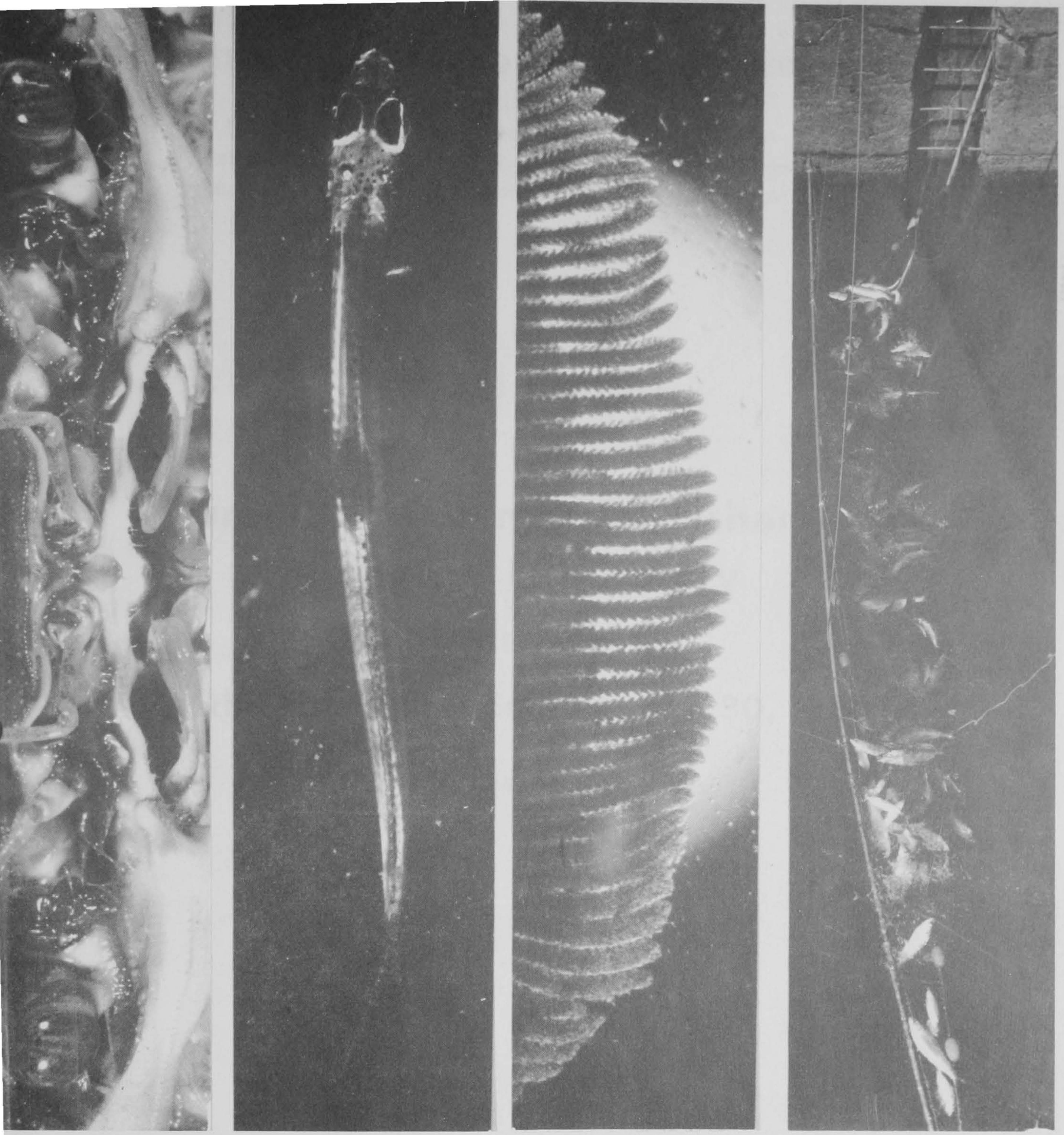

ANNUAL REPORT for Fiscal Year 1963

U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

BIOLOGICAL LABORATORY
Beaufort, North Carolina

Circular 198

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UNITED STATES DEPARTMENT OF THE INTERIOR
Stewart L. Udall, *Secretary*
Frank P. Briggs, *Assistant Secretary for Fish and Wildlife*
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Annual Report of the Bureau of Commercial Fisheries Biological Laboratory Beaufort, N. C.

For the Fiscal Year Ending June 30, 1963

F. C. June, Acting Director

Circular 198

Washington, D.C.
November 1964

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

For the Fiscal Year Ending June 30, 1963

REPORT OF THE DIRECTOR

F. C. June, Acting Director

Research highlights: Under the blue crab studies, the search for blue crab larvae was intensified in 1963, with our efforts concentrated in the ocean off Beaufort, N.C., and southward to Brunswick, Ga. The numbers and diversity of developmental stages were greater in collections made farthest offshore. A newly designed sampler was successfully employed for collecting early-stage crabs on or near the bottom where they normally escape standard plankton and trawl gears. A study of the food habits of the blue crab showed that they fed on a variety of organisms, and usually on those which were most available. The biological field station located at Green Cove Springs, Fla., continued to provide a base for blue crab studies in the St. Johns River.

Menhaden research yielded a great deal of valuable information on many different phases of the program. Measures of the current condition of the Atlantic menhaden population indicated a decline in abundance, due principally to the poor survival of the 1959-61 year classes. The 1962 year class of juveniles in estuarine nurseries was found to be above average in abundance, but it is doubtful that this year class will sustain the fishery in 1963; hence, a reduction in yield is expected. A study of the variation in the number of vertebrae of adult Atlantic menhaden showed that fall and spring spawners constitute two distinct groups of fish which appear to be self-sustaining. Our preliminary tests employing a small metal tag for marking young menhaden were successful. These results now make feasible larger scale field experiments to study the migrations and mortality rates of the fish.

There were two notable achievements during the year from our research work on the American shad. One was the successful transplanting, in the Susquehanna River, Pa., of fertilized eggs from Columbia River parent fish (which originally came from fertilized eggs transplanted from Susquehanna River parent fish). Survival of young, through the juvenile stage, indicated that water impoundments above existing dams in the Susquehanna River once again may support stocks of shad. The other, a consequence of our sampling upstream spawning runs and downstream migrations of anadromous fishes in the Cape Fear River, N.C., was the demonstration that navigation locks can be utilized successfully for passage of fish over proposed and existing barriers. These findings will have important implications in the planning of water use developments elsewhere.

Estimates of the size and age composition of the striped bass populations in North Carolina and in upper Chesapeake Bay in most instances demonstrated fairly close agreement between the predicted and observed yield and catch composition.

We continued the cooperative program with the Woods Hole Oceanographic Institution and the U.S. Coast Guard for the monthly release of seabed drifters over the Continental Shelf, between Capes Hatteras and Fear, N.C. Surface drift bottle releases and surface water temperature observations were added to the monthly station schedule. Recoveries of seabed drifters and bottles furnished information on the direction and velocity of currents. This knowledge not only is important to our biological studies, but aids the U.S. Coast Guard in its air-sea rescue operations in the area of the coast, known as "the graveyard of ships."

Some major changes occurred at the laboratory during the year. The Radiobiological Program was separated from the Biological Laboratory and is now known as the Radiobiological Laboratory. Also, G. B. Talbot, formerly director of the BCF laboratory in Beaufort, transferred to the Bureau of Sport Fisheries and Wildlife and is now director of the Tiburon Marine Laboratory, Tiburon, Calif.

Atlantic States Marine Fisheries Commission: A status report on Atlantic menhaden research was given at the 21st annual meeting held in Atlanta, Ga., in September. Research reports on blue crab, striped bass, shad, and menhaden also were prepared for inclusion in the minutes of the meeting.

Training programs: F. T. Carlson participated in a course on radioisotope techniques presented by the staff of the Mobile Laboratory of the Oak Ridge Institute of Nuclear Studies. K. J. Fischler attended the Southern Regional Graduate Summer Session in Statistics at the University of North Carolina at Raleigh, N.C.

Work conferences:

(Attendance shown in parentheses.)

Industrial Products Division, National Fisheries Institute, Morehead City, N.C. (1)

Middle Atlantic and Chesapeake Bay Sections of The Atlantic States Marine Fisheries Commission, Solomons, Md. (2)

South Atlantic Section of the Atlantic States Marine Fisheries Commission, Sapelo Island, Ga. (2)

Third Seminar on Biological Problems in Water Pollution, Cincinnati, Ohio (1)

STAFF

Frederick C. June, Acting Director
(vice Gerald B. Talbot, transferred 9-21-62)

Blue Crab Program:

George H. Rees	Chief (vice P. R. Nichols, 9-16-62)	Beaufort, N.C.
Donnie L. Dudley	Fishery Biologist	"
Grady P. Frymire	"	Green Cove Springs, Fla.
Mayo H. Judy	"	Beaufort, N.C.
Peggy M. Keney	"	"
Marlin E. Tagatz	"	Green Cove Springs, Fla.
Lonnie A. Daniels	Summer Aid	"
Gary C. Williams	"	"

Shad and Striped Bass Program:

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Robert B. Chapoton	Fishery Biologist	"
Randall P. Cheek	"	"
Robert M. Lewis	"	"
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Menhaden Program:

John W. Reintjes	Acting Chief (vice F. C. June)	Beaufort, N.C.
Frank T. Carlson	Fishery Biologist	"
Joseph R. Higham, Jr.	"	"
William R. Nicholson	"	"
Anthony L. Pacheco	"	"
Kenneth W. Daniels	Fishery Aid	"
James F. Guthrie	"	"
George N. Johnson	"	"
Mary K. Hancock	Clerk	"
Fronnie A. Jones	Airplane Pilot (WAE)	"
Lyle E. Brumfield	Summer Aid	Reedville, Va.
Carlos Carrion-Torres	"	Port Monmouth, N.J.
Robert K. Cissel	"	Amagansett, N.Y.
Jack V. Guthrie	"	Port Monmouth, N.J.
Gene C. Mason	"	Lewes, Del.
Martin A. Roessler	"	"
Wesley L. Rouse	"	Reedville, Va.
Lawrence P. Tractenberg	"	Lewes, Del.

Staff Services:

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Correna S. Gooding	Clerk-Typist	"
Anna F. Hall	Librarian (WAE) (vice Elizabeth F. Talbot resigned 9-28-62)	"
Margaret L. Rose	Clerk-Stenographer	"
David W. Windley	Writer-Editor	"

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Thelma C. Nelson	Administrative Assistant	Beaufort, N.C.
Margaret M. Lynch	Clerk-Typist	"
Inez J. Nierling	Clerk-Stenographer	"
Claude R. Guthrie	Foreman (Repair and Maintenance)	"
Glenshaw Henry, Sr.	Caretaker	"
Jack D. Lewis	Caretaker	"
Thomas R. Owens	Maintenanceman	"
Willie S. Rainey	Laborer	"
Donald R. Bell	Temporary Laborer	"
Ronald E. McLaren	Temporary Biological Aid	"

BLUE CRAB PROGRAM

George H. Rees, Chief

Research on the life history, ecology, and fishery of the blue crab (Callinectes sapidus) was continued at three locations:

North Carolina studies were based at the Biological Laboratory in Beaufort and were concerned with adult crab movements, abundance and distribution of larvae, and the species composition of crab populations.

