 199 after 23 days than those animals placed directly into the radioactive sea water.

A comparison was made of the accumulation of zinc 65 directly from the water by clams and oysters. Clams accumulated zinc 65 at a slower rate than oysters per unit weight (fig. 16). At 21 days, the concentration factor for radioactive zinc in the clams was 40.3 while that in the oyster was 336.6. At that time, there was no indication that the maximum uptake of zinc 65 had been reached in either organism.

Data collected in these experiments will aid in interpreting the metabolic role of radionuclides as well as their nonactive isotope. Also, if they become polluted by radioactivity, we need to know how long mollusks require to eliminate the nuclides. Such information is necessary to determine when they will again be safe to use as food.

ACCUMULATION OF RADIONUCLIDES AND THE EFFECT OF RADIATION ON CRUSTACEANS

George H. Rees

The blue crab, Callinectes sapidus, was selected as the experimental animal for this year's studies on the metabolism of radionuclides by crustaceans. As an estuarine species, blue crabs are a part of the marine community that appears most likely to be exposed to radioactive material in any appreciable concentration. As bottom dwellers and as omnivorous predators and scavengers, blue crabs are, at one time or another, in contact with virtually all of the components of their environment. If one or more of these components contain radionuclides, it is likely that eventually crabs will accumulate these nuclides.

Using cerium 144, we isolated and followed in the laboratory three major pathways by which blue crabs can accumulate an isotope from sea water. The pathways investigated were (1) absorption from the gastrointestinal tract, (2) absorption through the carapace, and (3) absorption through the surfaces of the gills and gill chambers.

To observe the movement of cerium 144 from the digestive tract, we injected the isotope directly into the cardiac stomach of the crab. The gills were the only tissue in which radioactivity was detected 24 hours after the injection (with the exception of the various parts of the alimentary canal). So that the passage of cerium 144 through the carapace could be observed, a plastic petri dish containing the isotope in sea water was inverted and fastened with beeswax to the dorsal surface of an adult blue crab. After 5 days in running sea water, the animals were dissected and the various tissues measured for radioactivity. Small amounts of cerium 144 were detected in all tissue samples, while the most active tissues were the gut and digestive gland.

The importance of the gill chambers as a site for the uptake of cerium 144 was investigated by pipetting sea water into each of the crab's two gill chambers. After periods of 3 and 4 days, the animals were sacrificed and the tissues measured for contained radioactivity. A total of 10 percent of the amount of cerium 144 originally introduced into the chambers was distributed to other parts of the body. Of the three pathways investigated, movement from the gill chambers into the tissues was the most rapid.

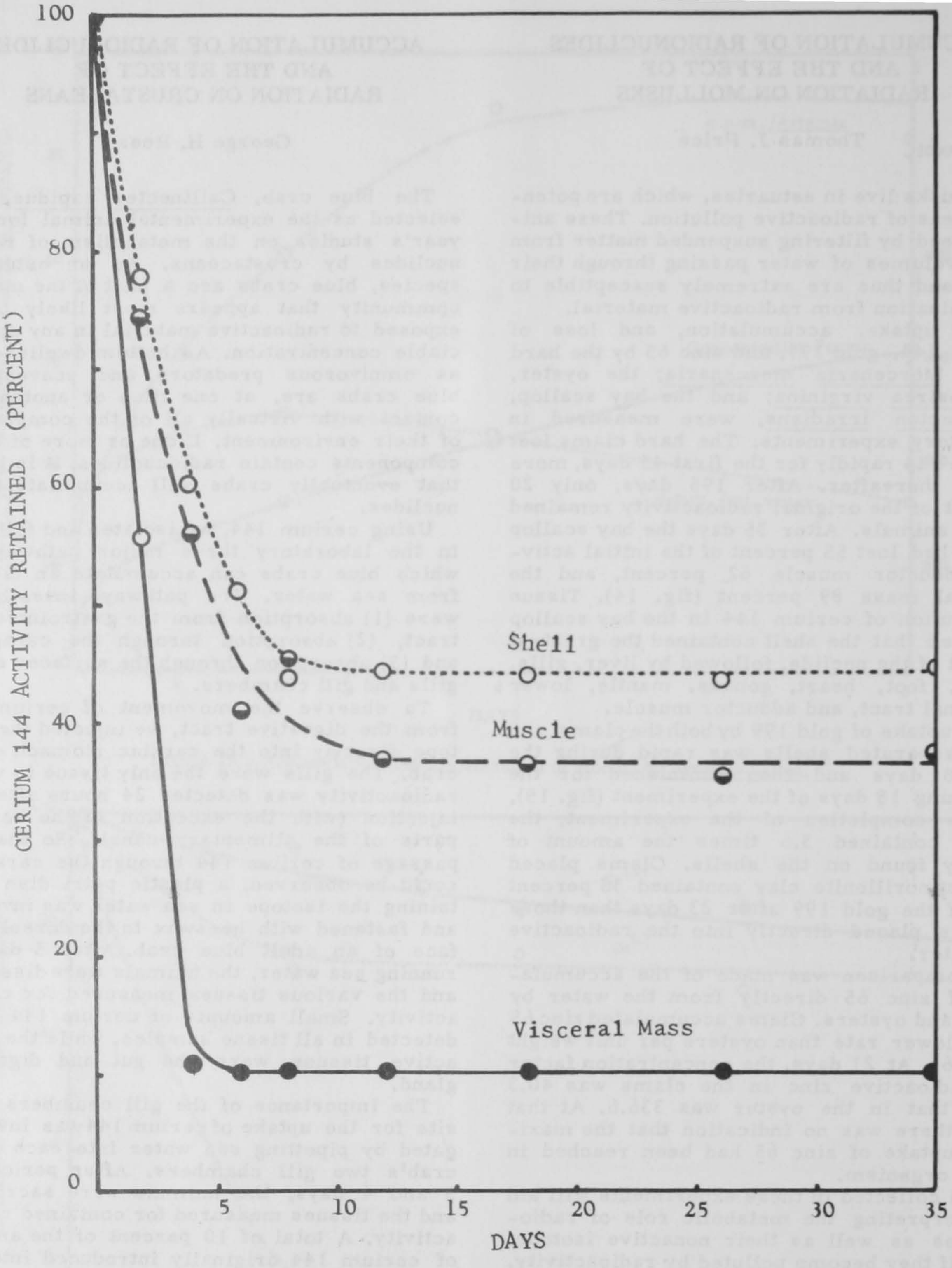

Figure 14.--Loss of cerium 144 by components of the bay scallop.

The retention of cerium 144 injected directly into the infrabranchial blood sinus was followed for a period of 6 weeks. We measured the percentage of activity remaining in the animals each day of this period. As indicated in figure 17, the loss was rapid for the first 2 days and then slower and fairly constant until the 30th day, when it began to show signs of leveling off. At the end of 6 weeks, 50 percent of the original radioactivity remained.

