Annual Report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C. For the Fiscal Year Ending June 30, 1964

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Circular 215

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

For the Fiscal Year Ending June 30, 1964

Kenneth A. Henry, Director

CIRCULAR 215

Washington, D.C.
June 1965

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For the Fiscal Year Ending June 30, 1964

REPORT OF THE LABORATORY DIRECTOR

Kenneth A. Henry

Research highlights: Research during the past year contributed important new data to our studies. In our research on blue crabs, we continued to tag and recover adult blue crabs to study their movements in North Carolina waters. Tagged female crabs did not move into the ocean to hatch their eggs as we had expected. This unusual behavior was possibly caused by the high salinity that prevailed in the area at that time. In St. Johns River, Fla., studies, our sampling indicated that this year's young crabs completed larval development in the ocean and were in the second or third crab stage when they entered the river. Experiments to determine the effects of salinity and temperature on survival of megalops and the time required for metamorphosis were completed. Statistical analyses of these data are under way.

The outstanding feature relative to our menhaden studies during fiscal year 1964 was the decline in 1963 landings of Atlantic menhaden particularly in the Middle Atlantic and North Atlantic areas. Our studies showed that the large 1958 year class has been the main support of these northern fishing areas since 1960, but these fish have almost disappeared. Because no significantly large year class has appeared since 1958, we expect that reduction in yield will continue in 1964. Since, on the basis of earlier field data, there were indications that temperature might be critical to menhaden larvae survival, we conducted laboratory experiments to determine the lower temperature tolerance limits of Atlantic menhaden larvae acclimated at different temperature.

Our menhaden investigations have been expanded by our beginning a study of Gulf menhaden during the year. This study will use the experience of the Atlantic Investigation and be patterned after it. Our early findings include the location of menhaden eggs off the Mississippi Delta in December, the first confirmed spawning locality for Gulf menhaden.

Some of the major highlights in our shad studies included a tagging and recovery program undertaken to estimate the number of shad entering Cape Fear River, N.C., the number of shad taken in the fishery, and the distribution of the spawning escapement to different tributaries.

Continued studies on use of navigation locks for fish passage showed that the number of shad passing per hour decreased below the previous season, while the number of river herring passing per hour increased. Fish passage problems at existing or proposed dams are becoming increasingly important on the East Coast. In the Susquehanna River studies, young shad hatched in the spring of 1963 successfully moved downstream and passed at least two of the three dams present during their downstream migration in the fall. We assume they passed the third dam also, but we have no direct evidence. Sonic tags were used to a limited extent in studying the movements of adult shad transferred above the impoundments. We expect to use these tags to a much greater extent in the studies next year.

Our striped bass research primarily was limited to cooperative studies on populations in Albemarle Sound, N.C., and Chesapeake Bay; some tagging was done to measure coastal migrations. The percentage age composition of 2- and 3-year-old striped bass in the Albemarle Sound commercial catch was somewhat above predicted pounds again this year. From results of trawling for young-of-the-year and sampling fish in the commercial catch we predicted the size of the population that would be available later to commercial fishermen. Their catch was close to our prediction.

Beginning in November, we made monthly flights aboard U.S. Coast Guard aircraft over coastal waters from Cape Hatteras, N.C., to Cape Fear, N.C., to obtain surface water temperatures by airborne infrared radiometry. We dropped drift bottles and seabed drifters at 25 locations in each flight to furnish information on direction and velocity of currents.

Atlantic States Marine Fisheries Commission: Reports of research on blue crab, striped bass, shad, and menhaden were prepared for inclusion in the minutes of the 22d annual meeting held in Boston, Mass., in September.

Training programs: David W. Windley, writer-editor, had a 4-month training assignment at the central office in Washington, D.C.

Work conferences:
(Attendance shown in parentheses.)

Delaware River Basin Fisheries and Wildlife Council, Dover, Del. (1)
Industrial Products Division, National Fisheries Institute, Morehead City, N.C. (3)
Northeast Division, American Fisheries Society, Hartford, Conn. (1)
South Atlantic Section, Atlantic States Marine Fisheries Commission, Charleston, S.C. (1)
Scientific Exploration of the Atlantic Shelf (SEAS), Washington, D.C. (2)
Susquehanna River Fishery Studies, Washington, D.C. (2)
Susquehanna River Basin Coordinating Committee, Binghamton, N.Y. (1)

Meetings:
(Attendance shown in parentheses.)

Atlantic Estuarine Research Society, Morehead City, N.C., and Sapelo Island, Ga. (9)
American Fisheries Society, Minneapolis, Minn. (1)
Conference on Estuaries, Jekyll Island, Ga. (2)
Gulf and Caribbean Fisheries Institute, Miami, Fla. (3)
Gulf States Marine Fisheries Commission, New Orleans, La. (1)
Pennsylvania Federation of Sportsmen, Harrisburg, Pa. (1)
Virginia Fishermen's Association, Old Point Comfort, Va. (2)

STAFF

Kenneth A. Henry, Director
(vice Frederick C. June, Acting Director, 8/25/63)

Blue Crab Program:

George H. Rees	Chief	Beaufort, N.C.
Donnie L. Dudley	Fishery Biologist	Do.
Grady P. Frymire	Fishery Biologist (resigned 8/16/63)	Green Cove Springs, Fla.
Mayo H. Judy	Fishery Biologist	Beaufort, N.C.
Peggy M. Keney	Fishery Biologist (transferred 12/9/63)	Do.
Marlin E. Tagatz	Fishery Biologist	Green Cove Springs, Fla.
Joel M. Brown	Summer Aid	Beaufort, N.C.

Shad and Striped Bass Program:

Paul R. Nichols	Chief	Beaufort, N.C.
Frank T. Carlson	Fishery Biologist	New Cumberland, Pa.
Robert B. Chapoton	Fishery Biologist (transferred 4/12/64)	Beaufort, N.C.
Randall P. Cheek	Fishery Biologist	Do.
Robert M. Lewis	Fishery Biologist (transferred 11/15/63)	Do.
Neil W. Crenshaw	Fishery Biologist (temporary)	New Cumberland, Pa.
Allen W. Johnson	do	Do.
Arlo Hannah	Fishery Aid (temporary)	Darlington, Md.
Berdell N. Presberry	do	Do.
John H. Webster	do	Do.
Robbie W. Daniels	Clerk-Typist (temporary)	Beaufort, N.C.
Ivey D. Graham	Summer Aid	Do.
Gertrude A. Smith	do	Do.

Menhaden Program:

Frederick C. June	Chief (transferred 3/2/64)	Beaufort, N.C.
John W. Reintjes	Acting Chief (vice F. C. June 3/2/64)	Do.
Frank T. Carlson	Fishery Biologist (transferred 7/21/63)	Do.

Menhaden Program--Continued

Robert B. Chapoton	Fishery Biologist	Beaufort, N.C.
William F. Hettler, Jr.	do	Do.
Joseph R. Higham, Jr	do	Do.
Robert M. Lewis	do	Do.
William R. Nicholson	do	Do.
Anthony L. Pacheco	do	Do.
Charles T. Arthur	Fishery Aid	Do.
Kenneth W. Daniels	Fishery Aid (resigned 9/13/63)	Do.
William G. Fulcher	Fishery Aid	Do.
Ronald L. Garner	do	Do.
James F. Guthrie	do	Do.
Walter P. House	do	Do.
George N. Johnson	do	Do.
Charles L. Lewis	do (resigned 2/14/64)	Do.
John T. Smith	Fishery Aid	Do.
Mary K. Hancock	Clerk	Do.
Lyle E. Brumfield, Jr.	Summer Aid	Morgan City, La.
Charles N. Edgerton, Jr.	do	Cameron, La.
Kenneth C. Johnson	do	Empire, La.
Enn Kotkas	do	Amagansett, N.Y.
Wayne M. Schenck	do	Beaufort, N.C.

Staff Services:

Kenneth J. Fischler	Fishery Biologist (Biometrician)	Beaufort, N.C.
Correna S. Gooding	Clerk-Typist	Do.
Anna F. Hall	Librarian (WAE)	Do.
Irene D. Huff	Clerk-Typist	Do.
Inez J. Nierling	Clerk-Stenographer	Do.
Margaret L. Rose	do	Do.
David W. Windley	Writer-Editor (transferred 6/15/64)	Do.

Administration and Maintenance:

Thelma C. Nelson	Administrative Assistant	Beaufort, N.C.
Margaret M. Lynch	Clerk-Typist	Do.
Claude R. Guthrie	Foreman (Repair and Maintenance).	Do.
Glenshaw Henry, Sr.	Caretaker	Do.
Jack D. Lewis	do	Do.
Clarence M. Roberts	Vessel Operator-Engineer	Do.
Willie S. Rainey	Mechanic Helper-Automotive	Do.
William B. Lewis	Temporary Laborer	Do.
Robert M. Lewis	do	Do.
Thomas R. Owens	Maintenanceman	Do.

BLUE CRAB PROGRAM

George H. Rees, Chief

The basic aim of the Blue Crab Program is to determine causes of fluctuations in abundance of marketable size crabs. These causes can be either the result of fishing activities or changes in the natural environment, or a combination of the two. Consequently, it is necessary to have detailed information, not only on the fishery for blue crabs, but on the life history, physiology, and ecology of the crabs. The emphasis of our research program during fiscal year 1964 was on the ecology and physiology of blue crabs, with studies at three locations.