Florida studies continued the investigation of the St. Johns River blue crab. This project was based at the field station, Green Cove Springs, Fla. Data were collected on the fishery, migrations, nursery areas, food habits, and the distribution and abundance of larvae.

Larval studies were continued under contract at the Duke University Marine Laboratory. Survival of different groups of zoeae kept under "identical" laboratory conditions was extremely variable, and increased emphasis was placed on experiments with the megalops and the early postlarval stages.

North Carolina Studies

Mayo H. Judy, Donnie L. Dudley, and Peggy M. Keney

Blue crab studies were shifted from the Newport River to adjacent waters in North Carolina, with emphasis on offshore plankton collections, offshore tagging, and examination of trawl catches in the ocean (4-9 and 15-20 fathoms (fm.)) for species composition of crab populations.

Crab larvae studies in the ocean off Beaufort, N.C., included the collection of monthly plankton samples throughout the year, and collections from the ocean between Brunswick, Ga., and Beaufort, N.C., during the Silver Bay cruise (January 15-21, 1963).

Surface and bottom plankton samples were taken at 13 locations in an oceanic area extending approximately 5 miles east and 5 miles west of the Beaufort Inlet and 7 miles offshore at the greatest distance. Most blue crab zoeae collected were first stage, followed in abundance by second and third stages. The fourth and fifth zoeal stages and the megalops were present also, but were less abundant. Plankton tows made 3-7 miles offshore generally produced more blue crab larvae and a greater diversity of stages than tows made 1/2-1 mile from shore. Experimental plankton collections (10-25 miles offshore) in September 1962 produced blue crab type megalops and all zoeal stages except the seventh stage. Ocean plankton samples, collected from regularly sampled locations closer inshore during the same month, produced only the first two zoeal stages and the megalops.

In addition to blue crab type larvae, the collections we made at the 13 ocean locations contained larvae of at least 24 other crab species of which the common genera were Uca (fiddler crabs), Hepatus (calico crabs), Pinnixa, Portunus, and five species of the family Xanthidae (mud crabs). During July-November 1962 and May-June 1963, the number of crab larval species present in samples ranged from 14-23 per month, with June, July, August, and September all having more than 20 species. No samples were taken in December 1962, and collections made January-April 1963 contained only 1-3 larval species per

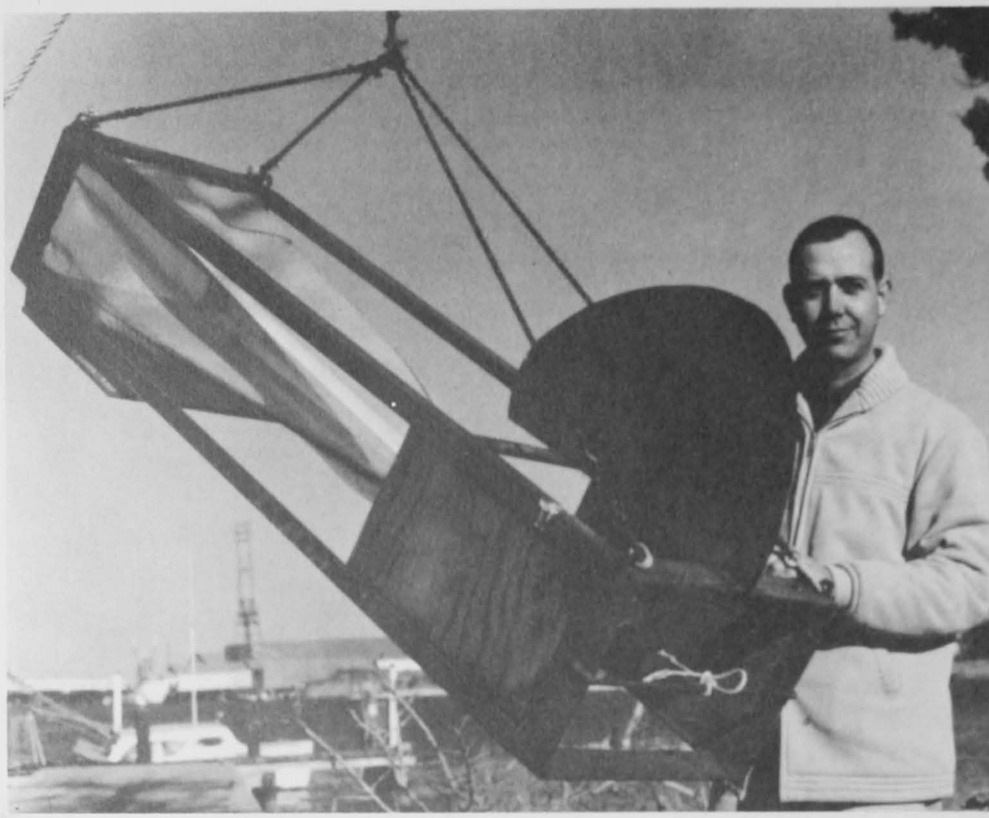

Figure 1.--Plankton sampler used to collect larval and early postlarval blue crabs moving on, or near, the bottom.

month. Plankton samples collected during the Silver Bay cruise contained very few crab larvae; no blue crab type was present.

During the last quarter of the fiscal year, we built a plankton sampler to collect larval or early postlarval crabs moving on or near the bottom. This sampler, weighing 90 pounds, is 6 feet long, has a rectangular opening 12 by 18 inches, and is equipped with a 5-foot net which tapers to fit a large plankton bucket with a 4-inch opening. The sampler faces into the current and is held stationary on the bottom by its own weight (fig. 1).

Blue crab movement in highly saline waters was studied by releasing tagged crabs in the ocean from July 1962 through March 1963. Many of the tags returned from crabs that had been tagged in the summer were recovered close to the tagging sites. Those crabs tagged during the fall and winter usually were recovered in inland waters during late winter and spring. A complete analysis of this study must await additional tag returns from the 1963-64 fishery.

In laboratory experiments designed to find a method whereby immature blue crabs would retain tags during molting periods, we tagged young crabs at the molt line beneath the lateral spine. Twenty-two percent of the crabs molted and retained the tag. We plan future work on this problem.

Figure 2.--Sorting trawl catch for species composition of crab populations.

We made biweekly trawls in the ocean (4-9 fm.) throughout the year to collect information on crab species composition, size, sex, and stage of development (fig. 2). Trawl sampling consisted of approximately eight 1/2-hour tows over a 2-day period with a 30-foot shrimp trawl having 7/8-inch stretch mesh. We restricted trawling to the vicinity of Beaufort Inlet in the same general area where the surface and bottom plankton samples were taken. Table 1 lists the crab species present by month in order of abundance for the fiscal year.

We also obtained information periodically from commercial trawlers working offshore at depths of 15-20 fm., and from exploratory trawling with commercial gear in other offshore areas. Samples taken from commercial gear in November-December 1962 and January 1963 were composed mostly of Portunus spinimanus, P. gibbessii, Ovalipes ocellatus (lady

Table 1.--Crabs caught by ocean trawling in area of Beaufort Inlet, N. C.

Species	1962						1963						Months species present
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	
	Number of crabs						Number of crabs						Number
Callinectes sapidus (Blue crab)	512s 1/	114s	247s	113s	84s	45	408	153		13	177s	177s	11
Callinectes ornatus (No common name)	229	149	357s	561s	634s	--	6	--		--	--	89	7
Portunus gibbesii (No common name)	160	125	70	161	98	4	76	31		153	179s	292s	11
Ovalipes ocellatus (Lady crab)	20	22	8	5s	--	2s	1	2s		8	110	762	10
Portunus spinemanus (No common name)	50	80	132s	250s	156	1	13	--		9	11s	7s	10
Ovalipes guadulpensis (Lady crab)	7	46	26	2	--	3	2	--	No sample	1	64	186	9
Hepatus epheliticus (Calico crab)	1	12s	27s	141s	77	1	15	7		9	5s	28s	11
Libinia species (Spider crab)	5	5	1	8	17	7	39	22		15	13	63s	11
Persephona punctata (Purse crab)	1	23	7	25	9	--	3	1		11	2	9s	10
Arenaeus cribrarius (Spotted crab)	--	--	1	3	7	--	26	--		--	--	--	4
Cancer borealis (Jonah crab)	--	--	--	--	--	--	1	5		4	3	--	4
Calappa flammea (Box crab)	--	--	2	4	--	--	--	--		--	--	--	2
Portunus sayi (No common name)	--	--	1	--	--	--	--	--		--	--	--	1
Number species per month	9	9	12	11	7	7	11	7		9	9	9	
Species with sponge	1	2	4	5	2	1	0	1		0	4	6	

1/ The letter "s" indicates the presence of sponge crabs.

crabs), Libinia sp. (spider crabs), and Calappa flammea (box crabs).

Plankton samples and tagging data collected in the Newport River, Bogue and Core Sounds, and the ocean outside the Beaufort Inlet are being analyzed. We have summarized plankton collections, and we are working on comparisons of distribution and abundance within and between years. Tag returns are revealing general trends in movement within and outside the tagging areas, as well as seasonal movement and distances traveled.

Florida Studies, St. Johns River

Marlin E. Tagatz and Grady P. Frymire

We sampled crabs with seine and small-mesh trawl in three nursery areas of the lower St. Johns River: Clapboard Creek (8 miles from the mouth of St. Johns River), Dunn Creek (14 miles from mouth), and Trout River (20 miles from mouth). During July and August 1962, juvenile crabs, primarily 1/4 to 1/2 inch, occurred in the nursery areas. We collected first stage crabs (1/12 to 1/10 inch), and relatively few of the next subsequent stages. Before this, there were few crabs under 4/5 inch in the nursery areas as the last influx of the 1961 spawning season had grown larger than this. The earliest crab stages, 1/6 to 1/10 inch, occurred during December and January (fig. 3). The majority of these crabs did not shed until higher temperatures in spring. By the end of June no appreciable number of early crab stages had occurred from the initial 1963 spawning run. Throughout the year, immature crabs in all size ranges between 4/5 inch and adult size occur in the nursery areas; some develop here to adults and others leave the nursery areas to develop in upriver areas.