We observed the uptake of gold 199 from sea water by crabs as well as the distribution of this isotope after injection into the cardiac

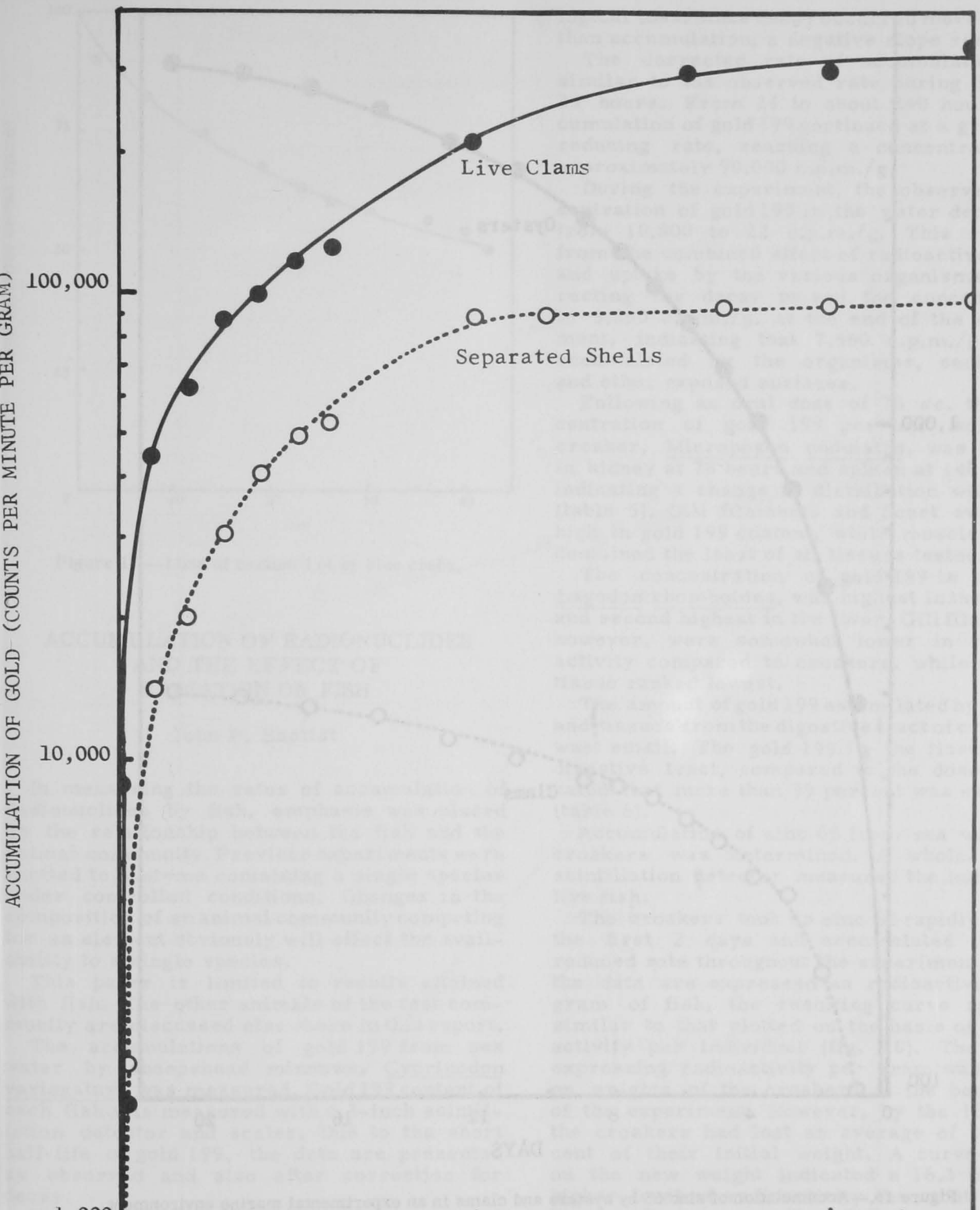

Figure 15.--Accumulation of gold 199 by clams and separated shells.

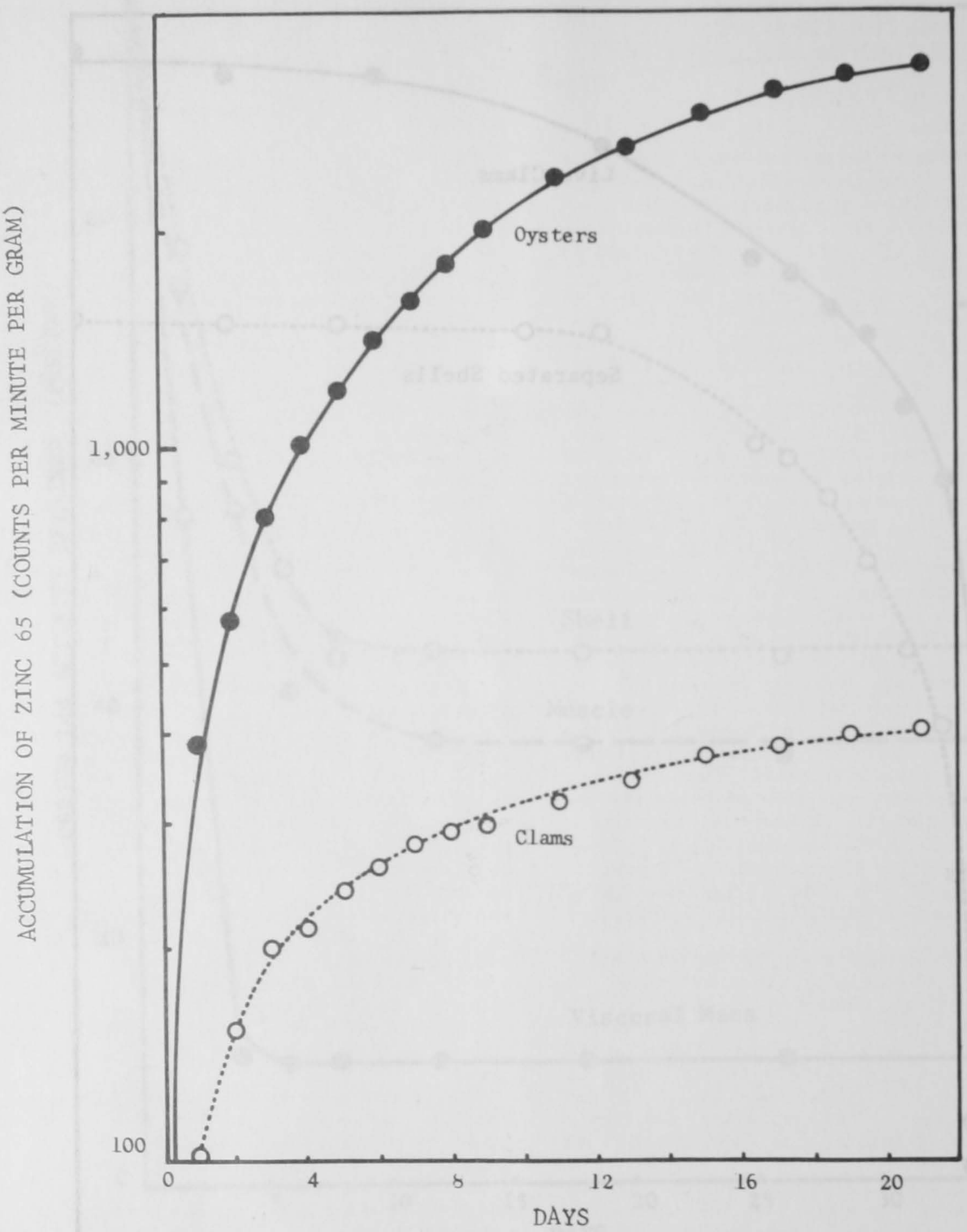

Figure 16.--Accumulation of zinc 65 by oysters and clams in an experimental marine environment.

stomach. The uptake of gold 199 from sea water was rapid, reaching a maximum level 48 hours after the introduction of the isotope (fig. 18). Crabs accumulated so much gold 199 that significant quantities remained in the organisms after radioactive decay had reduced the activity of the water to levels below the sensitivity of the detection instruments. All of the tissue samples taken from crabs injected with gold 199 4 days previous contained measurable amounts of radioactivity. The total activity contained in the crabs was slightly more than 17 percent of the administered dose. As indicated in table 4, only a small part of the gold 199 ingested was assimilated.