North Carolina studies were conducted from the Bureau of Commercial Fisheries Biological Laboratory at Beaufort and concerned mainly the movements of adult crabs. Female crabs tagged in lower White Oak River, N.C., did not move out into the ocean to hatch their eggs, as we had expected, but remained in the river. This possibly resulted from high-salinity water in that area during spring 1964.

Florida studies were made on St. Johns River from a field station at Green Cove Springs, Fla. Our sampling program in the lower St. Johns indicated that, in 1964 at least, most of the crabs went through their complete larval development in the ocean and were in the second or third crab stage when they entered the river. In the St. Johns this year we also began studying growth and mortality of juvenile crabs confined in floats.

Research on blue crab larvae was continued under contract at Duke University Marine Laboratory. Survival rates of larvae continued to vary, and emphasis was placed on studies of oxygen consumption and total nitrogen content to see if there are intrinsic differences between different groups of larvae.

North Carolina Studies

Mayo H. Judy and Donnis L. Dudley

We studied blue crabs in White Oak River, Bogue Sound, and in the ocean off Beaufort, N.C. Emphasis was placed on tagging adult blue crabs and analyzing crab movements as shown by these and previous tagging studies. We also continued trawling in the ocean (4-9 fathoms) to determine what species make up the crab populations.

We tagged blue crabs in three separate locations, all within a 30-mile radius of Beaufort Inlet. Bogue Sound was the central tagging area, with Core Sound to the east and White Oak River (including the inland waterway between Bogue and Browns Inlets) to the west (fig. 1). All three areas had rather high salinity (25 parts per thousand or above, were near each other, and had large numbers of blue crabs.

Previous tagging in rivers and sounds around Beaufort Inlet had shown that female crabs have a general movement to and from the ocean. The movement to ocean waters was closely related to development of the sponge mass, and movement from the ocean was usually in late fall or early spring. In contrast, male crabs had shown little movement from one body of water to another.

To supplement past findings, we tagged and released a large number of male and female crabs, many in waters not previously used as tagging areas. White Oak River and the area between Bogue and Browns Inlets represent the most southerly tagging of blue crabs in North Carolina waters.

From August 1962 through March 1963, we tagged 723 female and 43 male crabs in the ocean off Beaufort, N.C. Crabs were caught by a 30-foot shrimp trawl pulled over bottoms being dredged by commercial clam fishermen. Also in March 1963, we tagged 299 female and 30 male crabs in Core Sound. A complete analysis of tag returns from these areas was not available for fiscal year 1963 annual report but is included in this paper.

Findings from the tagging study in the ocean showed that blue crabs moved to less saline waters in either late fall or early spring. This discovery was made evident by the large number of tag returns from fishermen working in the rivers and sounds. Commercial crabbing in inside waters starts by mid-October and lasts through June or July, depending on weather and market conditions, with a drop in effort usually between late December and mid-February.

Female crabs tagged in the ocean did not indicate any significant movement to inside waters until the following spring. From 307 female crabs tagged in the ocean through November, we had only 3 returns from inside waters before the following March. During March and April large numbers of tags were recovered in rivers and sounds. These included returns from most tagging months and seemingly indicated a more concentrated movement of crabs in early spring than in late fall or winter. Tag returns from females tagged during this study total 170 (23.5 percent) of which 138 (81.2 percent) were recovered in waters other than the tagging site and 125 (90.6 percent) of these were from rivers and sounds (table 1). Of the 43 male crabs tagged, 5 were recaptured, 2 at the tagging site and 3 from the sounds.

Blue crabs tagged in Core Sound during March 1963 included 299 female and 30 males. One hundred and nine females (36.4 percent) were recaptured. Of this number, 104 (95.4 percent) were returned from high-salinity waters of the rivers and sounds and 5 (4.6 percent) were returned from the ocean. These returns, taken over a 7-month period (March through October) cover the main spawning season for blue crabs. Since all returns were from high-salinity waters and recaptures made during the spawning season, we felt that this indicated the suitability of these lower rivers and sounds, as well as the ocean, for blue crab spawning. Of the 30 male crabs tagged, 17 (56.7 percent) were recaptured, 16 (94.1 percent) within the sound, and 1 (5.9 percent) in the ocean off Beaufort, N.C. These crabs moved little from the tagging site.

In high-salinity waters of the lower rivers and sounds, male crabs usually constitute less than 10 percent of the commercial catch and are not readily available for tagging. In certain waters of the rivers and sounds during some seasons, male crabs are more abundant than at other times. One of these areas is the east-west center of Bogue Sound during the fall season.

In September 1963 we tagged 343 male and 24 female crabs in Bogue Sound. Tags were

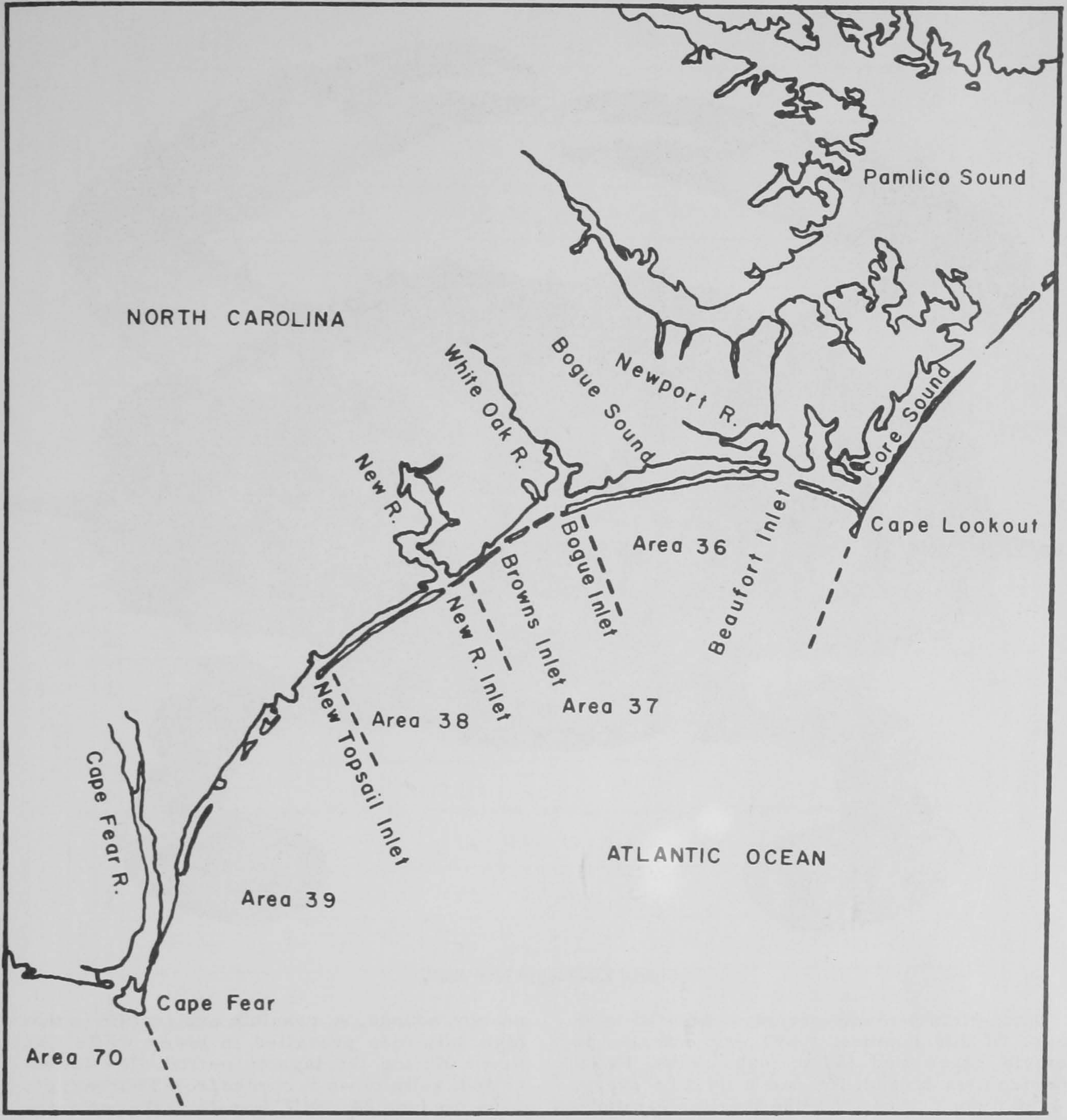

Figure 1.--A section of the North Carolina coast showing areas where studies of blue crab movement were made.

returned by commercial fishermen from September through April. Ninety-nine (28.9 percent) male and four (16.7 percent) female tags were recovered. All of these recoveries were made within the sound, and most of the recaptured crabs had traveled less than 5 miles from the tagging site. These results concur with the pattern of limited movement generally shown by other studies of male crab-tagging.

The largest and most southerly blue crab tagging study in North Carolina waters during this fiscal year was made in White Oak River area; we tagged crabs near the mouth of the river and in inside waters between Bogue and Browns Inlets. From mid-February through June, we purchased adult crabs weekly from commercial fishermen in these areas. Crabs were tagged at or near the site of capture.