The vicinity of Buoy 24, Picolata (60 miles upriver from mouth), was sampled for the occurrence of crabs. This location supports the largest concentrations of immature crabs over 4/5 inch in the entire river. Crabs 4/5 to 4 inches occur at all sizes the year around, and the sex ratio is approximately equal. Most

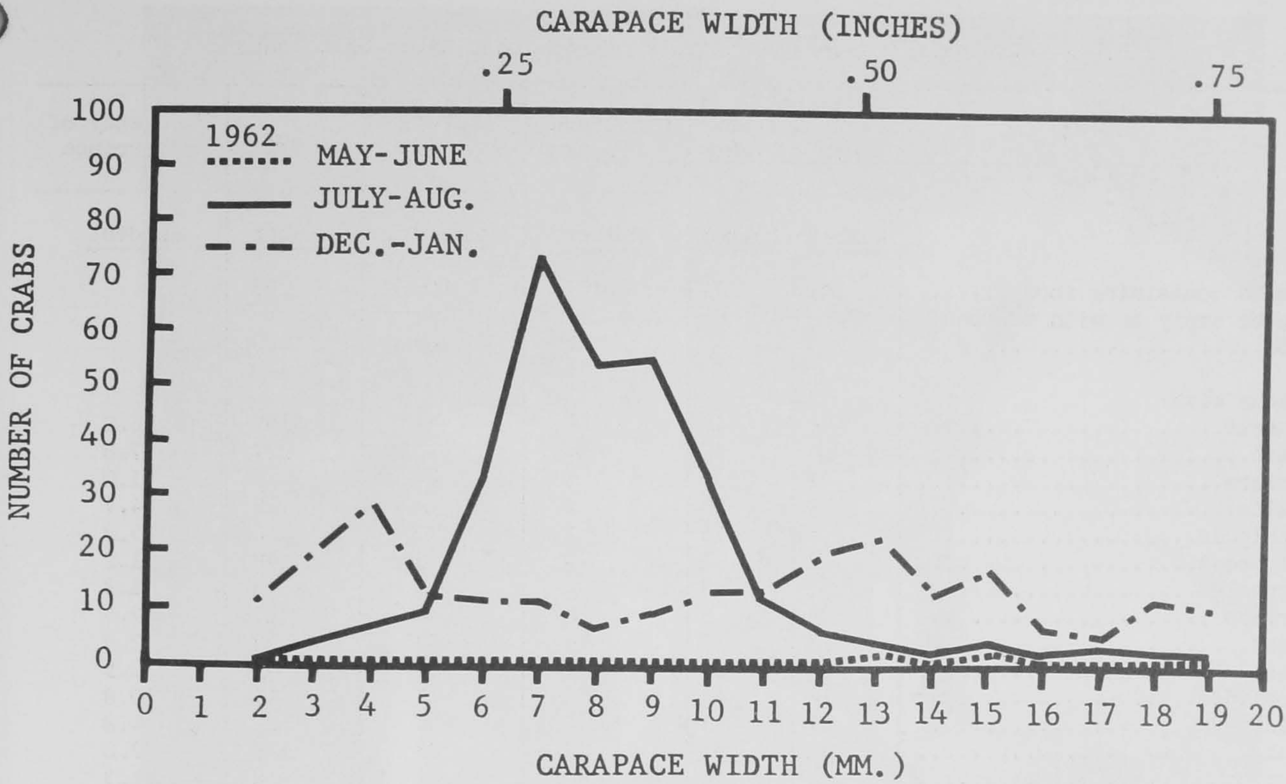

Figure 3.--Occurrence of early crab stages, Dunn Creek, St. Johns River, Fla., 1962. (1 MM. = 0.0394 inch.)

males, upon reaching about 4 inches, move upriver while females remain at Picolata to mature. Tagging results indicate that many males return to Picolata as adults and that females upon reaching maturity migrate downriver almost at once. Early crab stages down to 1/4 inch occurred during the same period as in the nursery areas, July and August.

A Clarke-Bumpus sampler was used to obtain 12 series of surface and bottom plankton collections in the lower 20 miles of river. The samples had first and second zoeae and megalops of blue crab.

To determine the food of all sizes of blue crabs, we analyzed stomachs, beginning in December, at four locations. Of the 700 stomachs examined, 600 contained more than a trace of food, including mussels, clams, amphipods, barnacles, shrimp forms, ostracods, snails, polychaetes, crabs, fish, insects, bryozoans, and plants (table 2). Small crabs (less than 2 inches) fed primarily on clams, amphipods and other crustaceans, polychaetes, fish, insects, and plants. Larger crabs fed primarily on mussels, clams, amphipods, crabs, and fish. There was little seasonal variation in choice of food items. Dredge and net collections of the aquatic flora and fauna at each location indicated that crabs usually fed on the most available foods. Buoy 24, Picolata, had an abundant and diverse assortment of crab foods that could account for crab concentrations in that area.

We conducted a tagging program in order to follow the movements of adult blue crabs. During the fiscal year we tagged 3,067 crabs in the St. Johns River and 1,335 off the mouth of the St. Johns. Throughout the year, the vast majority of male crabs tagged in the St. Johns River and recaptured some distance away from the tagging area were recovered downriver from the tagging sites. Many of these returns were from the inland waterway (north to the Nassau River and south to St. Augustine), from the ocean (north to Fernandina Beach and south to Cocoa Beach), and from the Nassau River. During spring and summer, female crabs tagged in the river were recaptured en route to the ocean or in the ocean. Tag returns indicated that during late fall and winter females congregated in the river about 25 miles from the mouth. Recoveries were obtained during all seasons from the inland waterway (north to Cumberland Sound and south to Salerno) and from the Ft. George and Nassau Rivers. Many of the female crabs tagged in the ocean were recaptured in the St. Johns, Ft. George, Nassau, and Cumberland Rivers. Some crabs, wintering in the ocean, entered rivers during the early spring before spawning.

Each month, we sampled unculled commercial crab catches by pots and trawls in major production areas to obtain measurements of sex and width, and to determine the stage of maturity. In the lower 20 miles of river, females were in the minority during November, December, and January, and were in the

Table 2.--Analysis of stomach contents of St. Johns River blue crabs

	Dunn Creek	Trout River	Clapboard Creek	Picolata Buoy 24	Total	Frequency of occurrence
	Number	Number	Number	Number	Number	Percent
Stomachs containing food........	141	172	141	146	600	
Stomachs empty or with trace of food........................	35	27	18	20	100	
Stomachs with:						
Mussels......................	6	48	9	94	157	26.2
Clams........................	64	68	84	11	227	37.8
Oysters......................	1	--	5	--	6	1.0
Snails.......................	1	23	2	2	28	4.7
Amphipods....................	5	15	2	70	92	15.2
Ostracods....................	3	1	--	3	7	1.2
Barnacles....................	1	3	--	4	8	1.3
Shrimps......................	2	5	8	--	15	2.5
Crabs........................	13	27	14	23	77	12.8
Crustacean fragments.........	18	22	12	11	63	10.5
Annelids.....................	16	41	6	2	65	10.8
Insects......................	21	3	1	4	29	4.8
Fish.........................	52	56	67	23	198	33.0
Bryozoans....................	2	4	--	2	8	1.3
Higher plants................	13	15	6	12	46	7.7
Algae........................	9	19	10	9	47	7.8
Organic debris...............	82	50	37	44	213	35.5

majority during the rest of the year. Beyond 50 miles from the mouth of the river, males predominated the year around. In 1963, females first had sponges (egg masses) in the middle of March, 1 month later than in 1962. Crabs less than 5 inches wide comprised 5 to 10 percent of the January-April commercial catches; they made up less than 5 percent in other months.

We continued to collect catch and effort data from the approximately 90 pot fishermen and 35 trawlers engaged in the commercial blue crab fishery.

Larval Studies

(Contract No. 14-17-0002-30)

John D. Costlow, Jr.
Duke University Marine Laboratory

Laboratory rearing of large numbers of blue crab larvae has been continued to determine the effects of salinity and temperature on survival and development. We followed the development of 30 series of larvae, obtained from eggs of 30 different females. Even though the larvae were maintained under environmental conditions, which were as identical as possible (temperature, 25° C.; salinity, 30 p.p.t.; length of day, 14 hours; food, Arbacia (sea urchin) eggs and Artemia (brine shrimp) nauplii), survival was extremely variable and quite low. Larvae from some series survived only to the second or third zoeal stage, while in other series, small numbers of larvae persisted through later stages of development. We obtained several new experimental antibiotics from The Lilly Corporation but, in the concentrations used, they have not improved the survival of the larvae.

As material became available, we continued research on the effect of salinity on rate of oxygen consumption of all larval stages of blue crabs (fig. 4). We extended this study to include daily measurements of oxygen consumption during the development of each larval stage. While data are available from two complete series of larvae, we will need to repeat some portions of the experiments to provide additional data for the later zoeal stages and the megalops stage. Initially, total nitrogen content of the larval stages was measured to provide a base for comparison of rates of oxygen consumption throughout larval development. We also extended this phase of the study to include total nitrogen content of larvae for each day of development for each larval stage. Preliminary analysis of the data suggests that there are regular changes in total nitrogen content of developing larvae. Although some changes in nitrogen content are associated with normal growth and

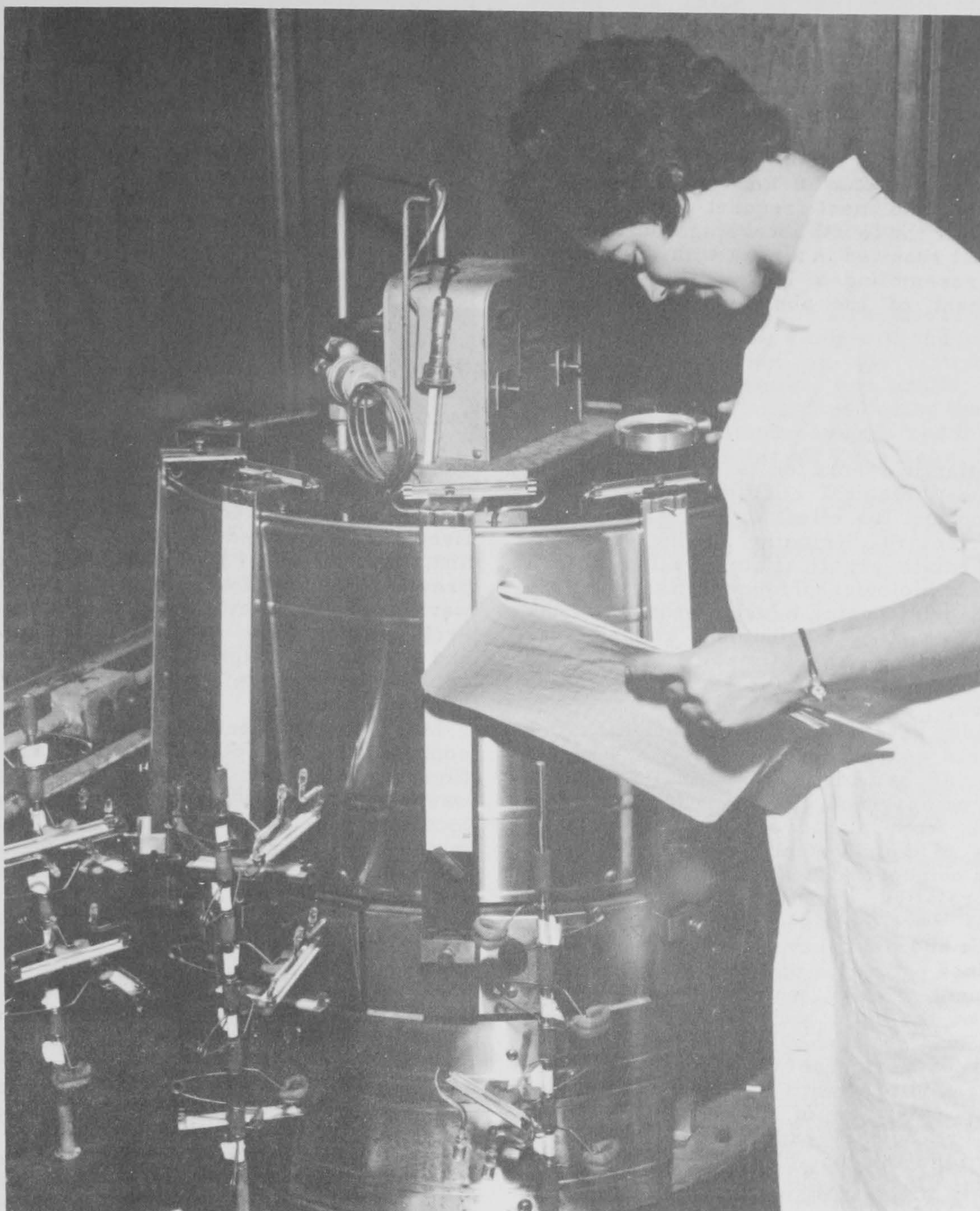

Figure 4.--Using a microrespirometer to measure the oxygen consumption of blue crab larvae reared in different salinities.

development, it is possible that other changes are concerned with the molting cycle of the larvae.