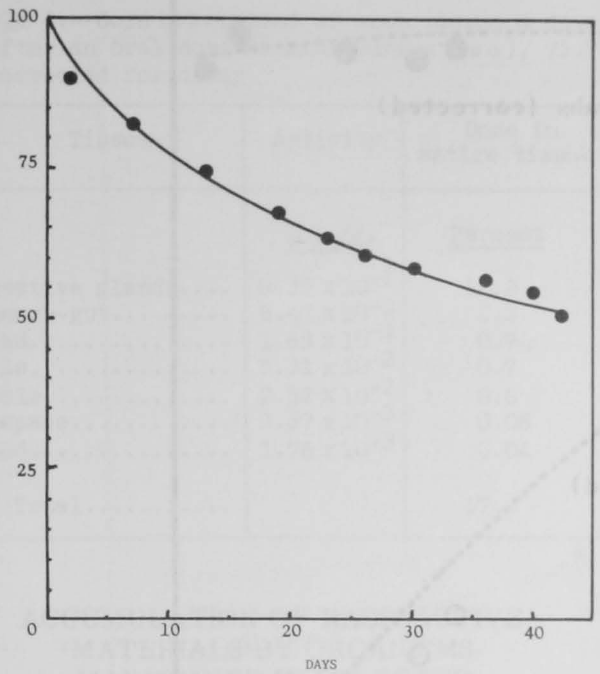

Figure 17.--Loss of cerium 144 by blue crabs.

ACCUMULATION OF RADIONUCLIDES AND THE EFFECT OF RADIATION ON FISH

John P. Baptist

In measuring the rates of accumulation of radionuclides by fish, emphasis was placed on the relationship between the fish and the animal community. Previous experiments were limited to systems containing a single species under controlled conditions. Changes in the composition of an animal community competing for an element obviously will effect the availability to a single species.

This paper is limited to results attained with fish. The other animals of the test community are discussed elsewhere in this report.

The accumulations of gold 199 from sea water by sheepshead minnows, Cyprinodon variegatus, was measured. Gold 199 content of each fish was measured with a 3-inch scintillation detector and scaler. Due to the short half-life of gold 199, the data are presented as observed and also after correction for decay.

The rate of accumulation was most rapid during the first 24 hours (fig. 19). Maximum concentration occurred from 60 to 120 hours at approximately 18,000 counts per minutes per gram (c.p.m./g.) and decreased steadily during the remainder of the experiment. The apparent loss of gold 199 during the latter part of the experiment was the effect of radioactive decay rather than an actual biological loss. Since decay occurred more rapidly than accumulation, a negative slope resulted.

The corrected rate of accumulation was similar to the observed rate during the first 24 hours. From 24 to about 240 hours, accumulation of gold 199 continued at a gradually reducing rate, reaching a concentration of approximately 90,000 c.p.m./g.

During the experiment, the observed concentration of gold 199 in the water decreased from 10,800 to 22 c.p.m./g. This resulted from the combined effect of radioactive decay and uptake by the various organisms. Correcting for decay raised the concentration to 3,250 c.p.m./g. at the end of the experiment, indicating that 7,550 c.p.m./g. were accumulated by the organisms, sediments, and other exposed surfaces.

Following an oral dose of 75 µc. the concentration of gold 199 per unit weight in croaker, Micropogon undulatus, was highest in kidney at 78 hours and spleen at 148 hours, indicating a change in distribution with time (table 5). Gill filaments and heart were also high in gold 199 content, while muscle tissue contained the least of all tissues tested.

The concentration of gold 199 in pinfish, Lagodon rhomboides, was highest in the kidney and second highest in the liver. Gill filaments, however, were somewhat lower in relative activity compared to croakers, while muscle tissue ranked lowest.

The amount of gold 199 assimilated by organs and tissues from the digestive tract of croakers was small. The gold 199 in the tissues and digestive tract, compared to the dose, indicated that more than 99 percent was excreted (table 6).

Accumulation of zinc 65 from sea water by croakers was determined. A whole-animal scintillation detector measured the individual live fish.

The croakers took up zinc 65 rapidly during the first 2 days and accumulated it at a reduced rate throughout the experiment. When the data are expressed as radioactivity per gram of fish, the resulting curve appears similar to that plotted on the basis of radioactivity per individual (fig. 20). The curve expressing radioactivity per gram was based on weights of the croakers at the beginning of the experiment. However, by the 16th day the croakers had lost an average of 16 percent of their initial weight. A curve based on the new weight indicated a 16.3 percent higher level of radioactivity than that shown by the first curve. This difference between the two curves represents the effect of a growth-uptake ratio. There is a reduction in body weight which produces a higher value of radioactivity per unit weight (broken line) than the value resulting from no growth (solid line). If the fish had experienced a substantial increase in weight, the radioactivity per unit weight would have been lower.