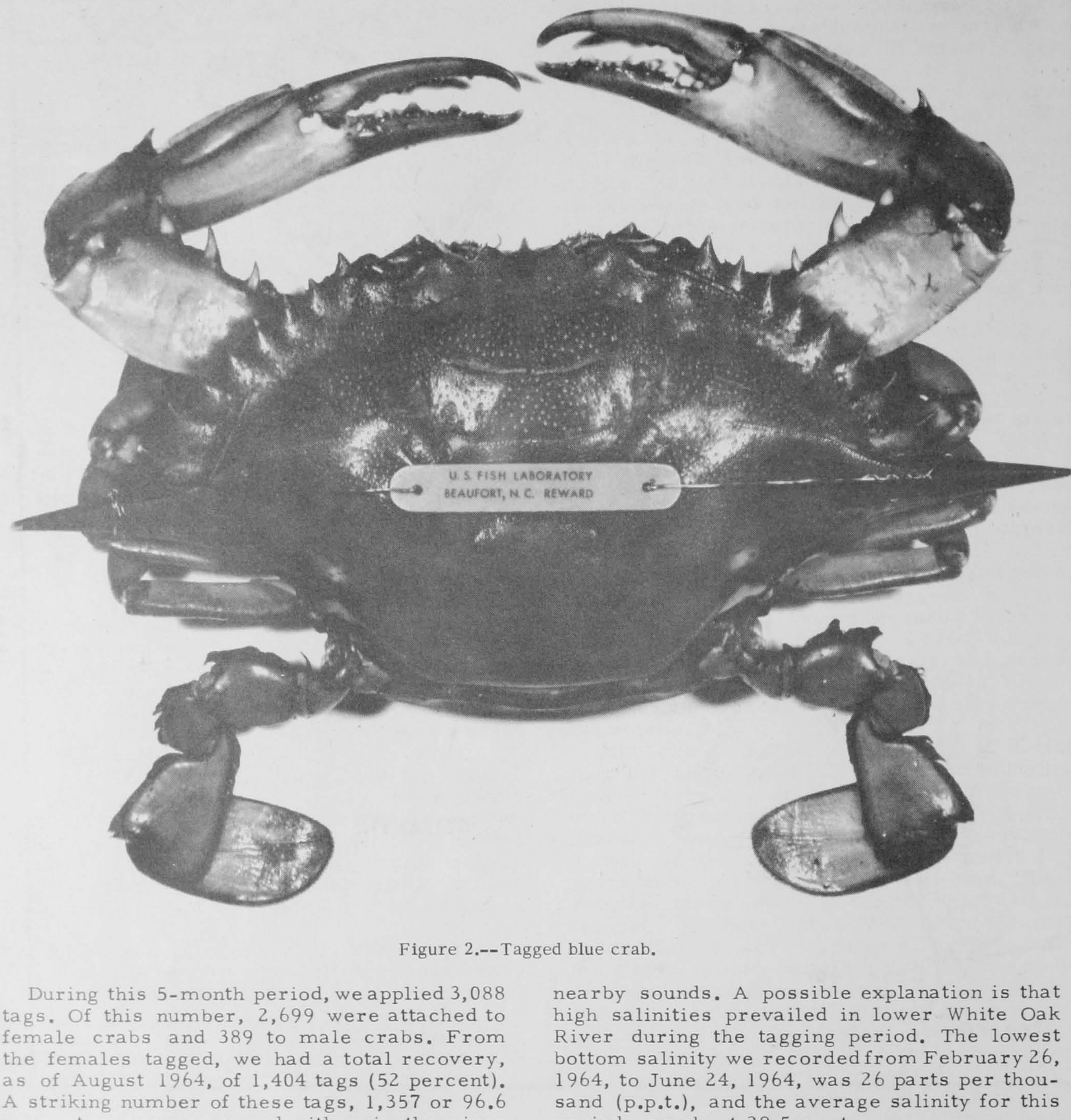

Figure 2.--Tagged blue crab.

During this 5-month period, we applied 3,088 tags. Of this number, 2,699 were attached to female crabs and 389 to male crabs. From the females tagged, we had a total recovery, as of August 1964, of 1,404 tags (52 percent). A striking number of these tags, 1,357 or 96.6 percent, were recovered either in the river or in the sounds (table 2). The remaining recoveries, 47 tags or 3.3 percent, were made in the ocean in an area reaching from Beaufort Inlet south of Cape Lookout to Little River Inlet south of Cape Fear. Of the 389 male crabs tagged in White Oak River area, 138 tags (35.5 percent) were recovered. All returns were from the general area of tagging.

We had expected that most of the females tagged in White Oak River would move into the ocean to hatch their eggs; instead, almost all of them remained in the river or went to nearby sounds. A possible explanation is that high salinities prevailed in lower White Oak River during the tagging period. The lowest bottom salinity we recorded from February 26, 1964, to June 24, 1964, was 26 parts per thousand (p.p.t.), and the average salinity for this period was about 29.5 p.p.t.

Spawning females may move from fresh and brackish water to mouths of rivers and into the ocean in response to a physiological need for higher salinities. If this is true, then the distances that females move downstream or into the ocean could be expected to vary from year to year, depending upon meteorological and hydrological conditions. Tag recovery is influenced greatly by changes in the fishing intensity in different areas; consequently, the catch statistics will have to be analyzed carefully before we arrive at final conclusions.

Table 1.--Movements of female blue crabs tagged in the ocean off Beaufort, N.C., 1964

Year Month	Number	Area	Recovery: Month 1962 Aug.	Sept.	Oct.	Nov.	Dec.	Month 1963 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Totals: Rivers and sounds Number	Rivers and sounds Percent	Ocean Number	Ocean Percent
1962 Aug.	94	Bogue Sound	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1.1		
		Total																	1	1.1		
		Ocean Area #36[1]	2	3	--	--	--	--	--	--	--	--	1	--	--	--	--	--			6	6.4
		Total																			6	6.4
Sept.	112	Core Sound	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1	.9		
		Bogue Sound	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	.9		
		Total																	2	1.8		
		Ocean Area #36	--	8	3	2	--	--	--	--	--	--	--	--	--	--	--	--			13	11.6
		Total																			13	11.6
Oct.	36	Core Sound	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	2	5.6		
		Bogue Sound	--	--	--	--	1	--	--	2	1	--	--	--	--	--	--	--	4	11.1		
		Total																	6	16.7		
		Ocean Area #37	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--			1	2.8
		Total																			1	2.8
Nov.	65	Core Sound	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	1	1.5		
		Newport River	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	1	1.5		
		Bogue Sound	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	1	3	4.6		
		New River	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	1.3		
		Total																	6	9.1		
		Ocean Area #36	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--			1	1.5
		#70	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--			1	1.5
		Total																			2	3.0
Dec.	42	Core Sound	--	--	--	--	--	--	--	5	3	--	--	--	--	--	--	--	8	19.0		
		Newport River	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1	2.5		
		Bogue Sound	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	1	4	9.5		
		Total																	13	31.0		
		Ocean Area #37	--	--	--	--	--	--	--	1	--	1	--	--	--	--	--	--			2	4.8
		Total																			2	4.8
1963 Jan.	330	Pamlico Sound	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1	.3		
		Core Sound	--	--	--	--	--	--	--	22	8	--	1	2	--	--	4	--	37	11.2		
		Newport River	--	--	--	--	--	--	--	2	3	--	1	--	--	--	--	--	6	1.8		
		Bogue Sound	--	--	--	--	--	--	1	11	4	--	1	--	--	--	2	6	25	7.6		
		White Oak River	--	--	--	--	--	--	--	8	12	1	--	--	--	--	--	--	21	6.4		
		Total																	90	27.3		
		Ocean Area #36	--	--	--	--	--	--	3	--	--	--	1	4	--	3	--	--			11	3.3
		#37	--	--	--	--	--	--	--	--	--	2	--	--	--	--	1	--			3	.9
		#38	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--			1	.3
		#70	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--			1	.3
		#17	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--			2	.6
		Total																			18	5.4
Feb.	14	Core Sound	--	--	--	--	--	--	--	4	1	--	--	--	--	--	--	--	5	35.7		
		Total																	5	35.7		
Mar.	30	Core Sound	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	1	3.3		
		White Oak River	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	1	3.3		
		Total																	2	6.6		
		Ocean Area #37	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--			2	6.7
		Total																			2	6.7
Total	723	Recaptured: Area 36 (Site)																			31	4.3
		Moved to other waters																	125	17.3	13	1.8
		Total																	125	17.3	44	6.1

[1] See Figure 1 for location of ocean areas.