Because of the variability in survival of larvae reared under "identical" environmental conditions in the laboratory, we have not been able to accurately determine the effects of salinity and temperature on all zoeal stages. Within the megalops stage, however, survival has been consistently high, and we have experimented to determine how salinity, temperature, and the combination of salinity and temperature affect development of the megalops stage and survival to the first "crab" stage. We have completed this phase of the program, as well as studies on the effects of salinity and temperature on postlarval molting and growth, and will prepare for publication when we have analyzed the data.

Because an "extra" eighth zoeal stage sometimes occur in the development of blue crab larvae in nature, we made additional experiments to see if there were variations in morphological characteristics or molting frequency during earlier phases of larval development. From detailed studies on a number of series of blue crab larvae, we found that some larvae skipped some of the stages described previously. The most frequent variations occurred after the fourth zoeal stage and involved a molt that resulted in a zoea with an anterior portion resembling a later stage, while the development of the abdominal portion was retarded and resembled an earlier zoeal stage. In some cases "skipping" of a stage was observed, that is, the stage normally considered to be the fourth zoea molted to a stage previously described as the sixth zoeal stage. Following these variations in molting pattern, the larvae continued the later molts in the manner previously described, and some did metamorphose to the first crab. Results of this phase of the work are now being prepared for publication.

MENHADEN PROGRAM

John W. Reintjes, Acting Chief

The Atlantic menhaden is being studied to determine biological characteristics of the population and the effect of natural and man-induced factors, including fishing, upon it. The immediate, practical aim of this research is to obtain biological information that will aid the menhaden industry to use menhaden stocks wisely. This objective includes an inventory of the resource, an estimate of the fishing effects upon it, and a forecast of future abundance.

Menhaden research in 1962 included studies on fishable and nursery stocks. We sampled purse seine catches systematically for age and size composition, compiled catch and effort statistics from plant records, and analyzed logbooks of daily vessel activities to determine the number and location of sets. Measures of the relative abundance of juveniles in estuaries were obtained from aerial reconnaissance and field surveys. From these data, we obtained estimates of year class abundance, recruitment, growth, mortality, and their effects upon the catch and distribution of fish. In addition, we studied the variation in the numbers of vertebrae of spring- and fall-spawning adult Atlantic menhaden to determine the existence of differences in these stocks. Preliminary experiments were made to determine the feasibility of using a small metal tag inserted in the body cavity for marking young menhaden.

We continued a cooperative study with the Woods Hole Oceanographic Institution and the U.S. Coast Guard to obtain information of transport currents over the Continental Shelf from periodic releases of drift bottles and sea bed drifters.

Sampling the Catch

William R. Nicholson and Joseph R. Higham

The 597,000-ton catch in the summer fishery (May-October) was approximately the same as in recent years, but the 29,000-ton catch in the North Carolina fall fishery (November-January) was only about 39 percent of the catch in recent years. The summer fishery commenced about 10 days earlier and continued about 10 days later than in most previous years. Exceptionally good catches were made in May, June, and October, and exceptionally poor catches in July, August, and September. High winds and unseasonably cold weather curtailed the fall fishery after November 24.

Most fishing occurred within the 20-fm. contour and, except for a significant reduction in fishing in the vicinity of Cape Cod, was concentrated in approximately the same locations as in previous years. The estimated 25,663 purse seine sets in the summer fishery was 95 percent of the annual mean number for the period 1955-61; the 513 sets in the fall fishery was 28 percent of the annual mean for the same period. The mean catch per purse seine set in the summer fishery was 23 tons, compared to 21 tons for the 7-year mean; in the fall fishery 57 tons, compared to 41 tons for the 7-year mean.

Fishing effort increased slightly over 1961 in the summer fishery and decreased by about 50 percent in the fall fishery. The number of standard vessel days was 7,700 in the summer fishery and 245 in the fall fishery, compared to means of 7,533 and 666 for the period 1955-61. Catch per standard vessel day was 78 tons in the summer fishery and 103 tons in the fall fishery.

Four age groups supplied 95 percent of the total number of fish landed. The 1958 year class (age-4) furnished 21 percent of the total catch, and for the fourth consecutive year, dominated the catches in the Middle and North Atlantic Areas and the North Carolina fall fishery. Age-1 fish (1961 year class) provided 24 percent, age-2 fish (1960 year class) 39 percent, and age-3 fish (1959 year class) 11 percent of the catch. Age-0 fish (1962 year class) furnished 2 percent, and ages 5-9, the remaining 3 percent.

Lengths and weights of the 1958 year class generally were less than in previous years,

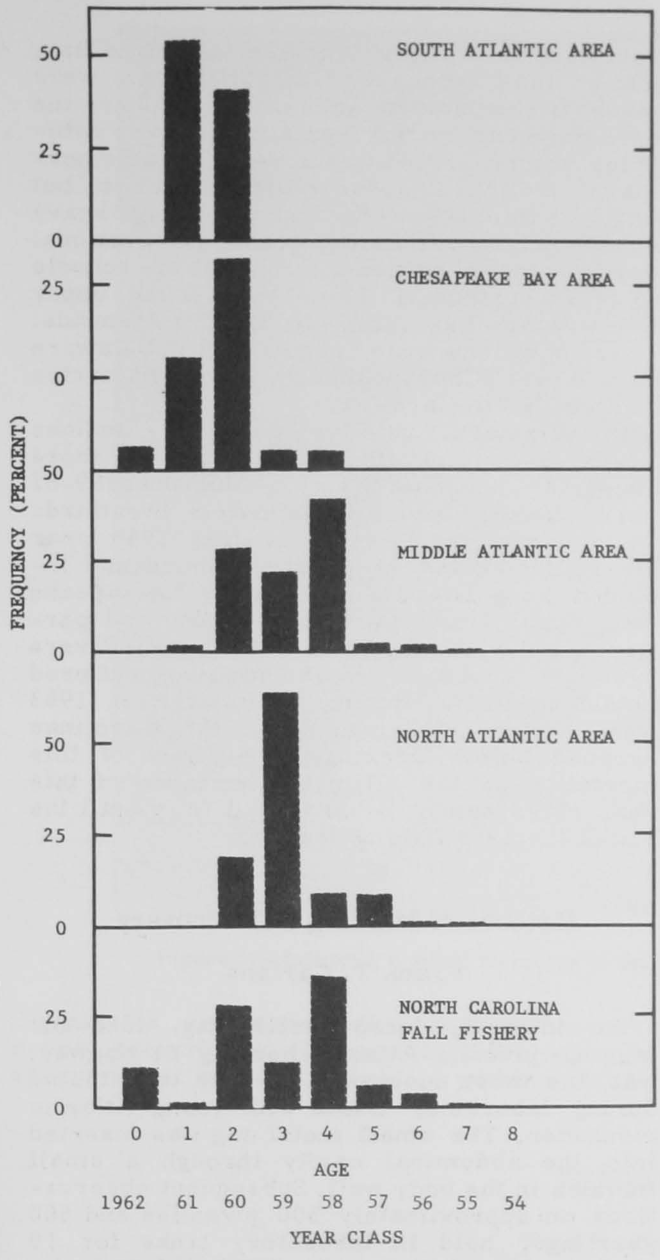

Figure 5.--Age composition of purse seine catches of Atlantic menhaden, by area, 1962.

while those of the 1959, 1960, and 1961 year classes generally were greater.

The average age of fish in the 1962 catches was greater than in previous years, primarily because of 1958 year class (age-4 fish) abundance. In past years, the combined catch in the North and Middle Atlantic Areas accounted for about 60 percent of the total catch and was composed primarily of fish age-2 and older. In 1962, however, age-4 fish constituted the greater percentage of the large catches made in these areas in May, June, and October, while age-2 and -3 fish constituted the greater percentage of the small landings in July, August, and September. Since the 1958 year class is not expected to contribute substantially to the catch in future years, the catch in the Middle and North Atlantic Areas is expected to decline drastically unless a series of strong year classes occurs and the amount of effort on age-1 fish is reduced.

Morphology and Population Studies

John W. Reintjes

The identification and structure of menhaden species populations, along with the accumulation of information on the distribution of eggs, larvae, juveniles, and adults, were the major continuing activities during the year.

We collected menhaden eggs and larvae to a distance of 50 miles off Cape Fear, N.C., and Cape Romain, S.C., during a cruise of the Bureau's exploratory fishing vessel Silver Bay in February 1963. The occurrence of these specimens supports the hypothesis that spawning occurs principally in the waters over the Continental Shelf. Generally, eggs and early larvae of Atlantic menhaden are known to occur only in oceanic waters, but exceptions to this distribution have been reported from Long Island Sound and Narragansett Bay.

In Florida waters we collected juveniles and adults of three species of menhaden, *Brevoortia tyrannus*, *B. smithi*, and *B. patronus*. These occurrences supported four postulations stated in previous reports:

1. All Florida rivers are nurseries for one or more species of menhaden.
2. Adults of the southern subpopulation of Atlantic menhaden migrate to the Cape Canaveral area in late fall.
3. A relatively large population of yellowfin menhaden occurs in Florida.
4. Large gulf menhaden occur off southwestern Florida during the winter.

We surveyed the coastal Caribbean waters of Honduras, Guatemala, British Honduras, and Mexico in June 1963. No juvenile or adult menhadens were obtained in the region. Atlantic thread herring, *Opisthonema oglinum*, and Atlantic anchoveta, *Cetengraulis edentulus*, were among the more abundant herringlike fishes encountered.