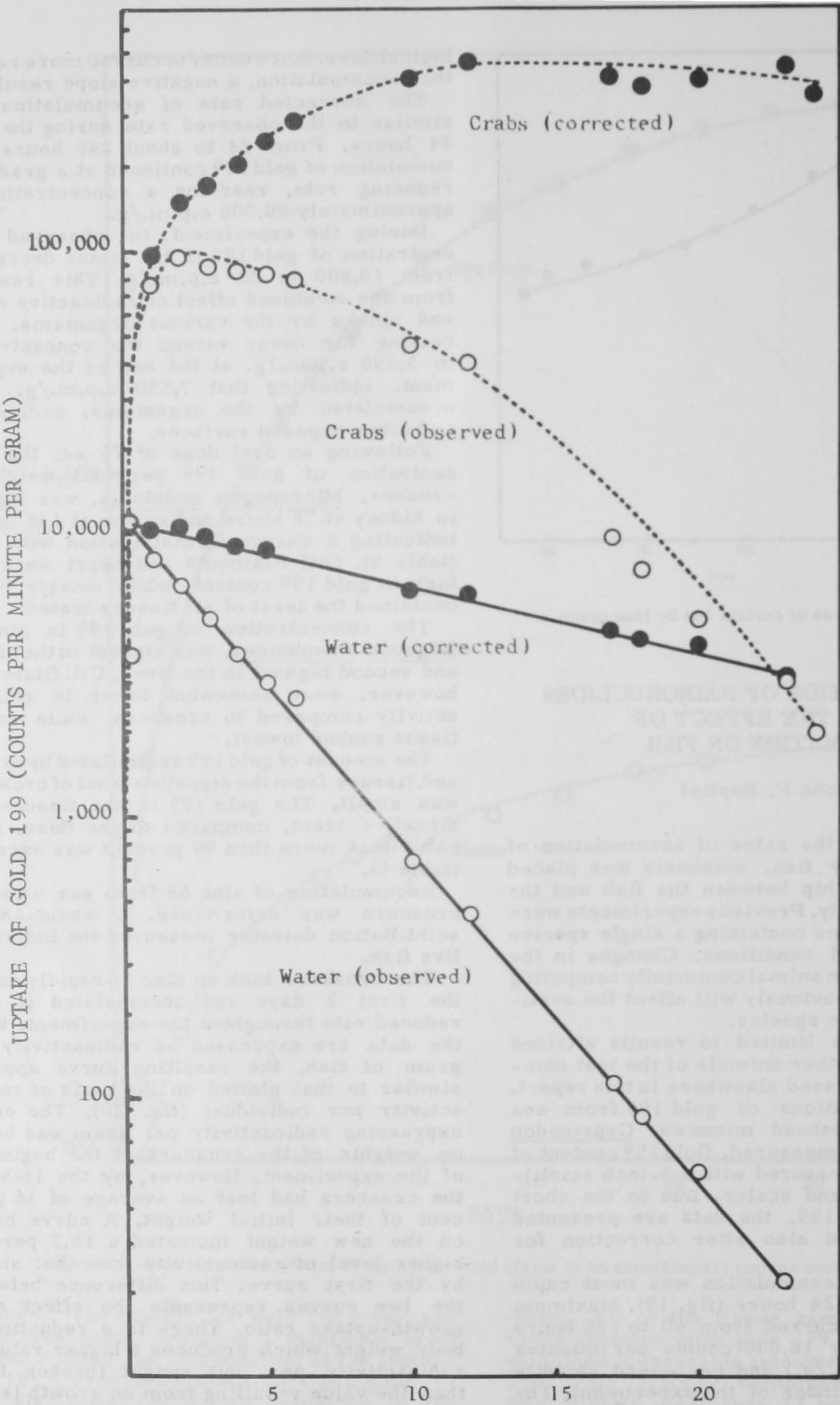

Figure 18.--Uptake of gold 199 from sea water by blue crabs.

Table 4.--Gold 199 content of crab tissue 4 days after an oral dose of microcuries (μc), 75.7 corrected for decay

Tissue	Activity	Dose in entire tissue
	$\mu c./g.$	Percent
Digestive gland.....	9.35×10^{-1}	12.2
Stomach-gut.........	8.47×10^{-1}	2.5
Gonad...............	1.63×10^{-1}	0.9
Gills...............	5.31×10^{-2}	0.7
Muscle..............	2.52×10^{-2}	0.6
Carapace............	3.87×10^{-3}	0.08
Blood...............	1.76×10^{-3}	0.04
Total..........		17.3

ACCUMULATION OF RADIOACTIVE MATERIALS BY ORGANISMS MAINTAINED IN SELECTED MARINE ENVIRONMENTS

Staff

The movement of radionuclides from sea water to components of marine communities was observed in laboratory tanks containing relatively large volumes (1,000 l.) of sea water. Rates of accumulation of radioactive elements, as well as levels of radioactivity reached by marine organisms maintained in these tanks, were more consistent with those found in the natural environment than rates and levels obtained using individual species in relatively small volumes of water. Results of experiments conducted in this manner not only revealed the effect of a contaminant on an entire community, but also permitted evaluation of individuals in relation to the ecosystem.

Recent interest by the Corps of Engineers in applying radioactive gold to follow silt movement, and the evident lack of information on the bioaccumulation of this element in a marine environment, prompted a tank experiment with gold 199. To follow the cycling of gold 199 in a marine community, we established an experimental environment and placed as components of this community, clams, crabs, fish, and sediments in a fiberglass tank containing 1,000 l. of cotton-filtered sea water with gold 199. Individual organisms were sampled periodically, and their radioactivity was measured with a scintillation detector. The animals were place alive in the detector, their radioactivities measured, and then they were returned to the tank. This procedure eliminated the need for killing the animals, thus the number of individuals was not reduced each time a sample was taken.

An apparent steady state was reached in 225 hours, between the gold 199 in the water and in the components (fig. 21). This steady state could have been a result of the gold saturating the available surfaces, or of the decreased availability of the gold due to sediment and animal accumulation (these data were corrected for physical decay). Surface adsorption was probably the primary mode of accumulation, because of the colloidal nature of gold in sea water and the lack of a definite physiological need for this element by marine organisms. If the radioactivity of the water is considered as one, the relative concentrations of the isotope by the organisms were as follows:

Crabs	4.5
Sediment	3.8
Clams	2.6
Fish	1.0

The cycling of zinc 65 in an experimental environment was also observed. Since the rate at which the zinc 65 is accumulated by organisms and sediments depends in part upon the amount of the radioisotope present in relation to the amount of stable zinc present, the stable zinc content of water, sediments, and animal life, as well as their zinc 65 content, was measured. Oysters, clams, crabs, fish, and sediments were placed in 1,200 l. of sea water containing zinc 65, and, with the water, were measured periodically for zinc 65 content. At the end of the experiment, animals and sediment were analyzed for stable zinc content. Chemical analysis of the sea water showed a steady increase in the stable zinc content of the water from the time the animals were added until the end of the experiment. Oysters accumulated more zinc 65 and contained more stable zinc than did the other organisms (fig. 22). Fish, in spite of a relatively high stable zinc content, showed a slow rate of accumulation of zinc 65 in comparison to the other organisms.

RADIOECOLOGICAL SURVEY OF THE SAVANNAH AND WILMINGTON RIVER ESTUARIES

John P. Baptist

The Bureau of Commercial Fisheries and the U.S. Public Health Service made a joint radioecological survey of the Savannah and Wilmington Rivers Estuary from November 1960 through December 1961. The primary objectives of the survey were to develop methods of evaluating the extent of radioactive contamination in an estuary and to establish a basis for predicting effects of chronic low level radioactivity on an estuarine environment. A secondary objective was to make