Table 2.--Movements of female blue crabs tagged in White Oak River, N.C., 1964

Release		Recovery								Totals			
Month	Number	Area	Month							Rivers and sounds		Ocean	
			Feb.	Mar.	Apr.	May	June	July	Aug.	Number	Percent	Number	Percent
Feb.	679	White Oak River....	1	266	92	20	9	--	--	388	57.1		
		New River..........	--	--	5	2	1	--	--	8	1.2		
		Bogue Sound........	--	5	7	1	--	1	--	14	2.1		
		Total..........								410	60.4		
		Ocean Area #37[1]....	--	--	--	3	1	--	--			4	.6
		#39.....	--	--	--	--	1	--	--			1	.1
		#70.....	--	--	1	1	--	--	--			2	.3
		Total..........										7	1.0
Mar.	941	White Oak River....	--	332	171	62	15	1	--	581	61.7		
		New River..........	--	--	2	2	2	--	--	6	.6		
		Bogue Sound........	--	7	12	8	3	--	--	30	3.2		
		Core Sound.........	--	--	1	--	--	--	--	1	.1		
		Total..........								618	65.6		
		Ocean Area #37.....	--	--	--	3	6	--	--			9	1.0
		#39.....	--				2		--			3	.3
		#70.....	--	--	1	--	--	--	--			1	.1
		Total..........										13	1.4
Apr.	310	White Oak River....	--	--	42	45	8	1	--	96	31.0		
		New River..........	--	--	--	2	2	--	--	4	1.3		
		Bogue Sound........	--	--	--	--	2	--	--	2	.6		
		Total..........								102	32.9		
		Ocean Area #36.....	--	--	--	--	1	--	--			1	.3
		#37.....	--	--	--	2	4	--	--			6	1.9
		#39.....	--	--	--	--	2	--	--			2	.6
		Total..........										9	2.8
May	398	White Oak River....	--	--	--	96	40	--	--	136	34.2		
		New River..........	--	--	--	--	2	--	--	2	.5		
		Bogue Sound........	--	--	--	2	--	--	--	2	.5		
		Total..........								140	35.2		
		Ocean Area #36....	--	--	--	1	3	--	--			4	1.0
		#37....	--	--	--	1	4	1	--			6	1.5
		#39....	--	--	--	--	1	1	--			2	.5
		Total..........										12	3.0
June	371	White Oak River...	--	--	--	--	80	6	--	86	23.2		
		Bogue Sound.......	--	--	--	--	--	1	--	1	.3		
		Total..........								87	23.5		
		Ocean Area #38....	--	--	--	--	--	1	--			1	.3
		#39....	--	--	--	--	2	2	1			5	1.3
		Total..........										6	1.6
Total	2,699	Recaptured: White Oak River (Site)........								1,287	47.7		
		Moved to other waters........								70	2.6	47	1.7
		Total........								1,357	50.3	47	1.7

[1] See Figure 1 for location of ocean areas.

Florida Studies, St. Johns River

Marlin E. Tagatz

Female blue crabs from St. Johns River, Fla., normally migrate to the mouth of the river or a short distance into the ocean to hatch their eggs. The larvae go through seven or eight zoeal stages and a final larval form, the megalops, before reaching the first crab stage. Plankton samples collected from the river have contained only the first and second zoeal stages and the megalops. Plankton samples collected from the ocean contained large numbers of early stage zoeae near the beaches with a progression to advanced stages 20, 40, and 60 miles offshore (Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C. Annual Report 1962, 1963). Crabs occur in the river in all sizes from adults down to the earliest crab stages.

It is fairly clear that the major portion of larval development takes place in the ocean and that at some time during the megalops stage, or shortly thereafter, the young crabs make their way into the river where they grow to maturity. It is important to know how, when, and in what quantities the young crabs enter the river.

We continued sampling with a seine and a small-mesh trawl during the past year at four locations that we had previously found to be preferred habitats of small crabs. These locations were Clapboard Creek, 8 miles from the mouth of St. Johns River; Dunn Creek, 14 miles from the mouth; Trout River, 20 miles from the mouth; and Buoy 24 at Picolata, 60 miles upstream from the mouth of the river.

The first catch of appreciable numbers of early crab stages in Dunn Creek, Trout River, and Buoy 24, Picolata, was in September 1963, 2 months later than in 1962. This was not unexpected, for spawning began later in 1963 than in 1962, probably because of lower water temperatures in spring 1963.

We collected relatively few of the first three crab stages (2-5 mm.) at the lower river stations (fig. 3), and none at the upper river site (fig. 4), indicating that most of the young crabs have already passed this period of development in the ocean before entering the river. It can be theorized that these small crabs are carried by tides and currents that move them into the river from considerable distances offshore. More information on this point needs to be developed.

There is little information available on the growth rate of blue crabs and none from the South Atlantic States. To provide some information on this subject, we began a study in St. Johns River in March 1963. The study consists of maintaining juvenile crabs in individual compartments in floats (fig. 5). The compartments are numbered and the length and width of each crab recorded. The floats are inspected every other day, the crabs fed cut fish, and newly molted crabs measured.

Since there is a possibility that growth of crabs in fresh water may differ from that in salt water, the study is being made at two locations: Clapboard Creek, 8 miles from the mouth of the river, and Palmo Cove, 58 miles from the mouth. There are 200 crabs at each location. The salinity at Clapboard Creek has ranged from 7.6 to 25.6 p.p.t. and has remained below 1 p.p.t. at Palmo Cove. Water temperatures at Clapboard Creek have been from 13.8° to 31.8° C. and at Palmo Cove from 17.4° to 31.6° C.

During the first 3 months of this study 914 molts occurred. Sixty-three crabs at the fresh-water location died and 27 at the salt-water location. One-third of the mortalities occurred during molting. We replaced dead crabs with live ones.

This new study is in progress, and the data are incomplete. At this time, however, there are no apparent differences between growth rates of crabs at the two locations.

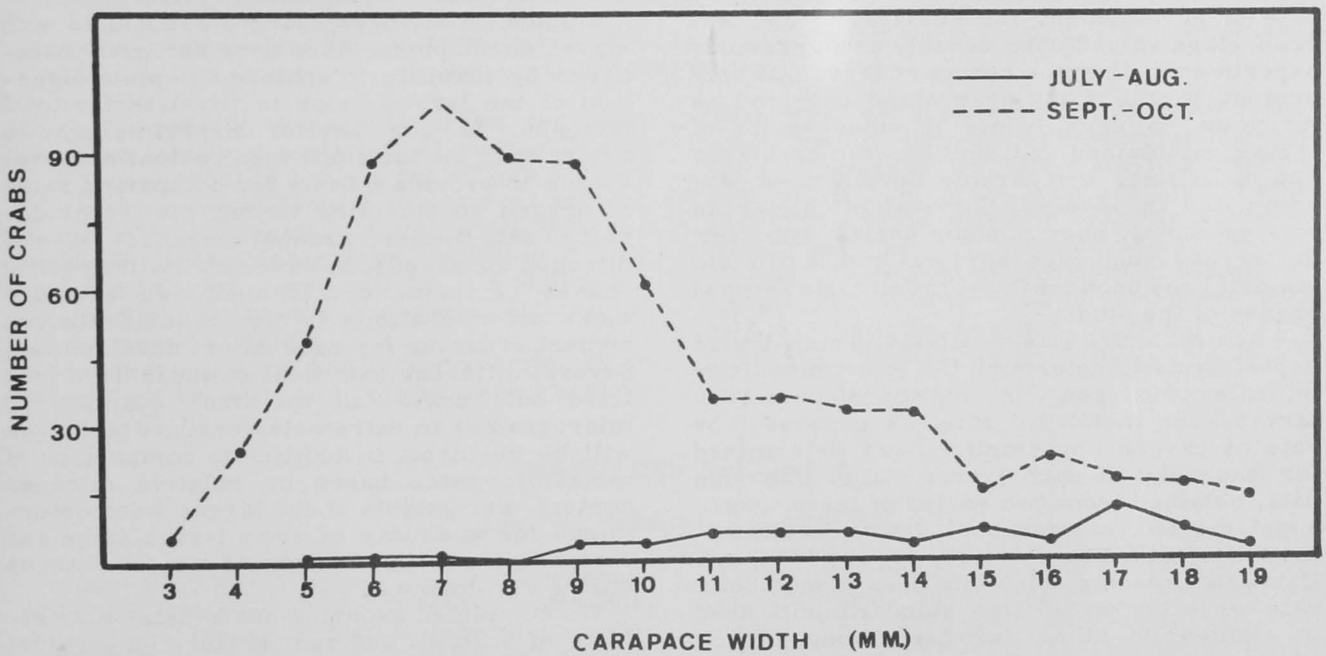

Figure 3.--Occurrence of blue crabs less than 20 mm. in width at Dunn Creek and Trout River, 1963.