To test the hypothesis that spring-spawning and fall-spawning Atlantic menhaden constitute 2 distinct subpopulations, we analyzed the counts of over 5,000 adults. On the average, spring spawners had significantly fewer vertebrae than fall spawners. The tendency for the vertebral count pattern to remain unchanged for 3 consecutive years, despite wide variations in environmental conditions during spawning and early development, suggests that the observed differences are genetic in origin.

Estimation of Juvenile Abundance

Anthony L. Pacheco

We continued our estimation of juvenile Atlantic menhaden abundance in estuarine nurseries. Although our objectives and methods remained unchanged from the previous year, we added three new locations (in the Carolinas) to the ground survey schedule and increased the aerial survey time to make counts of schools in all major river systems from Fernandina Beach, Fla., to Plymouth, Mass. We made an initial aerial survey of school abundance of Gulf menhaden in estuarine nurseries from Apalachicola, Fla., to Corpus Christi, Tex. Our major objectives were to (1) compare estimates of relative abundance derived by four independent methods in 15 locations in 1962 with similar estimates made in previous years, (2) calculate indices of abundance, including confidence limits, and sampling errors, and (3) accumulate ecological data relating to the estuarine phase of menhaden life history.

In general, catch-effort data at nearly every location suggested notable increases in juvenile abundance over 1961. The overall average increase was about 15 times that of 1961. In most new survey areas, high levels of relative abundance were indicated. These estimates of relative abundance (catch per unit of effort) were derived from seining and surface trawling in estuarine nurseries, using standardized gear. In addition, night seining was conducted in several localities. We also obtained estimates of absolute abundance from Petersen-type mark and recovery experiments conducted concurrently with seining operations.

We made comparisons of various survey results to evaluate techniques on the basis of fish behavior. Analysis of day versus night seine hauls showed more uniform catches at night, suggesting that the schools disperse in the dark. There was also a greater concentration of fish upstream at night. Catches from surface trawling demonstrated the same patterns of fish distribution as obtained from seining; however, trawl catches were considerably higher for the effort expended. Both gears sampled the same size classes of juveniles. Most variations in catch by gear were related to the location and time of sampling and the effects of tide, as well as to the increased catchability of the fish in upstream locations. During ground surveys, we counted surface schools during early morning and evening. Since wind greatly affects the efficiency of observation, such counts were of limited value in estimating the relative abundance of nursery populations.

We made aerial counts of juvenile menhaden schools along a flight track covering some 3,700 miles of estuarine waters. We expanded both flight time and area of coverage, particularly in Long Island, Chesapeake Bay, and North Carolina waters. Flights were made in September and early October, the period juveniles congregate in the river estuaries before emigrating to sea. Schools normally are easily counted from the air, but water turbidity, particularly during heavy runoff, sometimes limited school observations. Good water conditions for sighting schools were encountered in Long Island Sound, upper Chesapeake Bay, and the Carolina sounds. Poor conditions were encountered in Delaware Bay, lower Chesapeake Bay, and estuaries south of North Carolina.

In summary, relative abundance indices indicated that the 1962 year class was more abundant throughout the range than the 1959-61 year classes, and approximately two-thirds as abundant as the outstanding 1958 year class. Localities of greatest abundance included Long Island Sound, upper Chesapeake Bay, upper North Carolina sounds, and portions of the Charleston and Savannah Rivers systems. This year class, however, suffered untold mortality during the winter of 1963 when water temperatures in the Carolinas dropped below freezing. The effect of this mortality on the ultimate abundance of this year class cannot be assessed fully until the end of the 1964 fishing season.

Methods of Marking and Recovery

Frank T. Carlson

An internal, ferrometallic tag, used for tagging juvenile Atlantic herring in Norway, was the most successful of four tags tested during laboratory trials with young Atlantic menhaden. The small metal tag was inserted into the abdominal cavity through a small incision in the body wall. Subsequent observations on approximately 500 juveniles and 500 yearlings, held in laboratory tanks for 10 weeks, showed that only 1 of 4 lots had a slightly greater mortality of tagged fish than the controls. Approximately 10 percent of the fish shed the inserted tags during this period.

We also made preliminary tests at a menhaden reduction plant to determine the efficiency of magnets mounted in the fish meal conveyor system for recovering the small tags. The magnets, part of the normal plant installation for protection of the machinery, also provide quality control of the meal. We inserted tags in dead menhaden before they passed into the conveyor system, or dropped loose tags into the reduction machinery at different stages of processing. Sixty-five percent of the tags was recovered. The greatest loss was in the cookers.

We stopped work on a device for detecting menhaden marked with luminescent dyes. The detector, which excites dyes with an ultraviolet

Figure 6.--Inserting a small metal tag in the abdominal cavity of a juvenile Atlantic menhaden.

illuminator and senses the emitted fluorescence, required costly modifications, with no assurance of efficient operation within a plant. Pending the outcome of developmental work on the detector, we did not attempt the application of luminescent pigments to menhaden.

SHAD PROGRAM

Paul R. Nichols, Chief

Research activities shifted from studies of population dynamics of American shad (Alosa sapidissima) to biological problems encountered in the rehabilitation of the runs of shad and related species above existing and proposed impoundments and areas of channel improvements.

We continued our studies at navigation locks on the Cape Fear River, N.C.; Little Falls Dam fishway on the Potomac River, Md.; and Hadley Falls Dam fish lift on the Connecticut River, Mass. We began new investigations in the upper St. Johns River, Fla.; and the Susquehanna River, Pa.

In addition, we collected catch and effort statistics on the St. Johns, Cape Fear, Conn., and York, Va., Rivers for continued population inventories.

Dynamics of Shad Populations

Randall P. Cheek and Robert M. Lewis

Population inventories on the shad runs and the fisheries were made available to State authorities to aid in managing the resource, and to State and Federal agencies to help in evaluating the possible effects of water use developments on the shad populations.

Connecticut River--1963: The estimated commercial shad catch was 80,982 fish, the fishing rate 32 percent, and the calculated size of run 251,400 shad (table 3). We had predicted a population of 386,000 shad entering the river in 1963. We estimated the sport catch in both Connecticut and Massachusetts to be 52,100 shad--a 68 percent increase over 1962.

Table 3.--Statistics on the Connecticut River shad population, 1952-63

Year	Commercial fishery			Calculated population size	Escape-ment	Sport catch
	Effort	Catch	Fishing rate			
	S.f.u.[1] days	Number of Fish	Percent	Number of fish	Number of fish	Number of fish
1952	2,414	134,856	54	249,272	114,416	15,300
1953	2,143	114,695	50	229,850	115,155	19,500
1954	1,631	78,506	41	191,478	112,972	13,400
1955	1,331	60,449	35	172,711	112,262	19,700
1956	867	53,500	24	223,000	169,500	19,900
1957	921	81,368	26	313,000	231,600	34,300
1958	1,304	126,463	34	372,000	246,000	38,600
1959	1,160	107,902	31	348,000	240,000	45,600
1960	1,316	115,706	34	340,000	224,000	24,800
1961	1,542	123,593	39	317,000	193,000	16,000
1962	1,561	121,206	39	311,000	190,000	31,000
1963	1,206	80,982	32	251,400	170,418	52,100

[1] S.f.u. is 100 linear yards of drift gill net fished for 1 day.

The percentage difference between the calculated and predicted size of the shad runs entering the river steadily increased from 6 percent in 1960 to 54 percent in 1963. This increased difference probably is due to an overestimate of the escapement values used in prediction equations. Predictions of the size of the expected runs have been made on the basis of escapements from the commercial fishery 5, 4, and 1 years previous. In previous analyses, no consideration was given to the fish taken from the commercial escapement by the sport fishery above the fish lift at South Hadley Falls Dam or to the mortality of the adults above that dam, because relatively few fish were involved when the prediction relationship was established. However, in view of the significant increase in the numbers of fish both caught by sport fishmen and passed above the South Hadley Falls Dam, these fish no longer can be ignored in making predictions. Therefore, we will re-analyze the prediction relationship, taking into consideration the number of shad passed above the dam since the fish lift was put in operation in 1955, as well as the catch by sport fishermen.

York River--1963: The estimated commercial shad catch was 420,971 pounds, of which drift gill nets in the tributaries (Mattaponi and Pamunkey Rivers) caught 49 percent; stake gill and fyke nets in the York River 44 percent; and pound nets in the lower York, the remainder. The total effort was 15,579 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 58 percent, stake gill nets 39 percent, and pound and fyke nets the remainder (fig. 7). Based on catch-effort statistics, the estimated population size weighed 996,800 pounds, and the fishing rate was 46 percent. The catch decreased 28 percent, the effort decreased 10 percent, and the population size decreased 13 percent from our estimates of the previous season.

Cape Fear River--1963: The estimated commercial area shad catch was 114,745 pounds, of which the Cape Fear River produced 67 percent, the North East Cape Fear River 27 percent, and the Black River 6 percent. Drift gill nets took 93 percent of the catch, and anchor gill nets and haul seines the remainder. The inland area shad catch was 61,785 pounds, of which the North East Cape Fear River produced 83 percent and the Black River the remainder. The total catch of 176,530 pounds was 3.5 percent less than that in 1963 (table 4).

St. Johns River--1963: The estimated shad catch was 909,695 pounds, of which the commercial fishery produced 715,914 pounds and the sport fishery 193,781 pounds. Of the commercial catch, gill nets in the Mayport-Jacksonville area took 342,013 pounds and shad nets (haul seines) in the Welaka-Georgetown area 373,901 pounds (fig. 8). The calculated size of run entering the river was 2,940,000 pounds, and the total fishing rate was 31 percent. The commercial fishery catch increased 15 percent, and the sport fishery catch increased 11 percent over the previous season.

Figure 7.--"Riding down" stake gill net poles, York River, Va. (Photo courtesy Virginia Institute of Marine Science, Gloucester Point, Va.)

Table 4.--Catch statistics on the Cape Fear River, for certain years, 1896-1963

Year	River			Total
	Cape Fear	Northeast Cape Fear	Black	
	Pounds	Pounds	Pounds	Thousand pounds
1896	245,165	46,604	25,852	318
1904	238,117	27,167	44,066	309
1957	78,164	45,246	13,700	137
1958	87,995	39,965	13,150	141
1959	93,889	61,194	25,473	181
1960	106,033	63,356	43,374	213
1961	88,337	70,248	35,054	194
1962	77,353	79,128	26,555	183
1963	87,683	68,255	20,592	176

Figure 8.--Beaching a shad net, St. Johns River, Fla.

Fishway Studies

Robert B. Chapoton and Louis E. Vogele

Studies were continued (1) to observe the behavior of anadromous fishes in holding facilities in the fishway attraction chamber at Little Falls Dam on the Potomac River, Md., (2) to observe the passage of shad by the South Hadley Falls Dam fish lift on the Connecticut River, Mass., and (3) to determine the practicability of locking anadromous fishes upstream during their spawning runs, in lieu of installing fishways, on the Cape Fear River, N.C.

We began a cooperative study with the Bureau of Sport Fisheries and Wildlife to determine the possible effects of proposed flood control developments on the shad fishery in the St. Johns River, Fla.

In addition, the Bureau took an active part in a cooperative biological program entitled, "The suitability of the Susquehanna River, Pa., for the restoration of the runs of shad."