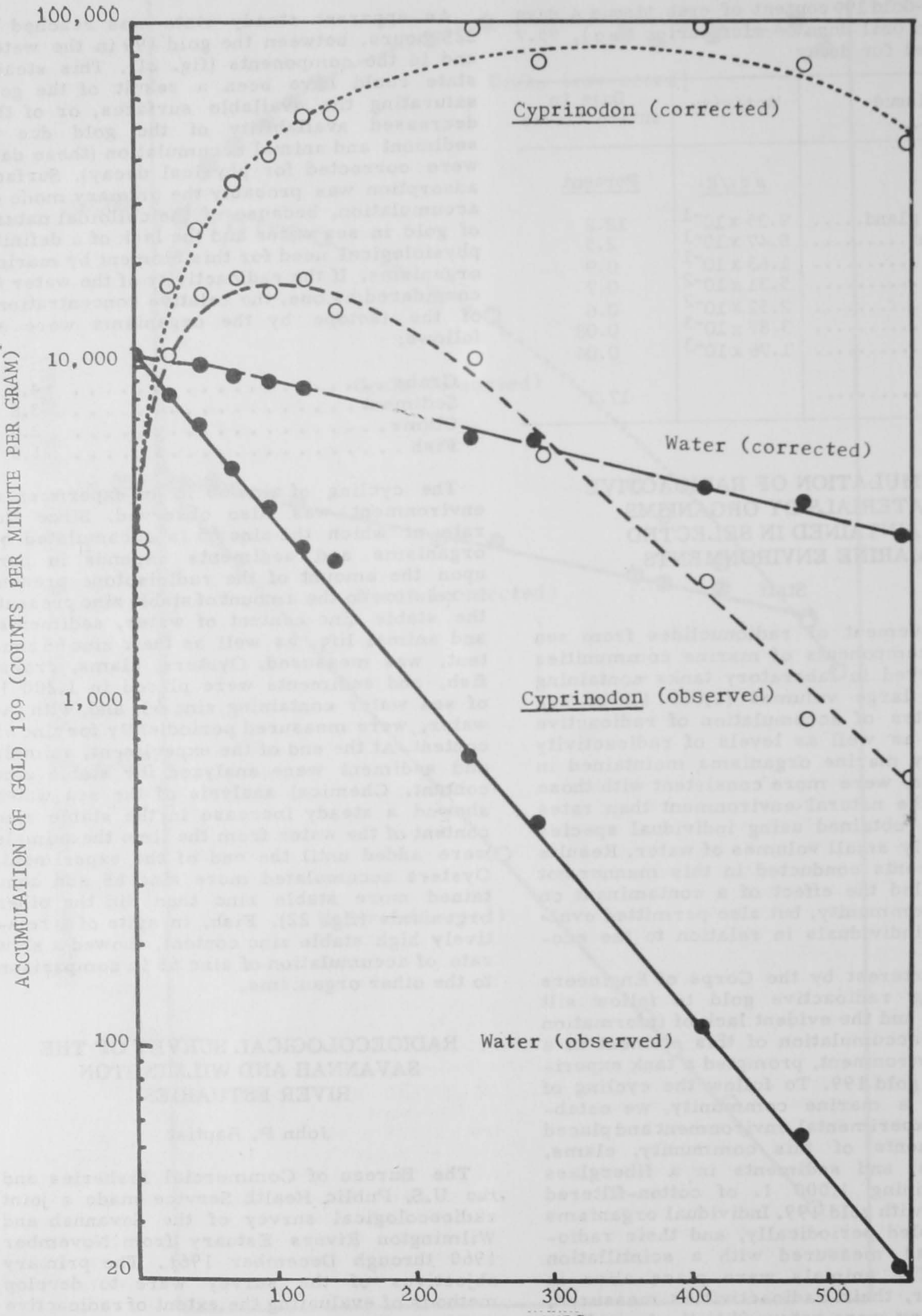

Figure 19.--Accumulation of gold 199 by Cyprinodon variegatus from sea water. Upper curve has been corrected for radioactive decay.

Table 5.--Tissue distribution of gold 199 in croakers and pinfish

Tissues listed in order of highest gold 199 content

Croakers				Pinfish	
78 hrs.		148 hrs.		124 hrs.	
	c.p.m./g.		c.p.m./g.		c.p.m./g.
Kidney	68,840	Spleen	424,067	Kidney	364,961
Gill filaments	9,439	Gill filaments	141,474	Liver	186,967
Heart	7,960	Kidney	19,864	Heart	59,052
Spleen	3,466	Liver	7,460	Gill Filaments	46,219
Liver	1,755	Heart	3,192	Spleen	31,868
Skin-scales	1,102	Skin-scales	961	Skin-scales	13,327
Muscle	205	Gonad	951	Gonad	3,662
		Muscle	219	Muscle	1,694

Table 6.--Distribution of gold 199 in croakers related to dose

Tissue	Total body weight	Dose: 78 hr. croaker	Dose: 148 hr. croaker
	Percent	Percent	Percent
Kidney..................	0.30	0.0388	0.0112
Gills..................	2.00	.0354	.5689
Skin, scales, other....	[1] 5.20	.0176	[2] .0094
Liver..................	2.00	.0069	.0239
Muscle.................	80.00	.0031	.0329
Heart..................	0.16	.0025	.0008
Spleen.................	0.16	.0010	.0424
Gonad..................	0.59	--	.0010
Bone...................	11.00	--	--
Percent assimilated...........................		.1053	.6902
Percent in digestive tract....................		.4248	.1277
Percent excreted (calculated).................		99.4699	99.1821

[1] Weight also includes digestive tract, brain, eyes, blood, etc.
[2] Gold 199 contents based on skin and scales only.

ecological observations of the organisms present. Since the Public Health Service was responsible for the radiological portion of the survey, the present report concerns the monthly collections of fishes in the estuary.

Five stations, representing different ecological habitats, were selected in the lower Savannah and Wilmington Rivers. Station 1 was located at the mouth of the Savannah River, where the salinity ranged from 21 to 32 ‰ and the bottom consisted almost entirely of sand. Station 2 was 3.5 miles upstream from Station 1, and, except for lower salinity (10.0-28.4 ‰), had similar characteristics. Station 3 was 11 miles upstream from Station 1 and had a salinity range of 0 to 13 ‰ ; the bottom consisted mainly of fine silt covered with debris. Station 4 was located in Wassaw Sound near the mouth of the Wilmington River, and had characteristics similar to Station 1. Station 5, located 7 miles upstream from Station 4 in the Wilmington River, had a salinity range of 15 to 32 ‰ and a muddy bottom.

Monthly fish collections were made at each station with an 18-foot otter trawl of 3/4-inch bar mesh. A U.S. Coast Guard 42-foot utility boat was used in making the net tows. Most of the fish were preserved in 70 percent alcohol and sent to the Public Health Service

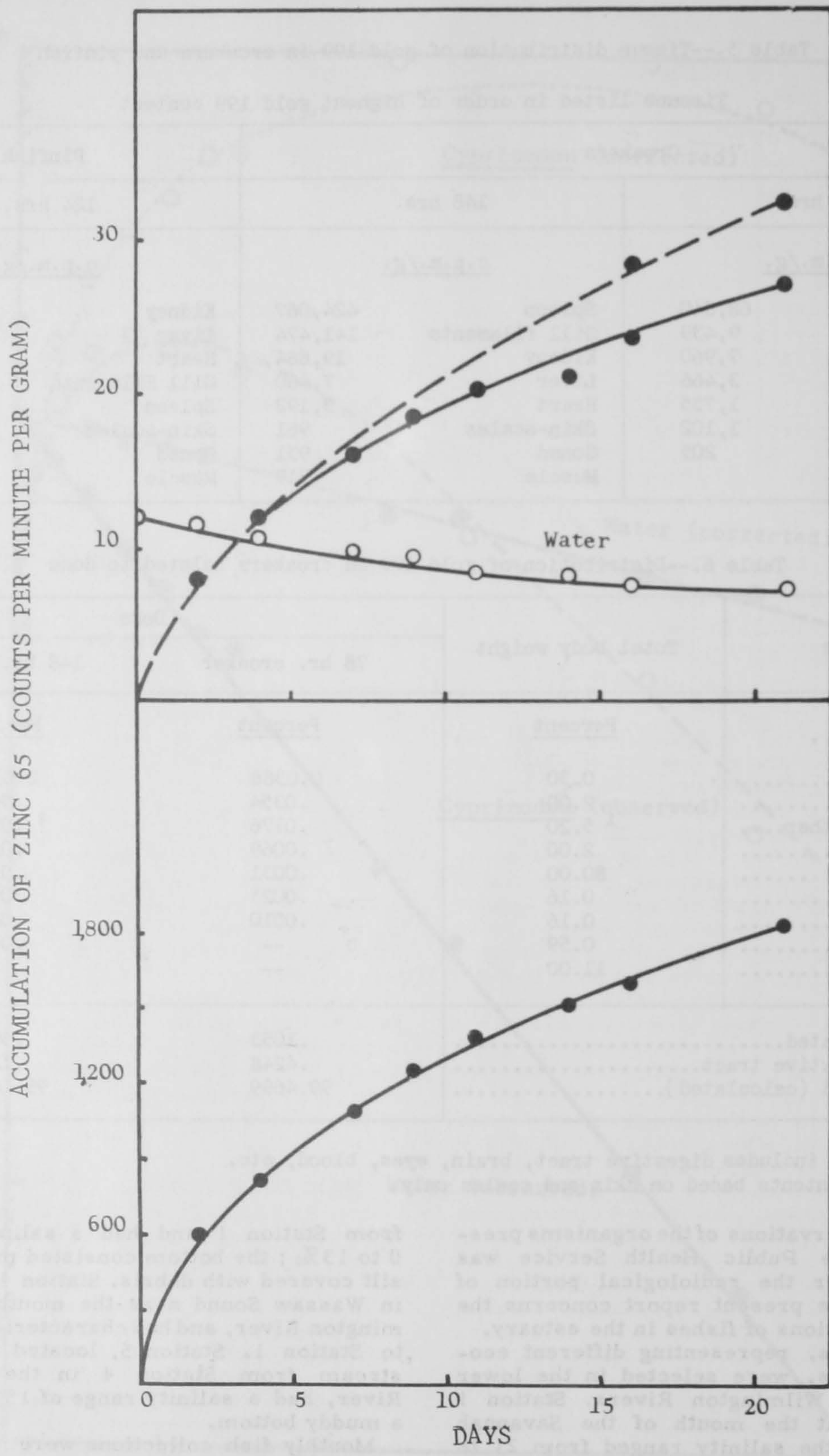

Figure 20.--Accumulation of zinc 65 by croakers. Broken curve in upper graph is based on actual weight of fish. Solid curve is based on initial weight.