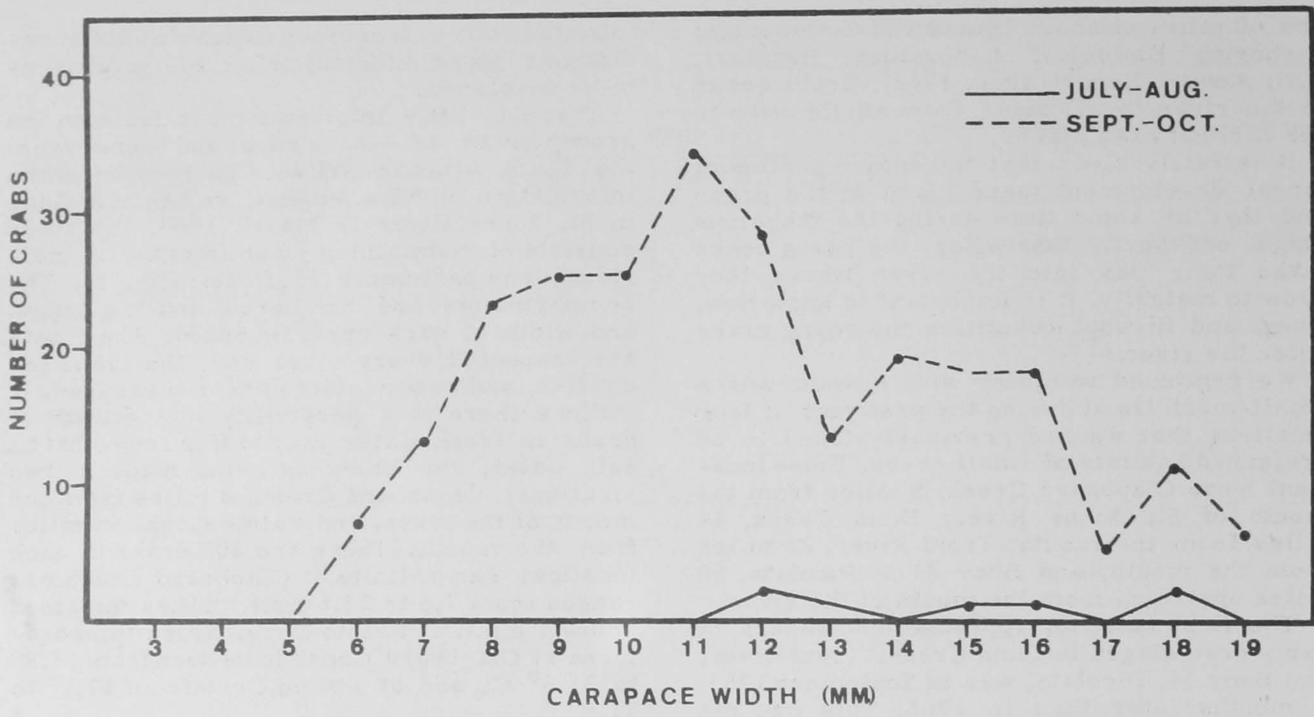

Figure 4.--Occurrence of blue crabs less than 20 mm. in width at Buoy 24, Picolata, 1963.

Larval Studies

(Contract No. 14-17-002-94)

John D. Costlow, Jr.
Duke University Marine Laboratory

Large numbers of blue crab larvae, obtained from different females, were maintained in the laboratory to provide experimental material for different phases of the program. The rate of development and survival to the first crab stage varied considerably as in previous experiments. In some series of larvae, development to the first crab stage required as many as 65 days, while in other series of larvae maintained at identical temperatures and salinities, comparable development was completed in 36 days. Survival of the larvae was extremely poor in some series, but a few series had such high survival that sufficient material has been available to complete several phases of the study.

When material was available, we continued experiments to determine the effect of salinity on rate of oxygen consumption of blue crab larvae. The metabolic rate, as expressed by rate of oxygen consumption, was determined for each day of each larval stage. Previous data, obtained from two series of larvae, were supplemented by additional determinations at the three salinities used (20, 30, and 40 p.p.t.). Data from earlier determinations of metabolic rate were converted into standard units used in studies on other animals. Using microliters of oxygen per larvae per hour, microliters of oxygen per microgram of weight per hour, and microliters of oxygen per microgram of nitrogen per hour, we compared experiments on different series of larvae. These units will permit comparison of our experiments with previous studies on larvae of many other marine species, as well as adult animals. Analyses were begun to determine if metabolic rates of developing blue crab larvae of the same stage vary significantly when the larvae are exposed to varying salinities.

Studies on nitrogen changes associated with larval development have been seriously hampered by inability to achieve complete digestion of the larvae prior to titration for total nitrogen. In our earlier experiments, we determined the total nitrogen content of larval stages to provide a basis for comparing rates of oxygen consumption throughout larval development. Because gradual increases in total nitrogen appeared to be associated with specific phases of larval development, we extended these determinations to include total nitrogen content of larvae for each day of development. Several different analytical methods have been tried but because of the small quantity (10 micrograms) an extremely sensitive technique will be required. In addition to comparison of metabolic rates based on relative nitrogen content, wet weights of the larvae were determined for each day of each larval stage and comparisons will be made of weight changes during development.

We completed experiments to determine effects of salinity and temperature on survival of megalops and the time required for metamorphosis. Using the computer facilities of

Figure 5.--Inspecting crab floats at Palmo Cove, St. Johns River, Fla. The biologist in this picture is measuring a crab that has molted since the last inspection.

Duke University, we are analyzing the data. We plan to use the statistical method of Box and Youle (1955) to project the effects of these two environmental factors over a much greater range of experimental combinations than are possible under laboratory conditions. This phase of the program will be completed this fall and winter when experimental animals no longer are available.

We are analyzing data from experiments on effects of salinity and temperature on early postlarval development of blue crabs. These experiments, designed to determine how salinity and temperature affect molting frequency and survival of crabs from the time of metamorphosis to the stage 10 crab, have provided data that also will require use of the Duke University computer. Portions of the analysis have been completed, and this phase of the program will be resumed when experimental material no longer is available.

MENHADEN PROGRAM

John W. Reintjes, Acting Chief

Since 1955 this program has been concerned with the biology of the Atlantic menhaden, Brevoortia tyrannus, and effects of environment and fishing on the populations that constitute the resource. Late in 1963 we began an additional investigation of the Gulf menhaden, B. patronus, and the purse seine fishery in the Gulf of Mexico. In April 1964, distribution and use of vessel logbooks and routine sampling of the catch were started for the Gulf menhaden fishery.

There were four major findings during fiscal year 1964: (1) Changes in year class and size composition of the Atlantic menhaden catch showed a drastic reduction in the numbers of older, larger fish so that fewer fish will be available to the fishery north of Chesapeake Bay at least for the next few years; (2) the estimated abundance of juveniles in the Atlantic coast estuaries indicated a relatively average abundance for the 1963 brood; (3) during the first half of the 1964 season, the catch of fine-scaled menhaden, B. smithi and B. gunteri, in the Gulf of Mexico was negligible; and (4) menhaden eggs were located off the Mississippi Delta in December, the first confirmed spawning locality for Gulf menhaden.

We began surveying surface water temperatures by airborne infrared radiometry as part of a cooperative study of the Continental Shelf. Monthly flights over coastal waters from Cape Hatteras to Cape Fear were made aboard U.S. Coast Guard aircraft. Drift bottles and seabed drifters were dropped at 25 locations on each flight as part of the Woods Hole Oceanographic Institution's study of coastal transport currents.

Sampling the Atlantic Menhaden Fishery

Joseph R. Higham, Jr., and
William R. Nicholson

Sampling Atlantic menhaden landings and collecting logbook records from purse seine vessels were continued. Catch records, sampling data, and characteristics of the fishery showed the general features of the condition of the resource, although calculation of detailed biostatistics including catch and effort was not completed for 1963 pending the adoption of automatic data processing.

In all areas except the South Atlantic the season was the poorest in recent years, and the catch declined for the third consecutive year. The landings were 44,000 tons in the North Atlantic area (79,000 in 1962), 137,000 tons in the Middle Atlantic area (307,000 in 1962), 116,000 tons in the Chesapeake Bay area (166,000 in 1962), and 69,000 tons in the North Carolina fall fishery (29,000 tons in 1962).

No single age group dominated the catch. In the Chesapeake Bay and lower Middle Atlantic areas, age-1 and age-2 fish, in about equal numbers, supplied most of the catch, with age-0 fish contributing large numbers of fish in late summer in the Chesapeake Bay area. In the Middle Atlantic area, fish age 2 to age 5, in about equal numbers, accounted for, roughly, 90 percent of the catch. In the North Atlantic area the 1958 year class (age 5) constituted the most abundant age group in the samples (40 percent), with age groups 3, 4, and 6 supplying most of the remainder. Age-1 and age-2 fish contributed the largest part of the catch in the South Atlantic area, with age-1 fish about 1.5 times the number of age-2 fish. Age-0 to age-3 fish constituted over 90 percent of the fish caught in the North Carolina fall fishery.

Sampling the Gulf Menhaden Fishery

Robert B. Chapoton

We began sampling commercial catches of Gulf menhaden and collecting catch and effort statistics during the year. Port samplers at Pascagoula, Miss., Empire, Morgan City, and Cameron, La. began sampling catches for age, size, sex, and species composition at the beginning of the fishing season in April 1964. Logbooks for recording the number and locations of purse seine sets were placed aboard vessels at all Gulf coast ports, and routine collections of data sheets continued through the fishing season. Records of daily vessel landings in 1963 and in all prior years, if available, were obtained at all plants. We have not completed or analyzed the data, pending adoption of automatic data processing methods.

Morphology and Population Studies

John W. Reintjes

We obtained some knowledge of the population structure of the Atlantic menhaden from (1) analyses of vertebral numbers of juveniles and adults, (2) movements and distributions by size and age, and (3) occurrence of fall-spawning fish and spring-spawning fish. Results indicated the existence of at least two groups of menhaden along the Atlantic coast. Apparent movements along the Atlantic coast determined from fishing activity and distributions by age and size indicate some mixing of these groups as adults. Spawning and non-spawning fish occur together in the Middle and North Atlantic areas during spring, summer, and early fall, but only spawning fish occur in North Carolina during late fall and winter. Further inquiry into population structure by analysis of vertebral counts is not indicated unless some confirmation of the apparent differences can be obtained from more direct methods.