In this report, we consider studies carried beyond the end of fiscal year 1963, in some instances, to include survival of young shad and success of their downstream migration in the autumn.

Little Falls Dam Fishway, Potomac River--1963: From April 22 to 24 and from April 29 to May 23, we observed the behavior of anadromous fishes placed in a holding pen immediately below the fishway entrance. We made the pen by placing a wire screen in one of the attraction water stoplog openings, while leaving stoplogs in place in the other openings. The only escapement route for the held fish was upstream through the fishway.

There were numbers of each species available to the fishway on any 1 day: 1 to 43 American shad over a 27-day period; 2 to 20 striped bass (Roccus saxatilis) over a 20-day period; 1 to 23 alewives (Alosa pseudoharengus) over a 17-day period; 7 to 17 white perch (R. americanus) over a 12-day period; and 3 hickory shad (A. mediocris) over a 6-day period (table 5). The fishway was operated with various combinations of attraction flow. The water temperature ranged from 13.3° to 20.6° C.

During the experiment, we observed daily the fishes' behavior, and operated a trap in the fishway exit 67 times. We did not trap any of the held fish nor did we see them in the fishway transportation pools. There was random

Table 5.--Number of each species in the holding facility available to use the Little Falls Dam fishway, and the operative conditions, April 22-24 and April 29 to May 23, 1963

Date	Water depth transportation channel	Time operated	8:00 a.m. water temp.	American shad	Striped bass	Alewives	White perch	Hickory shad
	Inches	Hours	°C.	Number	Number	Number	Number	Number
April								
22	46	24	15.6	4	6	21	12	--
23	45	24	16.1	4	6	18	12	--
24	45	24	16.1	4	6	18	12	--
29	30	5	16.1	3	--	16	14	3
	42	19	16.1	3	--	16	14	3
30	42	24	16.1	3	--	16	14	3
May								
1	42	24	13.3	3	--	16	14	3
2	42	24	11.7	1	--	11	8	3
3	41	24	13.3	1	13	22	17	3
4	41	24	14.4	1	13	10	11	--
5	41	24	16.1	1	13	11	10	--
6	41	24	18.3	1	20	15	17	--
7	40	24	19.4	--	15	3	7	--
8	40	24	18.9	1	8	1	--	--
9	40	24	20.6	8	6	1	--	--
10	40	24	20.6	8	6	1	--	--
11	40	24	20.0	4	4	1	--	--
12	39	24	20.0	4	4	1	--	--
13	39	24	20.6	18	2	--	--	--
14	14	24	20.0	36	2	--	--	--
15	20	8	20.0	43	2	--	--	--
	39	16	20.0	43	2	--	--	--
16	24	24	20.0	41	2	--	--	--
17	32	24	20.0	31	2	--	--	--
18	36	17	20.0	22	2	--	--	--
19	40	19	20.0	9	2	--	--	--
20	40	24	20.6	5	--	--	--	--
21	40	24	20.6	4	--	--	--	--
22	40	24	20.6	1	--	--	--	--
23	41	24	19.4	1	--	--	--	--

movement by all species and at no time did the fish appear to be schooled. Shad usually swam near the surface in the calm waters of the attraction chamber, while the other species stayed nearer the bottom. None of the species appeared to respond to changes in attraction flow.

The reason why the held fish, especially shad, failed to use the fishway is not readily apparent. It is possible that the holding pen was too small, and therefore the fish remained excited and did not school. It also is possible that having several species in the attraction chamber at one time prevented them from getting reoriented. Mortality in the holding pen was unusually high--many of the fish appeared to never fully recover from transporting and handling, and many became infested with fungus.

We operated the fishway and monitored it for fish passage from April 25 to 28 and from May 24 to June 12. It operated successfully for river fishes during the monitoring period. We neither trapped nor saw any shad or related species in the fishway.

From May 24 to June 12, we obtained approximately 490,000 fertilized American shad eggs from commercial fishermen at Gunston Cove, Va. (river mile 80) and distributed them to hatching boxes located above Little Falls Dam (river mile 111). Approximately 50 percent of the eggs were distributed to Glen Echo, Md. (river mile 113), 15 percent to Copley, Md. (river mile 117), and 35 percent to Great Falls (river mile 120).

Survival of the fertilized eggs to the eyed stage averaged 58 percent (range: 20 to 85 percent). Survival of eggs placed in black-painted or unpainted hatching boxes averaged 73 percent, while survival in white-painted hatching boxes averaged 48 percent. Peak hatching in all instances occurred in 68 hours in 23^{o}-25^{o} C. water temperature and in 88 hours at 18^{o}-20^{o} C. No difference in hatching survival was noted among different locations.

During August 20-23, we looked for young shad at the hatching sites. We observed shad-like feeding activity throughout the area between the Little Falls Dam and Glen Echo, but none at the other sites. On August 21, we surfaced trawled seven young shad ranging from 3 to 3-1/2 inches fork length in the impoundment above Little Falls Dam.

Preliminary findings indicated that the river above Little Falls Dam is suitable for the hatching of shad eggs and development of the young. The area provides an excellent field laboratory for the study of anadromous fishes' behavior.

Hadley Falls Dam Fish Lift on the Connecticut River--1963: The fish lift was operated on 26 days from May 22 to June 24 (table 6). Passage of shad totaled 30,052 fish--an increase of 41 percent over the number passed in 1962. Numbers of other species using the fish lift were 32 alewives, 270 bass (*Micropterus* sp.), 99 trout (*Salmo* sp.), 32 perch (*Perca flavescens*), 8 walleyes (*Stizostedion vitreum*), 2 catfish (*Ictalurus* sp.), 2 carp (*Cyprinus carpio*), and 64 lamprey (*Petromyzon marinus*). During lifting operations, the water temperatures varied from 15.0^{o} to 22.2^{o} C., and peak numbers of shad were lifted at water temperatures from 19^{o} to 21^{o} C.

In samples of young shad taken September 23, those hatched above the dam ranged in fork length from 3 to 5-1/4 inches, with a mean length of 4-1/2 inches; those hatched below the dam ranged in fork length from 3 to 5-1/2 inches, with a mean length of 4-1/3 inches. This finding is significant, since in previous seasons the area above the dam had been superior, for growth of the young shad, to that below the dam.

Table 6.--Shad passed by fish lift, Hadley Falls Dam, Connecticut River, 1963.[1]

Date operated	Daily lift	Cumulative total	8:00 a.m. water temp.
	Number	Number	^{o} F.
May 22	61	61	59
23	6	67	60
24	14	81	59
28	1,599	1,680	62
29	245	1,925	61
30	1,642	3,567	61
31	2,280	5,847	63
June 1	1,850	7,697	65
2	3,395	11,092	67
3	2,442	13,534	68
4	3,094	16,628	70
5	2,484	19,112	71
6	1,818	20,930	72
7	1,519	22,449	72
8	258	22,707	72
10	241	22,948	72
11	326	23,274	71
12	279	23,553	69
13	617	24,170	68
14	482	24,652	69
17	1,186	25,838	68
18	583	26,421	69
19	1,710	28,131	70
20	1,024	29,155	71
21	263	29,418	70
24	634	30,052	71

[1] Data supplied by Holyoke Water Power Company, Holyoke, Mass.

Experimental lockage of fish at Lock and Dam No. 1, Cape Fear River--1963: Field studies of the practicability of locking anadromous fishes upstream during their spawning migration, in lieu of installing fishways, were continued in cooperation with the U.S. Army Corps of Engineers and the North Carolina Wildlife Resources Commission. We began periodic sampling of fish movement through Lock No. 1 on April 9 and continued through June 7. During this interval, we observed 13 lockages, requiring a total of 21 hours. The Corps of Engineers operated the lock for fish passage for an additional 145 hours. Based on the number of fish netted in the lock chamber during periodic sampling with haul seine, an estimated 2,208 American shad, 5,458 glut herring (*Alosa aestivalis*), and 24 striped bass were passed. Of the fish passed, 1,725 shad, 5,458 glut herring, and 4 striped bass were passed in 54-1/2 hours of operation during April; 396 shad were passed in 91-1/2 hours of operation during May; and 60 shad and 20 striped bass were passed in 20 hours of operation in June. The water temperature ranges were 15.5^{o}-20.0^{o} C. in April, 18.3^{o}-22.2^{o} C. in May, and 22.2^{o}-23.9^{o} C. in June. The number of shad and glut herring passed per hour was 40 and 150 percent respectively greater than in the previous season. The striped bass migration was probably a random feeding movement, since all fish passed were young-of-the-year fish.

We sampled the river above Lock No. 1 with 1-meter plankton nets from May 21 to 23, and found that shad and glut herring spawned throughout the area to Lock No. 2, approximately 33 miles above Lock No. 1. Although most spawning by both species was within 500 yards of Lock No. 2, herring type larvae were found throughout the river between the two locks.

In mid-August, we collected young shad, between 2 and 2-1/2 inches in fork length, throughout the river between Locks No. 1 and No. 2. The area appeared suitable for the survival and development of young shad, since as many as 37 were taken per 10-minute trawl. Continued weekly sampling after mid-August above and below Lock No. 1, by surface trawl and rotenone, indicated that young shad remained distributed throughout the river until mid-November, at which time they moved out of the river during an increase in water level from 7.6 to 16.7 feet (lock lower pool level) and a drop in water temperature from approximately 16° to 11° C. At the time the young shad moved out of the river they were from 3-2/3 to 5 inches in fork length, with a mean of 4-1/3 inches.

Preliminary findings indicated that the locks in the Cape Fear provide an excellent outdoor laboratory for fish passage studies, and the findings can be immediately applicable in the planning of water developments, such as the St. Johns River flood control project.

Practicability of fish passage facilities, upper St. Johns River--1963: Development of biological studies to determine the possible effects on the shad fishery of a proposed flood control project in the upper St. Johns River, Fla., followed requests from the Bureau of Sport Fisheries and Wildlife on the feasibility of fishways at two impoundments included in the proposal. The structures would be a 4-foot dam, immediately south of Lake Harney, and a 10-foot dam midway between Highways 50 and 520, approximately 25 miles south of Lake Harney (fig. 9). The objective of the studies was to determine the magnitude of the shad sport fishery in the upper river and the utilization of the area by shad for spawning and nursery grounds.

Shad fishing began south of Lake Harney in January and continued until the end of March. The estimated catch was 22,335 shad in 3,650 man-days fishing, of which 5,485 shad were landed in 1,000 man-days at Highway 50 bridge, 15,417 in 2,340 man-days at Highway 520 bridge, and 1,433 in 310 man-days at Highway 192 bridge. The estimated total river catch was 72,830 shad, of which the area south of Lake Harney produced 31 percent. Previous studies by the Bureau, in 1958, indicated that less than 200 shad were taken south of Lake Harney.

To identify the utilization, by shad for spawning, of the river south of Lake Harney, we took 30 egg-net samples in mid-March at 19 locations. Results indicated that shad spawned throughout the area from Lake Harney to 1 mile south of Sawgrass Lake. Most spawning occurred between the bridges on Highways 46 and 520, with as many as 10,000 eggs taken per sample in a 24-hour set (fig. 10). Previous studies by the Bureau, in 1953, indicated that spawning occurred upstream only to approximately 10 miles south of Lake Harney.