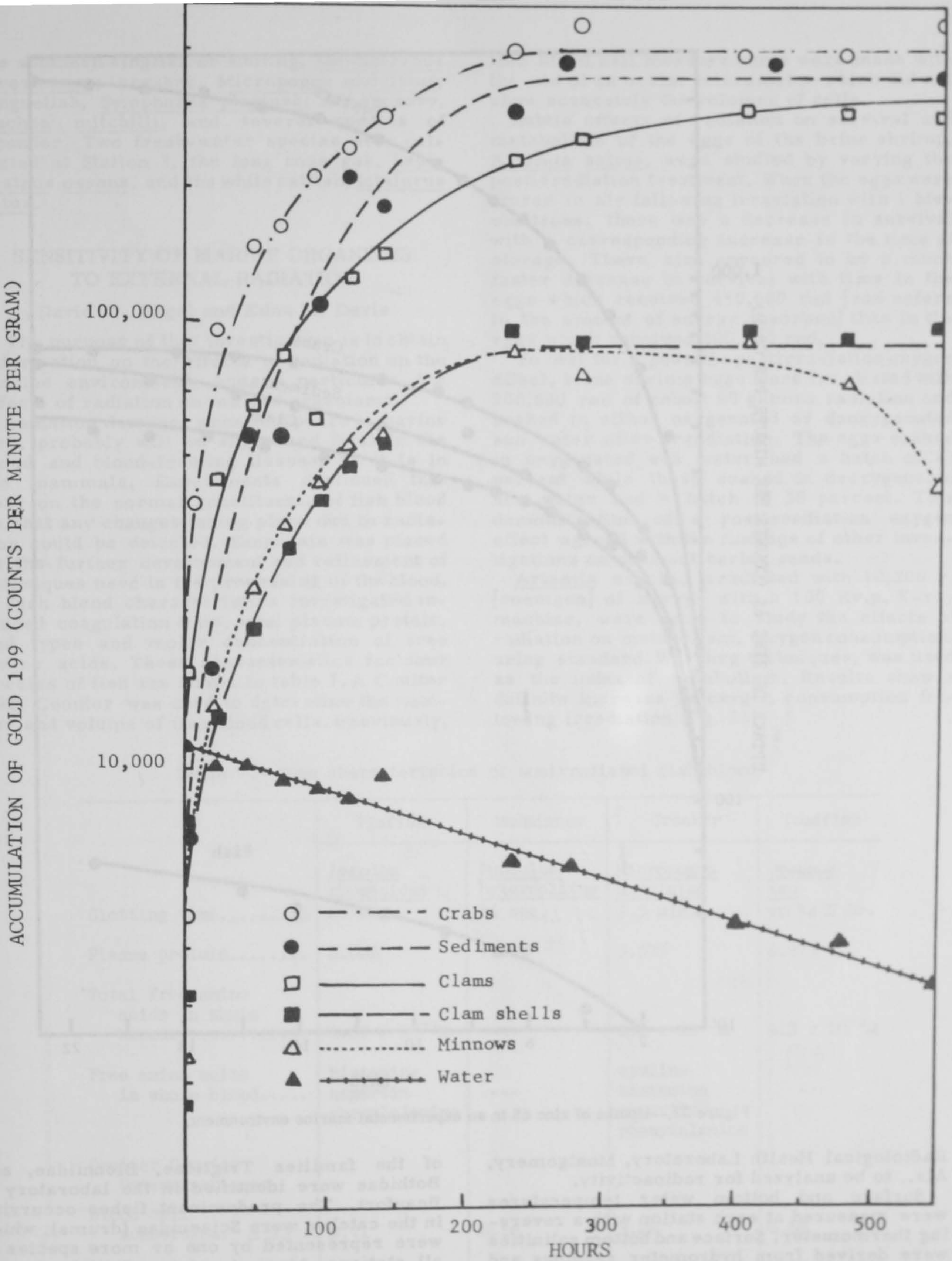

Figure 21.--Accumulation of gold 199 by sediments and animal life in an experimental marine environment.

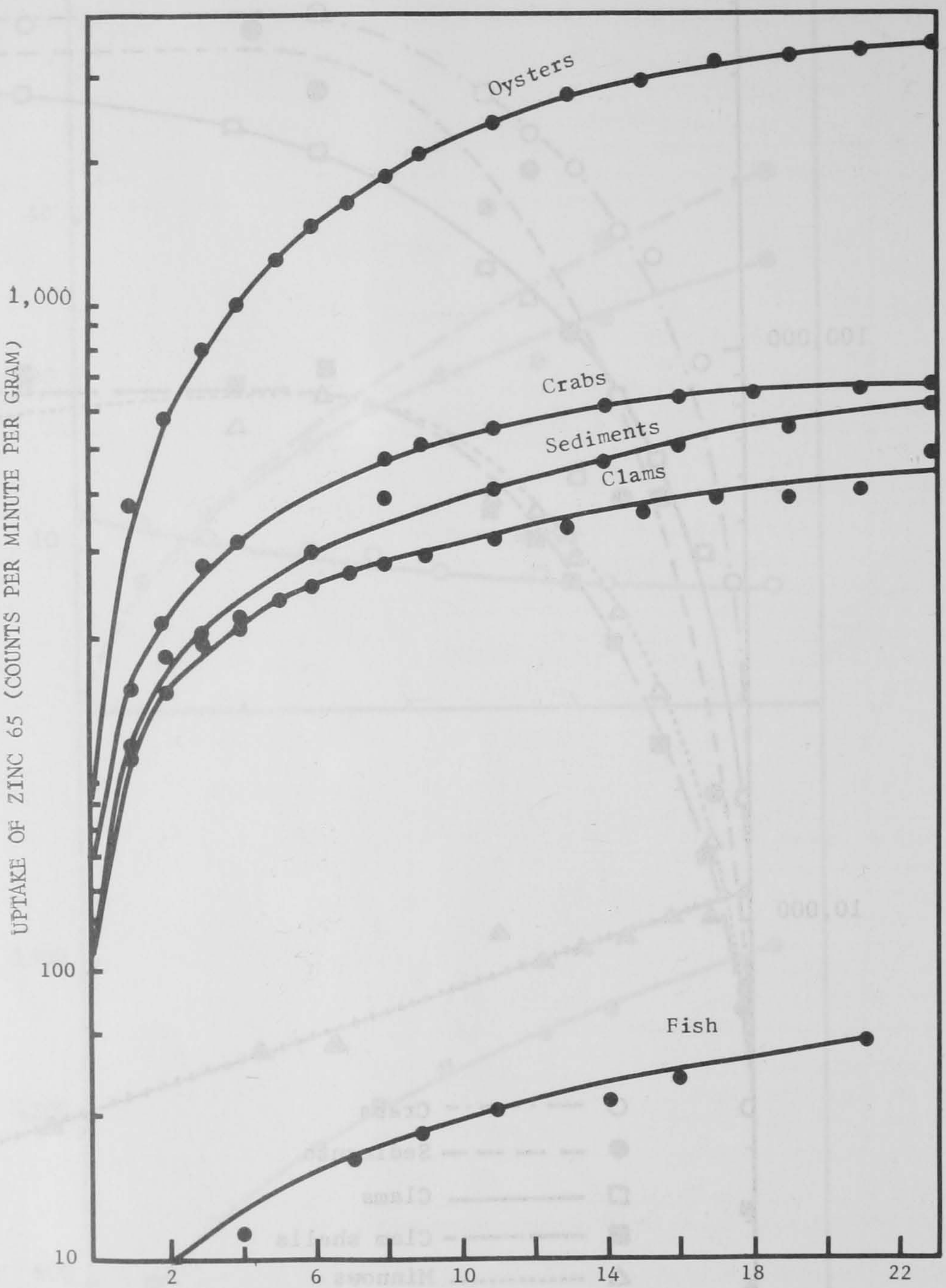

Figure 22.--Uptake of zinc 65 in an experimental marine environment.