We are studying distribution and morphology of the two fine-scaled menhadens, B. gunteri and B. smithi, to provide a key for identification. The similarity in body shape and the overlap of meristics make species identification difficult in the field. Only small quantities of fine-scaled menhaden have appeared in the

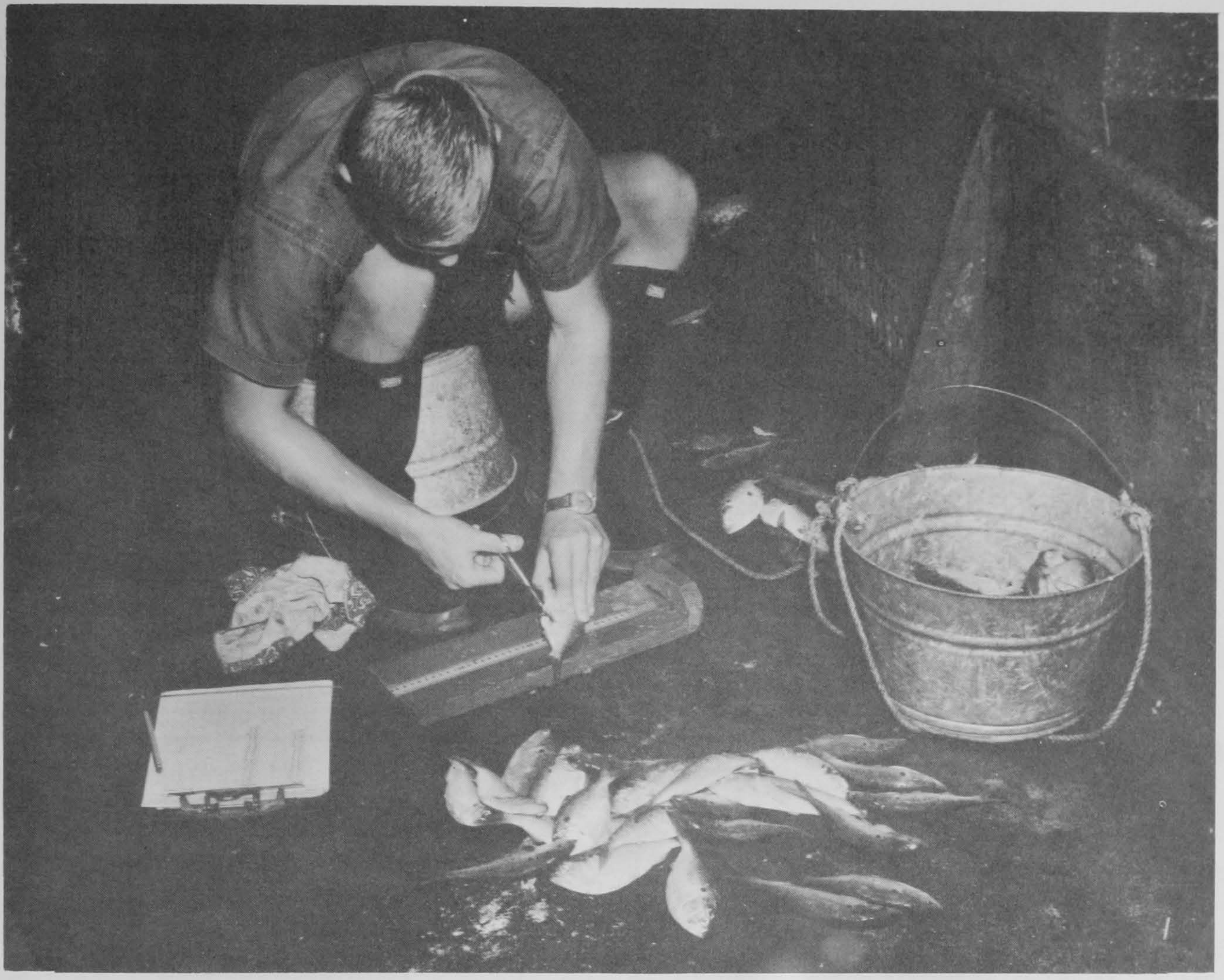

Figure 6.--Sampling the purse seine landings for size, age, and sex composition of Gulf menhaden.

purse seine landings in the Gulf of Mexico. Unconfirmed reports of large catches of these species in some years have caused us to continue our surveillance.

Estimation of Juvenile Abundance

Anthony L. Pacheco

Our principal effort in estimating abundance of juvenile Atlantic menhaden of the 1963 year class in selected estuarine nurseries was to continue standard survey techniques for the third consecutive year. In conjunction with Petersen mark-and-recovery experiments, we conducted seining and surface trawling for relative, as well as absolute, estimates of abundance during July and August. We counted schools of juvenile menhaden from an airplane during September and October, the time when schools were migrating from nurseries. This aerial survey included one track across the inshore waters of the Gulf of Mexico to obtain an estimate of juvenile Gulf menhaden abundance. In addition, exploratory surface trawling was done at eight estuarial locations during late June to gather information for initial estimates of the 1964 year class.

Population estimates from marking experiments in eight selected tributaries from South Carolina to Massachusetts are shown in figure 7 with results of the 3 consecutive years of relative abundance estimates from standard seine hauls. The data indicate that in many of the tributaries surveyed juveniles of 1963 were more abundant than were the 1961 and 1962 year classes, particularly in North Carolina and parts of Chesapeake Bay. Although consistently large numbers of juvenile menhaden have occurred in Massachusetts, we have no information to suggest these fish contribute materially to commercial stocks of the North Atlantic area.

Replicate flights from Massachusetts to northern Florida covered over 5,400 miles of

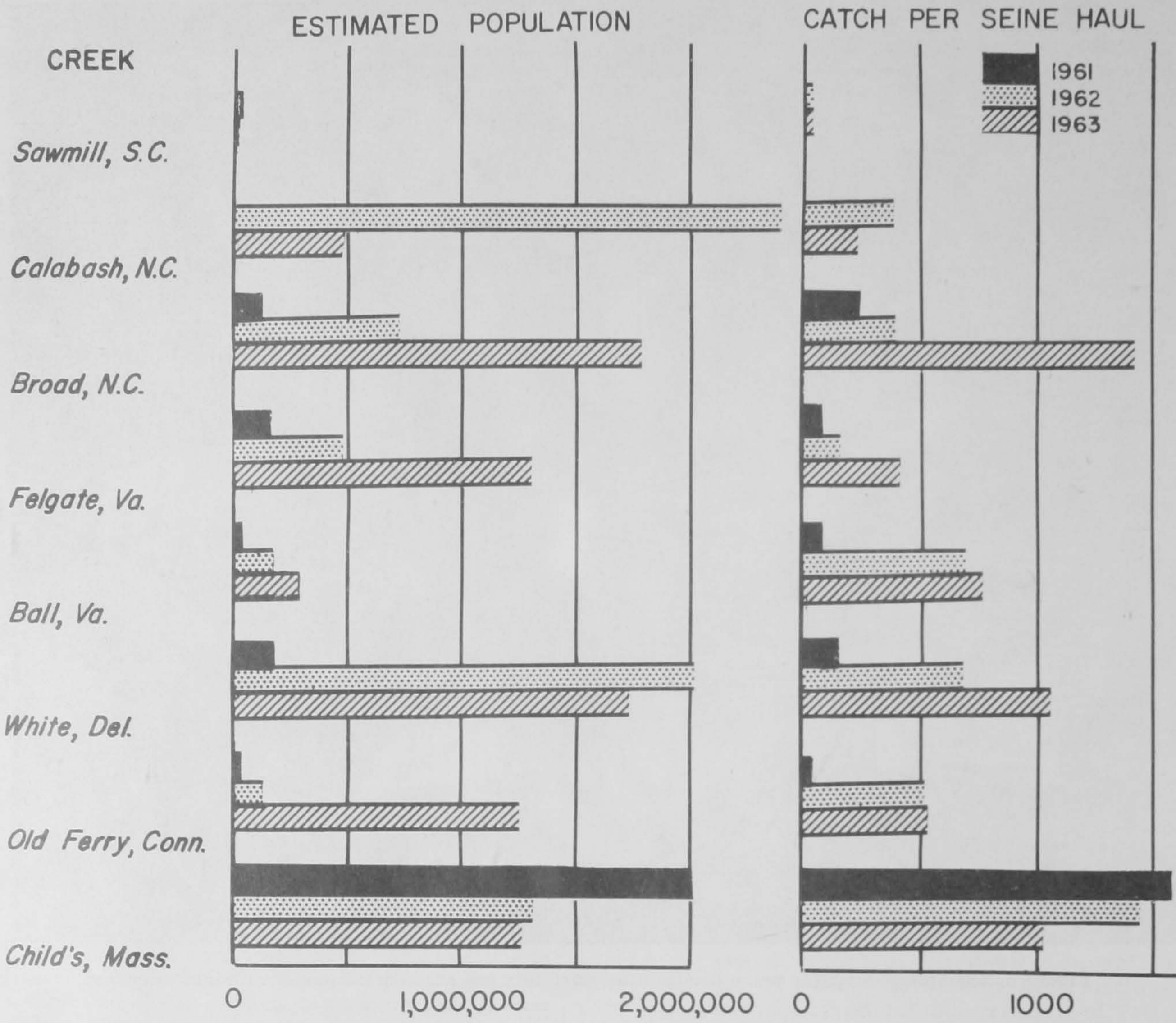

Figure 7.--Estimated summer population and their average catch per haul seine of juvenile menhaden in eight small Atlantic coast tributaries from 1961 to 1963.

estuarine shore. It was necessary to repeat flights in order to have optimum conditions, with regard to weather and distribution of fish in important large nursery areas. Counts of menhaden schools from selected Atlantic coast estuaries are summarized below and compared with 1962 results.