In mid-August, we surface trawled young shad from Lake Harney to Puzzle Lake, but did not collect any between Puzzle Lake and Lake Washington. During the sampling period the water temperatures ranged from 28.9° to 33.3° C.

The preliminary findings are significant, since previous observations did not indicate that shad spawned in the upper river or were used in an extensive sport fishery. We do not know why large numbers of shad suddenly appeared in the river south of Lake Harney. It is possible that the runs may be at such a high level that shad need the area for spawning, since there has been a significant increase in the number of them entering the river in the past 5 years. It also is possible that the fish may have entered the area in previous seasons but were never discovered, or unusually high waters this season may have incited this movement.

Cooperative Susquehanna River fishway studies--1963: The Bureau of Commercial Fisheries cooperated with the Bureau of Sport Fisheries and Wildlife, the Maryland Department of Research and Education, the Pennsylvania Fish Commission, and the New York Conservation Department, in biological studies to determine if the Susquehanna River was suitable for restoring shad runs. Development of the study followed a 1962 study by Pennsylvania that indicated it would be possible to construct a series of fishways, at the dams along the river, allowing upstream migration by shad and other related species. Features of the study plan were to determine (1) the suitability of the waters above the impoundments for successful hatching of shad eggs and larval development, (2) the suitability of the river and its tributaries above the impoundments for survival of young shad, and, if they could move through the impoundments during their fall migration, and (3) the extent and nature of upstream and downstream movement of adult shad transplanted from the river below the dams and released above the impoundments.

In studies on egg survival, approximately 30,000 fertilized shad eggs, collected from the Susquehanna Flats area, were distributed to hatching boxes located at Clarks Ferry, Pa., on the main river. The Fish Commission of Oregon and the Washington Department of Fisheries supplied an additional 11 million fertilized Columbia River shad eggs. These were distributed to hatching sites in the Juniata River, North Branch of the Susquehanna, and Clarks Ferry and Sunbury, Pa.

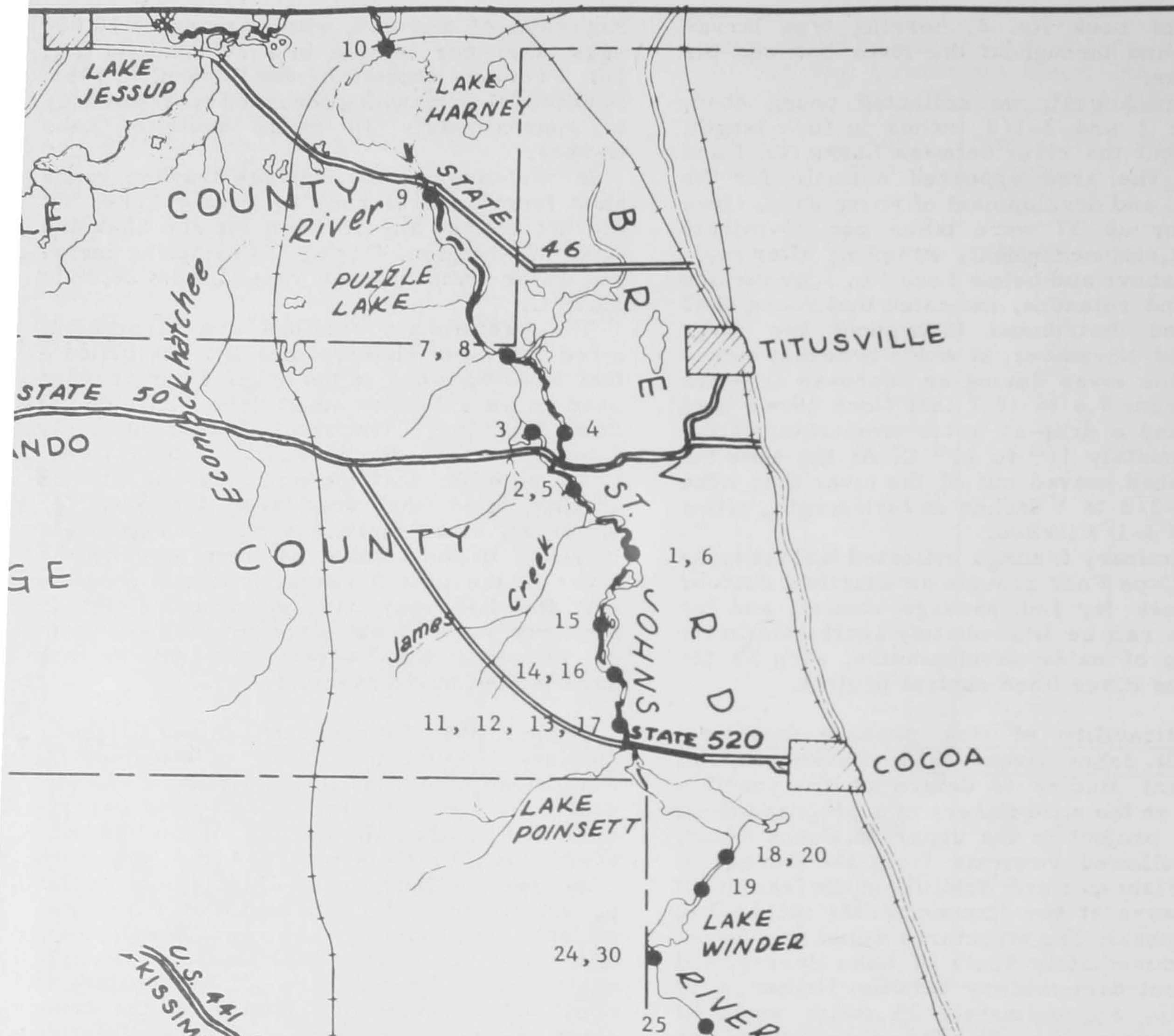

Figure 9.--Upper St. Johns River showing egg-net sampling stations.

Figure 10.--Setting egg-net in upper St. Johns River.

The eggs were transplanted from the West Coast to Pennsylvania in oxygen-filled plastic shipping containers, styrofoam insulated packaging, by fast air transportation. Water temperature in the Susquehanna ranged from 24° to 32° C. during the period that eggs were being distributed from the Columbia, where the water temperature ranged from 15° to 17° C. Survival of eggs from the Susquehanna Flats was 75 percent, and hatching occurred in 5 to 6 days at water temperatures from 16° to 22° C. Survival of eggs from the West Coast was 65 to 85 percent of those received within 23 hours, and less than 5 percent for those received between 23 and 36 hours. Eggs placed directly in the warmer water and eggs tempered in plastic bags to hatching site temperature showed no difference in survival. Eggs placed in water of more than 29° C. did not hatch. Dead larvae were found in the hatching boxes when the water temperature exceeded 27° C.

Preliminary findings indicated that fertilized shad eggs could be transported from the Columbia River with high survival. Water quality in the Juniata River and the North Branch of the Susquehanna River, at least in some sections, supported hatching of shad eggs and development of the young.

ATLANTIC COAST STRIPED BASS PROGRAM

Paul R. Nichols, Chief

The chief areas of striped bass research, were Albemarle Sound and Chesapeake Bay, where the combined annual commercial catch in recent years has been approximately 5 million pounds. Research efforts were concerned primarily with continued studies of abundance, exploitation, age composition, and migration. We made the findings available to State authorities to aid in the independent or cooperative management of the resource.

Albemarle Sound Cooperative Study

Robert M. Lewis and Randall P. Cheek

Studies on the striped bass populations of Albemarle Sound and the Roanoke River were continued with William W. Hassler of the Zoology Department, University of North Carolina at Raleigh.

In Albemarle Sound, trawling for young-of-the-year and sampling the commercial catches provided an index for predicting relative year class strength and population size 1 year in advance of exploitation. Based on catch-effort statistics, population estimates were made.

Albemarle Sound--1963: The estimated fishable population weighed 2,697,864 pounds, the fishing rate was 21.1 percent, and the catch 571,208 pounds. The estimated population size was the largest yet recorded since the study was begun in 1956. The catch was 8.7 percent greater than the 6-year average of 525,667 pounds. The estimated fishing rate was 25.7 percent less than the 6-year average of 28.4 percent.

Age composition of the commercial catch was 91.2 percent in ages 2 and 3, and 8.8 percent in age 4 or older. Predicted age composition derived from regressions calculated prior to the fishing season showed that the catch should consist of 86.6 percent in ages 2 and 3 combined.

Regressions designed to yield estimates of fish in ages 2 and 3 separately showed that age 2 should comprise 53.3 percent of the catch. The observed percentage was 75.5. The estimated percentage composition of age 3 was 33.3, and the observed percentage was 15.7. Regressions designed to yield estimates of the weight of ages 2 and 3 in the catch resulted in a prediction of 1,328,962 pounds in the population, compared to 2,460,452 pounds estimated from tagging and catch-effort data. The reason for the difference in predicted and observed percentages of fish in ages 2 and 3 separately and the observed and predicted population size is not readily apparent. After commercial catch and young-of-the-year data have been obtained for an additional number of years, hypotheses may be formulated to account for these differences.

Using regression analyses, the following predictions are made for the 1963-64 fishing season: (1) the percentage of age 2 in the population should be 50.6 percent, and of age 3, 38.2 percent; and (2) the total fishable population of striped bass should weigh approximately 1,581,300 pounds.

Roanoke River--1963: The Roanoke River in North Carolina produces young striped bass which grow to maturity in Albemarle Sound. In the river, the sport and commercial fisheries for the adults on their spawning migration have made annual catches in recent years ranging from 15,000 to 44,000 striped bass. Because data concerning the 1962 spawning population were not available when the previous annual report was written, this annual report contains information on both the 1962 and 1963 spawning runs.

To estimate the size of the population and fishing intensity, a total of 399 striped bass were tagged and released during their spawning run in the Roanoke River in 1962. Based on tag recaptures, the fishing rate was 24.0 percent--an increase of 252.9 percent from the previous season. The catch in 1962 was 25,394 fish--an increase of 23.2 percent from the previous season. The population estimate was 105,548 striped bass.

The catch in 1963 was 19,941 fish--a decrease of 21.5 percent from the previous season. The fishing rate was 23.6 percent or about the same as in the previous year. A total of 776 striped bass were tagged in 1963. Based on tag recaptures, the estimated spawning run into the river in 1963 was 84,563 striped bass.

Chesapeake Bay Cooperative Study

Robert B. Chapoton and Randall P. Cheek

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--1963: Tagging studies were conducted on the striped bass fishery during a 3-year study period, 1959-61, and tentative population estimates were made. On the basis of catch-effort data, population estimates were made for 1962 and 1963. In 1963, the population available to the commercial fishery at the beginning of the spring season weighed 2,422,810 pounds, the commercial catch was approximately 724,258 pounds, and the fishing rate was 33.4 percent. Stake gill nets took 88.4 percent of the catch, pound nets 10.6 percent, and haul seines and drift gill nets the remainder. The 1963 catch was approximately 4.9 percent less than the previous season.