Radiological Health Laboratory, Montgomery, Ala., to be analyzed for radioactivity.

Surface and bottom water temperatures were measured at each station with a reversing thermometer. Surface and bottom salinities were derived from hydrometer readings and Knudsen's (1901) hydrographic tables.

Collections comprised 14,390 fish, representing 33 families and 53 species. Species of the families Triglidae, Blenniidae, and Bothidae were identified in the laboratory at Beaufort. The predominant fishes occurring in the catches were Sciaenidae (drums), which were represented by one or more species at all stations. More star drum, Stellifer lanceolatus, were caught in a single drag than any of the other species. Among other species occurring frequently during the year were the southern kingfish or whiting, Menticirrhus americanus; croaker, Micropogon undulatus; tonguefish, Symphurus plagiusa; bay anchovy, Anchoa mitchilli; and several species of flounder. Two fresh-water species were collected at Station 3, the long nose gar, Lepisosteus osseus, and the white catfish, Ictalurus catus.

SENSITIVITY OF MARINE ORGANISMS TO EXTERNAL RADIATION

David W. Engel and Edna M. Davis

The purpose of this investigation is to obtain information on the effects of radiation on the marine environment, and, in particular, the effects of radiation on marine organisms.

Radiation damage, when it appears in marine fish, probably will be expressed first in the blood and blood-forming tissues, as it is in the mammals. Experiments continued this year on the normal constituents of fish blood so that any changes taking place due to radiation could be detected. Emphasis was placed on the further development and refinement of techniques used in the processing of the blood.

Fish blood characteristics investigated included coagulation time, total plasma protein, and types and molar concentration of free amino acids. These characteristics for four species of fish are shown in table 7. A Coulter Cell Counter was used to determine the number and volume of fish blood cells. Previously, fish blood cell measurements were made with the aid of an ocular micrometer which did not show accurately the volumes of cells.

Subtle effects of radiation on survival and metabolism of the eggs of the brine shrimp, Artemia salina, were studied by varying the postirradiation treatment. When the eggs were stored in air following irradiation with 1 Mev electrons, there was a decrease in survival with a corresponding increase in the time of storage. There also appeared to be a much faster decrease in survival with time in the eggs which received 450,000 rad [rad refers to the amount of energy absorbed] than in the eggs which received 300,000 rad.

To test for a possible postirradiation oxygen effect, brine shrimp eggs were irradiated with 300,000 rad of cobalt 60 gamma radiation and soaked in either oxygenated or deoxygenated sea water after irradiation. The eggs soaked in oxygenated sea water had a hatch of 23 percent while those soaked in deoxygenated sea water had a hatch of 38 percent. This demonstration of a postirradiation oxygen effect agreed with the findings of other investigations on dormant barley seeds.

Artemia nauplii, irradiated with 10,200 r. [roentgen] of X-rays with a 100 Kv.p. X-ray machine, were used to study the effects of radiation on metabolism. Oxygen consumption, using standard Warburg techniques, was used as the index of metabolism. Results show a definite increase in oxygen consumption following irradiation (fig. 23).

Table 7.--Some characteristics of nonirradiated fish blood

	Pinfish	Mudminnow	Croaker	Toadfish
	Lagodon rhomboides	Fundulus heteroclitus	Micropogon undulatus	Opsanus tau
Clotting time.........	43 sec.	34 sec.	2.5 min.	up to 2 hr.
Plasma protein........	8.08%	7.08%	5.57%	6.27%
Total free amino acids in whole blood.............	1.85×10^{-3}M	---	1.6×10^{-3}M	4.3×10^{-4}M
Free amino acids in whole blood.....	histamine aspartic phenylalanine	---	cystine histamine aspartic phenylalanine	---
Coulter Counter Determinations:				
Blood cell numbers/mm.^{3} x 10^6..	3.71	3.16	3.28	0.68
Volume of cells in major peak (cubic microns).....	260	130	204	670