	Schools per mile	
	1963	1962
Long Island Sound (N. shore)......	7.2	18.9
Upper Chesapeake:		
Severn River to Patuxent	6.5	12.0
Patuxent River....................	8.6	16.7
Potomac River.....................	12.0	13.6
Lower Chesapeake:		
Rappahannock River..............	2.1	9.9
York River..........................	0.9	0.3
James River........................	3.9	3.4
Albemarle Sound	13.2	3.4
Pamlico Sound	6.1	2.8
Charleston River....................	23.8	12.4
Savannah River (visibility poor in 1963)	2.6	21.2

Counts of schools along the Atlantic coast suggested fewer 1963 juveniles compared with those of 1962, except in North Carolina and

South Carolina where counts increased 2 to 3 times over the previous year.

In addition, we made an aerial survey along the Gulf coast from Apalachee, Fla., to Corpus Christi, Tex. Results from the 2,500-mile survey track indicated fewer juvenile menhaden schools compared with a similar 1962 survey, as follows:

	Survey miles	Schools per mile	
		1963	1962
Open shore	390	0.4	5.6
Large sounds	110	2.0	4.2
Embayments and rivers	1,980	2.4	5.0
Overall mean		2.1	5.1

Exploratory surface trawling was conducted in August for an estimate of 1964 juvenile abundance (fig. 8). These results are compared with similar data collected from the same areas in late June. Most areas showed a decline in relative abundance in the August surveys, although Calabash and Bath showed increases. These results point out the variability encountered in these studies.

Suitably timed with regard to location and tide, surveys in late June show promise of developing into a standard estimation method. Fish are small, concentrated in tributaries, and probably at their highest level of availability to the surface trawl. This technique would be particularly useful in the Chesapeake, South Atlantic, and Gulf of Mexico nursery tributaries.

By obtaining comparative data from a variety of estimation techniques, we plan to evaluate their respective ability to measure annual changes in availability. When mean indices are established and correlated with the catch of yearlings in the fishery, we should be able to predict the density of juveniles between and within areas on an annual basis, 6 to 12 months before they are available to the fishery.

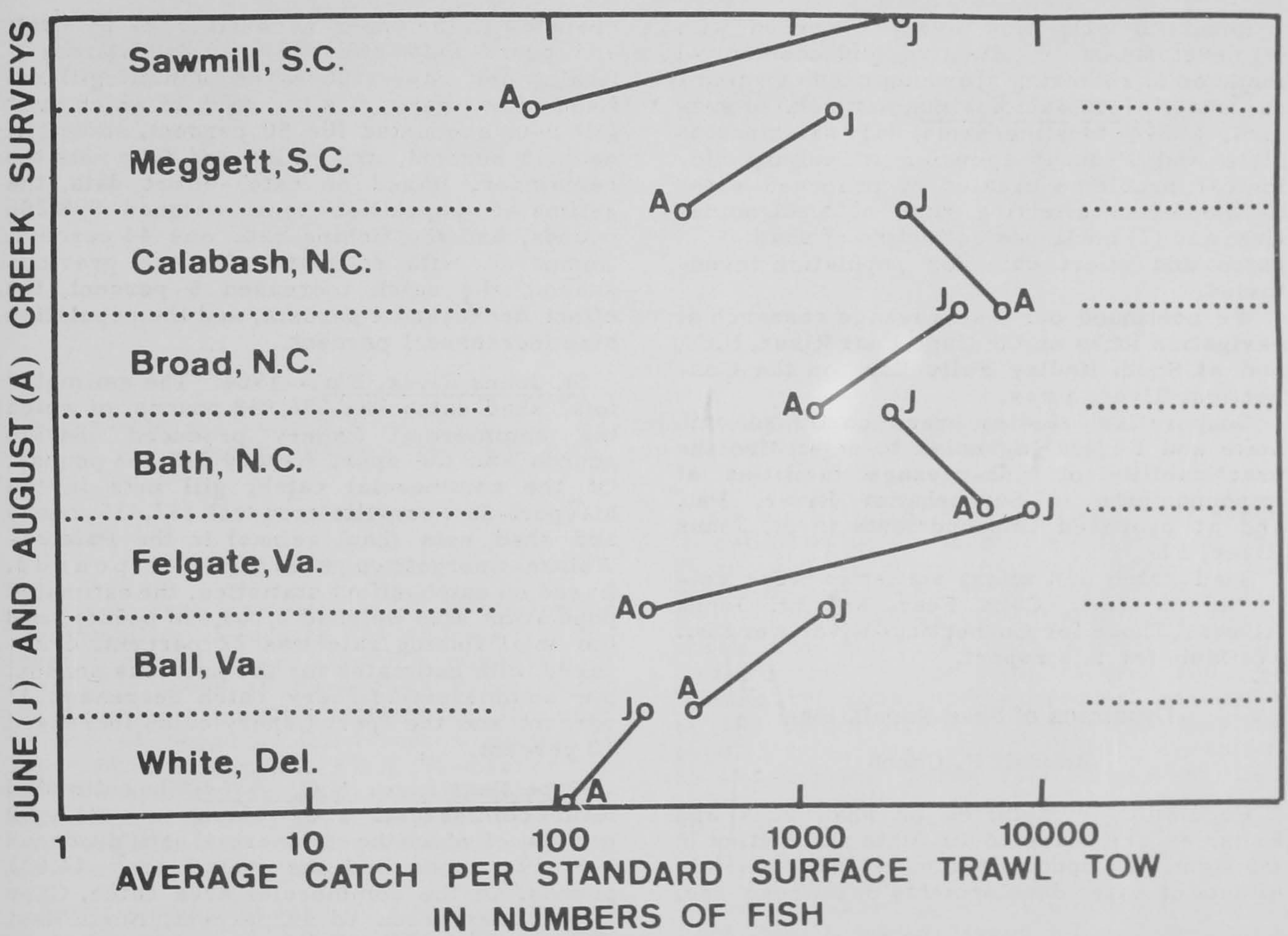

Figure 8.--The catch of juvenile menhaden in 5-minute tows made in late June and August 1963 at eight Atlantic coast tributaries. (Upper point--June; lower--August for each area.)

Estuarine Biology of Young Atlantic Menhaden

Robert M. Lewis

Laboratory experiments were made to determine the lower temperature tolerance limits of Atlantic menhaden larvae held at various acclimation temperatures. Acclimation temperatures were a factor in limiting the number of larvae that died at a specific test temperature.

Larvae were acclimated for 12 hours or longer at temperatures of 7.0°, 10.0°, 12.5°, 15.0°, and 20.0° C., then held at temperatures between 0.0° and 6.0° C. by half-degree intervals. For each test the median value to 50 percent mortality was calculated from four replications.

With few exceptions, larvae acclimated at 7.0° C. survived 0.0° to 4.0° C. for about 1.5 to 3.5 times longer than those acclimated to warmer temperatures. There was a marked difference in survival time of larvae acclimated at different temperatures and tested at 4.5° C. For example, larvae acclimated at 7.0° and 10.0° C. lived over twice as long as those acclimated at 12.5° or 15.0° C. Larvae lived equally well at 5.0° C. for all acclimation temperatures. Those tested at 5.5° C. and above survived for about 6 days or more, except for larvae acclimated at 15.0° C. This series showed poor survival at 6.0° C., probably because of factors other than temperature.

Based on these data, it appears that acclimation temperature is more important to survival of larvae at test temperatures less than 5.0° C. than at 5.0° C. and above.

SHAD PROGRAM

Paul R. Nichols, Chief

Research activities were concerned with (1) development of effective and economical methods of restoring spawning runs of American shad, Alosa sapidissima, and related species, above existing dams; (2) assistance to State and Federal agencies in solving biological problems created by proposed water developments affecting runs of anadromous fish; and (3) continued collection of shad catch and effort data for population inventories.

We continued our fish-passage research at navigation locks on the Cape Fear River, N.C., and at South Hadley Falls Dam on the Connecticut River, Mass.

Cooperative studies were continued with State and Federal agencies to determine the practicability of fish-passage facilities at impoundments in Susquehanna River, Pa., and at proposed impoundments in St. Johns River, Fla.

Shad catch and effort statistics were collected on York, Cape Fear, and St. Johns Rivers. Those for Connecticut River were not available for this report.

Dynamics of Shad Populations

Randall P. Cheek

Population inventories on shad runs and fisheries are made to aid State authorities in managing the species and to evaluate possible effects of water developments on the resource.

York River, Va.--1964: The estimated commercial shad catch was 440,892 pounds. Of this total catch, drift gill nets operated in the tributaries (Mattaponi and Pamunkey Rivers) caught 39 percent; stake gill and fyke nets operated in the upper York River, 52 percent; and pound nets effort was 15,210 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 50 percent, stake gill nets 43 percent, and pound and fyke nets the remainder. Based on catch-effort data, the estimated population size weighed 998,200 pounds, and the fishing rate was 44 percent. Compared with estimates for the previous season, the catch increased 5 percent, the effort decreased 4 percent, and the population size increased 1 percent.