Upper Chesapeake Bay--1963: Tagging and catch-effort studies in Chesapeake Bay were continued, and 3,100 striped bass were tagged and released. Preliminary analysis of the tag recovery data by the Petersen method and by the catch-effort statistics gave a population estimate of 963,700 pounds of fish. The preliminary population estimate by the modified DeLury method was 1,400,000 pounds of fish. The estimated rate of exploitation was 5.8 percent. The catch was composed of 84.0 percent age group 2 fish, 15.0 percent age group 3 fish, and 1.0 percent age groups 4, 5, and 6 fish.

Information obtained from the tag returns have supported the finding of 1962 that there is considerable winter movement by striped bass in the upper bay (fig. 11).

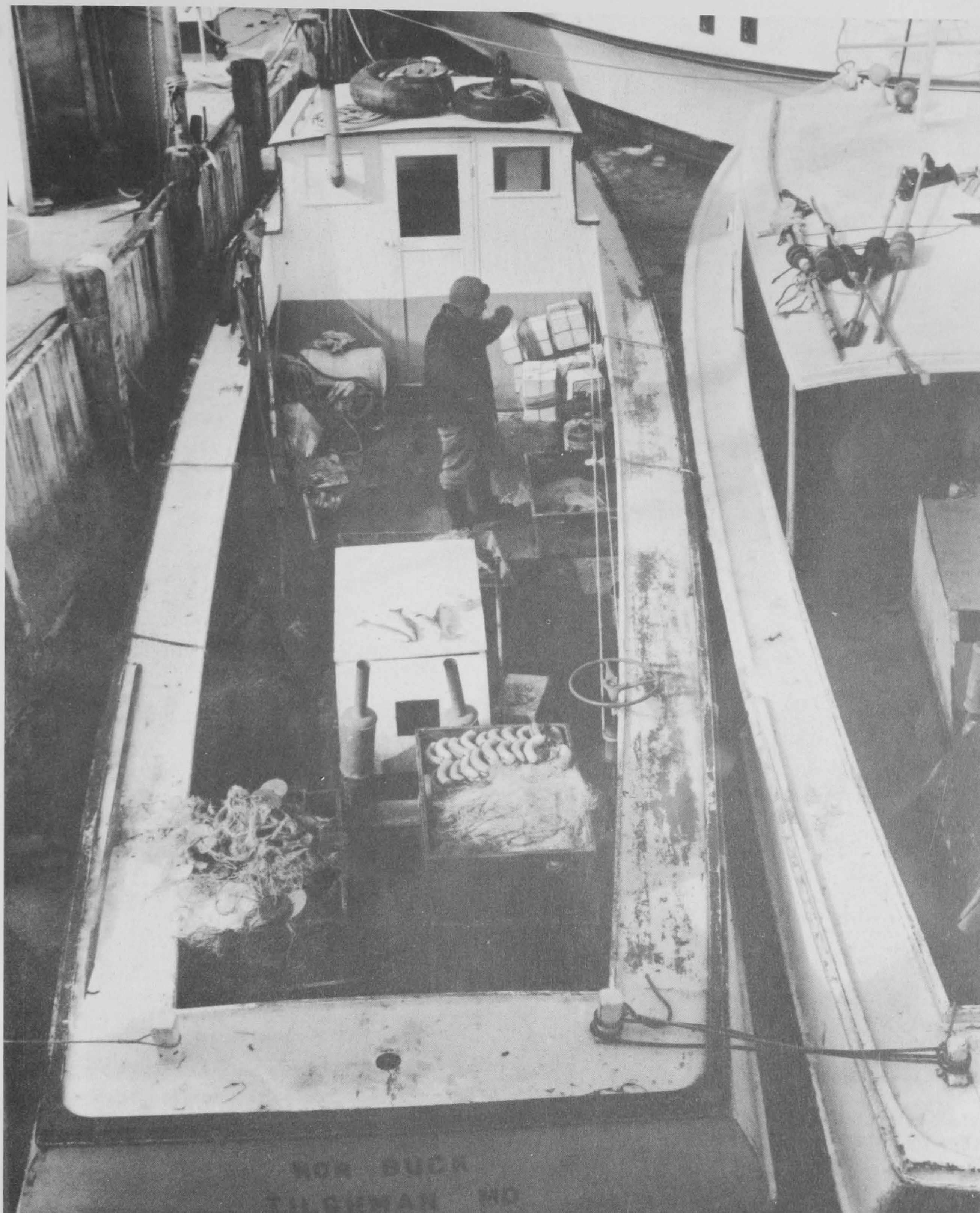

Figure 11.--Commercial drift gill net fishing boat used in Chesapeake Bay during winter fishery.

Figure 12.--Biologist removing ovaries from a 23-inch, 5-year-old striped bass.

Life History Studies

Randall P. Cheek and Robert B. Chapoton

Origin of stocks: We continued our cooperative studies with the States of New Jersey, New York, and Connecticut, and Massachusetts on the origin and migration of striped bass stocks along the New England coast. Preliminary findings indicate that Delaware Bay and its tributaries may be important contributors to the stocks of striped bass occurring along the New England coast. However, the returns from tags applied in this study have been too few to establish conclusively the origin or migration pattern of these fish.

Fecundity: Ovaries from 173 striped bass between 14 and 34 inches long were collected from the Roanoke River to augment collections made in 1958 and 1960. The objectives of this study were to determine (1) the distribution of mature ova within the ovaries, (2) the relation between weight, length, ovary index, and the age of the fish to the number of ova produced, and (3) whether these relations changed between years (fig. 12).

Preliminary findings indicated no significant difference between the number of mature ova present in the anterior, central, or posterior sections of the ovaries. The fish's body weight, length, and age were found to be equally reliable as factors in indicating ova production.

LIBRARY

Anna F. Hall

The addition to the card catalog of author analytic cards cataloging individual articles in selected journals has been one of the chief services added to the library during the past year. As a long-range project, these analytic cards will form a bibliography enabling laboratory personnel to locate an author's works owned by the library.

This library, founded in 1899 with the establishment of the laboratory at Beaufort, N.C., has accumulated an extensive historical and present-day research collection. As a result, there has been collected over the years a core of valuable fishery and biological publications. During the war years the laboratory was inactive. Gaps in some serial publications which occurred during this time are being filled whenever possible.

Twenty-seven books and 56 bound volumes of continuations were added during the year, making a total library collection of 4,373 volumes. No count of unbound materials was kept.

Current issues of 60 periodicals and numerous articles of special interest were displayed on 2 special racks. In addition, several unclassified publications of current interest were displayed on shelves for periods of 6 months to 1 year before being discarded.

New books may be charged out on temporary cards; current periodicals may be borrowed overnight. Properly bound and cataloged material may be taken for longer periods.

Interlibrary loans increased. Sixty-six items were borrowed from other libraries and 11 were loaned. Approximately 1,275 items were used in the library, and 358 volumes were loaned for periods longer than overnight. Lists of publications by staff members were exchanged with 126 individuals and institutions. Response to these exchanges has been good, and many items are now out of print.

A joint checklist of publications currently being received at the Bureau of Commercial Fisheries Laboratory, the Duke University Marine Laboratory, and the North Carolina Institute of Fisheries Research was compiled and published. This checklist will be revised and expanded at intervals to include all the serial holdings of the three libraries. This is the first joint checklist of scientific publications available in the local area.

SEMINARS

The Bureau of Commercial Fisheries Biological Laboratory and the North Carolina Institute of Fisheries Research cooperated with the Duke University Marine Laboratory in the following seminar program:

"The development of marine laboratories." A. F. Chestnut, Director, Institute of Fisheries Research, University of North Carolina, Morehead City, N.C.

"Insects of the herbaceous strata of salt marsh communities in the Beaufort area." Luckett Davis, Southwestern Louisiana Institute, Lafayette, La.

"The migration and homing behavior of some North American anadromous fishes." G. B. Talbot, Director, Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C.

"Pacemakers in coelenterate nerve nets." M. Passano, Department of Zoology, Yale University, New Haven, Conn.

"Metabolism of digenetic trematodes." Winona B. Vernberg, Duke University Marine Laboratory, Beaufort, N.C.

"Extreme halophilism in bacteria." Helge Larsen, Technical University of Norway, Trondheim, Norway.

"Schistosome dermatitis in Alaska." Reinard Harkema, Department of Zoology, North Carolina State College. The Arthur Sperry Pearse Memorial Lecture.

"Deep sea fauna." H. Sanders, Woods Hole Oceanographic Institution, Woods Hole, Mass.

"Acclimation in molluscs." E. Segal, Department of Zoology, Rice Institute, Houston, Tex.

"U.S. Antarctic research program in marine biology from the U.S.N.S. Eltanin." Robert J. Menzies, Duke University Marine Laboratory, Beaufort, N.C.

"Protein metabolism in fresh-water fishes." P. Blazka, Hydrobiology Laboratory, Academy of Sciences, Prague, Czechoslovakia.

MEETINGS ATTENDED

(Attendance shown in parentheses.)

Atlantic Estuarine Research Society, Ocean City, Md., and Hampton, Va. (9)
American Fisheries Society, Jackson Lake Lodge, Wyo. (1)
Atlantic States Marine Fisheries Commission, Atlanta, Ga. (1)
Gulf and Caribbean Fisheries Institute, Galveston, Tex. (1)
Gulf States Marine Fisheries Commission, Clearwater, Fla. (1)
Southern Division, American Fisheries Society, Charleston, S.C. (1)
Virginia Fishermen's Association, Old Point Comfort, Va. (2)

PUBLICATIONS

Fischler, Kenneth J., and Charles H. Walburg.
1962. Blue crab movement in coastal South Carolina, 1958-59. Transactions of the American Fisheries Society, vol. 91, no. 3, p. 275-278.

Lewis, Robert M.
1962. Sexual maturity as determined from ovum diameters in striped bass from North Carolina. Transactions of the American Fisheries Society, vol. 91, no. 3, p. 279-282.

June, Fred C.
1963. The menhaden industry. In Maurice E. Stansby (editor), Industrial Fishery Technology, p. 146-159. Reinhold Publ. Co., New York, N.Y.

Rees, George H.
1963. Progress on blue crab research in the South Atlantic. Proceedings of the Gulf and Caribbean Fisheries Institute, 15th Annual Session (1962), p. 110-115.

Reintjes, John W.
1963. Development of eggs and yolk-sac larvae of yellowfin menhaden. U.S. Fish and Wildlife Service, Fishery Bulletin 202, vol. 62, p. 93-102.

Roithmayr, Charles M.
1963. Distribution of fishing by purse seine vessels for Atlantic menhaden, 1955-59. U.S. Fish and Wildlife Service, Special Scientific Report--Fisheries No. 434, 22 p.

Sutherland, Doyle F.
1963. Variation in vertebral numbers of juvenile Atlantic menhaden. U.S. Fish and Wildlife Service, Special Scientific Report--Fisheries No. 435, 21 p.

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