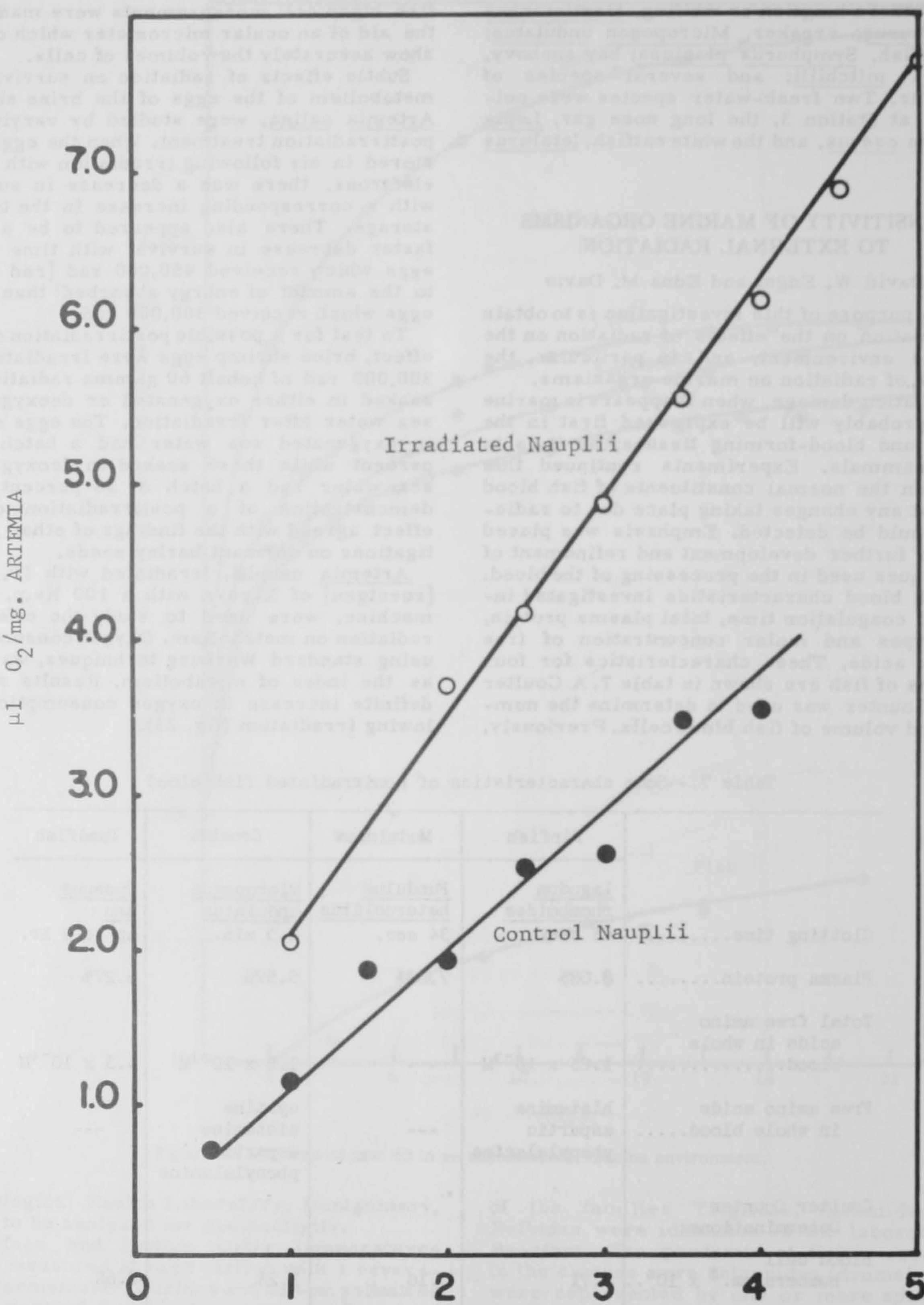

Figure 23.--Oxygen consumption of Artemia nauplii following a dose of 10,200 r. of X-rays.

LIBRARY

Elizabeth F. Talbot

Efforts were continued during the year to fill the gaps in some of the older serial publications.

Sixty-two books and 222 bound volumes of continuations were added during the year, making a total library collection of 4,211 volumes. No tabulation of unbound material was made. The policy was continued of binding, analyzing, and cataloging reprints as soon as enough were accumulated to make a volume--usually 20-40, depending on size.

Twenty-one volumes were borrowed and 44 loaned on interlibrary loan. Numerous requests were received for copies of various staff publications.

Current issues of 60 periodicals and serials and numerous miscellaneous pamphlets of special interest were displayed on two special racks. New books also were displayed on a special rack for a limited time. These new books and periodicals may be borrowed overnight; properly bound and catalogued material may be taken for longer periods.

SEMINARS

"Research techniques in pollution control." T. W. Duke, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Variation in vertebral numbers in juvenile Atlantic menhaden." J. W. Reintjes, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Tuna tagging program." M. R. Bartlett, Woods Hole Oceanographic Institution.

"Underwater photography in the Florida Keys." R. W. Whitney, University of North Carolina Institute of Fisheries Research.

"Report on the seminar on public health aspects of radioactive contamination in normal and emergency situations." T. R. Rice, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Blue crab movements in coastal South Carolina." D. L. Dudley, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Crab larvae, genus Callinectes from M/V Theodore N. Gill cruises, South Atlantic Coast of the United States, 1953-54." P. R. Nichols, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Distribution of fishing effort on Atlantic menhaden by purse seine vessels." W. R. Nicholson, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Radioactive dating." L. K. Akers, Oak Ridge Institute of Nuclear Studies.

"The development of marine laboratories." A. F. Chestnut, University of North Carolina Institute of Fisheries Research.

"Insects of the herbaceous strata of salt marsh communities in the Beaufort area." L. Davis, Vanderbilt University.

During the summer, the Bureau's Biological Laboratory and the University of North Carolina Institute of Fisheries Research cooperated with the Duke University Marine Laboratory in seminar programs. The following lectures were presented at the Duke University Marine Laboratory during the summer of 1961:

"Fungi associated with marine animals." T. W. Johnson, Jr., Duke University.

"Some current problems in the physiological ecology: a glorified area." F. John Vernberg, Duke University.

"Modern sediments of the Newport River-Beaufort Inlet area." R. L. Ingram, University of North Carolina.

"Larval development of Palaemonetes." A. C. Broad, Ohio State University.

"Accumulation of radioactive pollutants by marine organisms." T. R. Rice, Bureau of Commercial Fisheries Biological Laboratory, Beaufort.

"Clay minerals of the marine sediments of the Atlantic coastal plain." D. Herron, Duke University.

"Environmental control of phytoplankton production in succession in the Sargasso Sea." J. H. Ryther, Woods Hole Oceanographic Institution.

"Some local oceanographic problems." G. Posner, University of North Carolina Institute of Fisheries Research.

"Rates of development in embryos of a cyprinodont fish exposed to different temperature-salinity-oxygen combinations." O. Kinne, Department of Zoology, University of Toronto.

"Reproduction of a bay scallop, Pecten irradians." A. N. Sastry, Duke University Marine Laboratory.

"Tobacco." F. Wolfe, Duke University. The Arthur Sperry Pearse Memorial Lecture.

MEETINGS ATTENDED

[Attendance shown in parentheses.]

American Institute of Biological Sciences, Lafayette, Ind., August (1)
American Fisheries Society, Memphis, Tenn., September (2)
First National Symposium on Radioecology, Fort Collins, Colo., September (4)
Atlantic Estuarine Research Society, Old Point Comfort, Va., October (12)
Gulf and Caribbean Fisheries Institute, Miami Beach, Fla., November (1)
Virginia Fishermen's Association, Old Point Comfort, Va., January (1)
Atlantic Estuarine Research Society, Morehead City, N.C., April (29)

PUBLICATIONS

Grant, George C.
1962. Predation of bluefish on young Atlantic menhaden in Indian River, Delaware. Chesapeake Science, vol. 3, no. 1, p. 45-47.

Judy, Mayo H.
1961. Validity of age determination from scales of marked American shad. U.S. Fish and Wildlife Service, Fishery Bulletin 185, vol. 61, p. 161-170.

June, Fred C.
1961. The menhaden fishery of the United States. U.S. Fish and Wildlife Service, Fishery Leaflet 521, 13 p.

Lewis, Robert M.
1961. Comparison of three tags on striped bass in the Chesapeake Bay area. In James E. Sykes, Coordinator, Contributions to the study of Chesapeake Bay striped bass. Chesapeake Science, vol. 2, no. 1-2, p. 3-8.

Pacheco, Anthony L., and George C. Grant.
1961. A frame used as a towing aid for small boats. U.S. Fish and Wildlife Service, Progressive Fish-Culturist, vol. 23, no. 4, p. 161.

Reintjes, John W.
1961. Menhaden eggs and larvae from M/V Theodore N. Gill cruises, South Atlantic coast of the United States, 1953-54. U.S. Fish and Wildlife Service, Special Scientific Report--Fisheries No. 393, 7 p.

Rees, George H.
1962. Effects of gamma radiation on two decapod crustaceans, Palaemonetes pugio and Uca pugnax. Chesapeake Science, vol. 3, no. 1, p. 29-34.

Sykes, James E.
1961. The Chesapeake Bay cooperative striped bass program. In James E. Sykes, Coordinator, Contributions to the study of Chesapeake Bay striped bass. Chesapeake Science, vol. 2, no. 1-2, p. 1-2.

1962. Tagging tells fish secrets. The Science Teacher, vol. 29, no. 4, 2 p.

Tagatz, Marlin E.
1961. Reduced oxygen tolerance and toxicity of petroleum products to juvenile American shad. Chesapeake Science, vol. 2, no. 1-2, p. 65-71.

1961. Tolerance of striped bass and American shad to changes of temperature and salinity. U.S. Fish and Wildlife Service, Special Scientific Report--Fisheries No. 388, 8 p.

Tagatz, Marlin E., and Donnie L. Dudley.
1961. Seasonal occurrence of marine fishes in four shore habitats near Beaufort, N.C., 1957-60. U.S. Fish and Wildlife Service, Special Scientific Report--Fisheries No. 390, 19 p.

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