St. Johns River, Fla.--1964: The estimated total shad catch was 696,958 pounds, of which the commercial fishery produced 484,375 pounds and the sport fishery 212,583 pounds. Of the commercial catch, gill nets in the Mayport-Jacksonville area took 152,435 pounds and shad nets (haul seines) in the Palatka-Welaka-Georgetown area 331,940 pounds. Based on catch-effort statistics, the estimated population size weighed 3,105,638 pounds, and the total fishing rate was 22 percent. Compared with estimates for the previous season, the commercial fishery catch decreased 32 percent and the sport fishery catch increased 10 percent.

Cape Fear River, N.C.--1964: The estimated total commercial shad catch was 213,150 pounds, of which the commercial area produced 168,529 pounds and the inland area 44,622 pounds. Of the commercial area catch, Cape Fear River produced 49 percent, North East Cape Fear River 48 percent, and Black River 3 percent. Of the inland area catch, North East Cape Fear River produced 93 percent and Black River the remainder. The total catch increased 17 percent over that in 1963.

Figure 9.--Fish wheel used on Roanoke River, N.C., for capturing shad and other migratory fish. (Fish wheels were once an important commercial fishing gear; this is the last one on the Atlantic coast.)

Fishway Studies

Paul R. Nichols

Studies were continued to (1) determine the practicability of locking anadromous fish upstream during their spawning migration at navigation locks in Cape Fear River, N.C.; (2) determine possible effects on the shad fishery of proposed flood control project in upper St. Johns River, Fla.; (3) observe fish passage by the fish lift at South Hadley Falls Dam, Connecticut River, Mass.; and (4) determine the suitability of Susquehanna River, Pa., for restoring runs of shad.

Experimental lockage of fish at Lock and Dam No. 1, Cape Fear River, N.C.--1964: We continued cooperative studies with the U.S. Army Corps of Engineers and the North Carolina Wildlife Resources Commission on the practicability of locking anadromous fish upstream during their spawning migration.

We tagged shad in lower Cape Fear River to estimate the number of shad entering the river, fishing rate, and distribution of the spawning escapement to North East Cape Fear River, Black River, and Cape Fear River above the mouth of Black River (fig. 10). Preliminary findings from tagging and releasing 685 shad, with subsequent recapture of 183 of the tagged fish, indicated that the population size was 259,200 fish, the catch 69,250, and the fishing rate 27 percent. Escapement of the spawning population was 109,410 fish to North East Cape Fear, 4,560 to Black, and 75,980 to Cape Fear above the mouth of the Black.

Periodic sampling of fish movement through Lock No. 1 began March 17 and continued through May 12. During this interval, we observed 18 lockages, requiring a total of 33 hours. The Corps of Engineers operated the lock for fish passage for an additional 62 hours. Based on the number of fish netted in

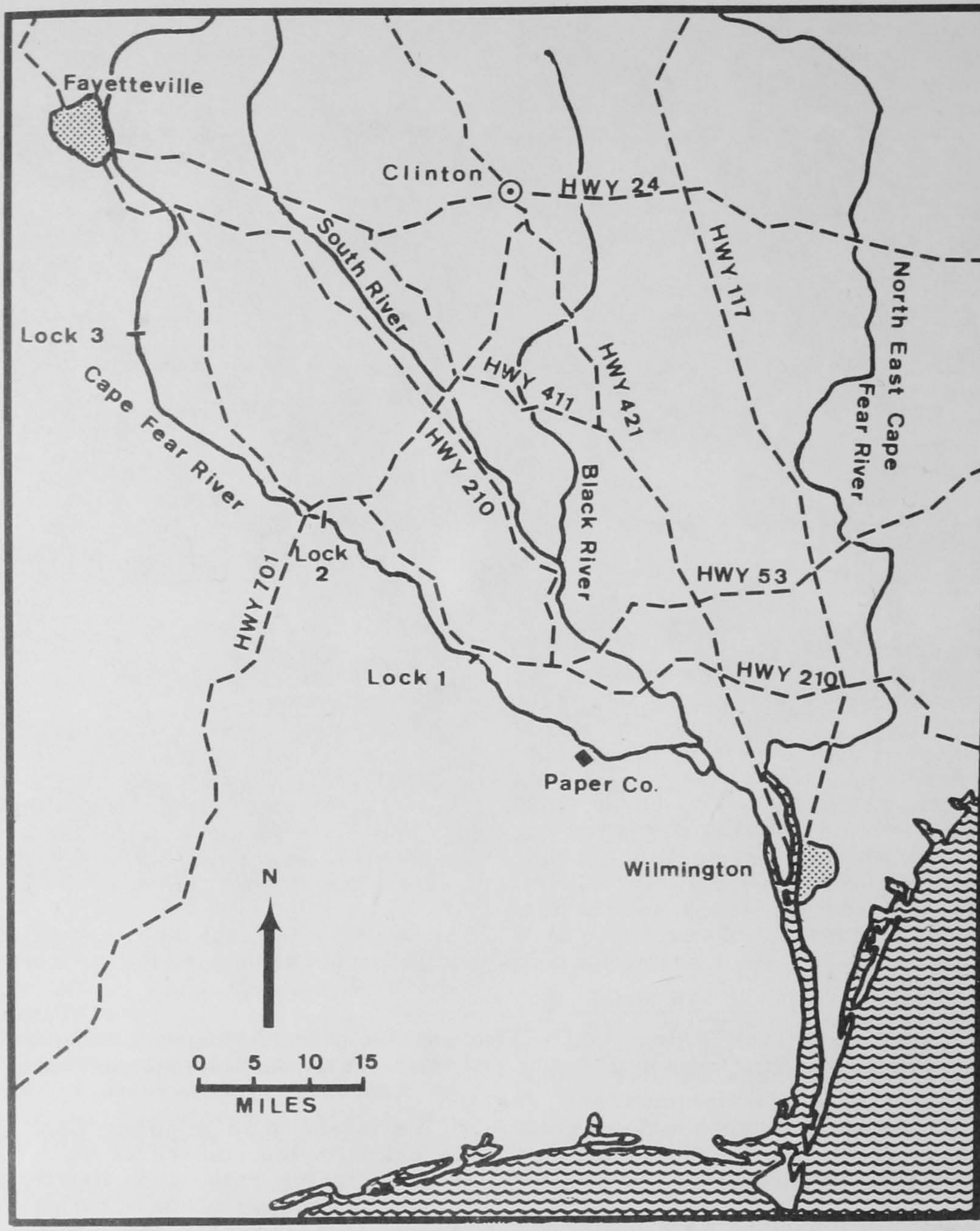

Figure 10.--Cape Fear River study area.

the lock chamber during periodic sampling with haul seine, an estimated 950 American shad and 4,180 alewives, A. pseudoharengus, and glut herring, A. aestivalis, were passed. Most of the fish are glut herring, but no export separation was attempted. During the sampling period, about 86 percent of the shad were passed from April 7 to May 7 when water temperatures ranged from 18.9° to 20.5° C., and 75 percent of the alewives and herring were passed from March 17 to April 7 when water temperatures ranged from 12.0° to 12.8° C. The number of shad passed per hour decreased 21 percent below the previous season, while the number of alewives and herring passed per hour increased 91 percent.

Lock No. 2, 35 miles upstream from Lock No. 1, was sampled for fish movement through the lock on May 14 and 22. On May 14, one lockage was made requiring 4½ hours, and 87 shad, 45 glut herring, and 2 striped bass, Roccus saxatilis, were passed. On May 22, one lockage was made requiring 4½ hours, and 77 shad and 1 striped bass were passed.

Practicability of fish passage facilities, upper St. Johns River, Fla.--1964: We continued cooperative studies with the Bureau of Sport Fisheries and Wildlife to determine possible effects on the shad fishery of a proposed flood control project in St. Johns River south of Lake Harney. The purpose of this study is to determine the size of the shad sport fishery in the upper river and use of the area south of Lake Harney by shad for spawning and nursery grounds.

The sport fishery began south of Lake Harney in mid-January and continued until the end of March. The estimated catch was 16,820 shad in 3,400 man-days' fishing--9,725 fish were landed in 1,750 man-days at Highway 50 bridge, 6,020 in 1,400 man-days at Highway 520 bridge, and 1,075 in 250 man-days at Highway 192 bridge. The estimated total river shad sport catch was 80,220 fish in 23,730 man-days' fishing, of which the area south of Lake Harney produced 21 percent of the catch and accounted for 14 percent of the man-days' fishing. Last year the river south of Lake Harney produced 31 percent of the sport catch and accounted for 20 percent of the effort.

To supplement information collected last year on use of the river south of Lake Harney by shad for spawning, we took 24 egg-net samples on March 24-27 at 19 stations. Preliminary analyses indicated that shad spawned throughout the area from Lake Harney to Lake Winder. Most spawning occurred between bridges on Highways 50 and 520. No eggs were collected south of Lake Winder. Larval stages were collected near Highway 50 bridge. When collections were taken, the water temperature ranged from 18.9° to 21.1 °C.

To supplement information collected last year on use of the river south of Lake Harney by shad for nursery grounds, we took 5 surface trawl and 30 "Pro-noxfish"[1] samples on August 4-13 at 19 stations. Young shad were taken near Puzzle Lake and Highway 46 bridge. During the sampling period the water temperature ranged from 26.7° to 33.3° C. Similar findings resulted from last year's sampling.

Preliminary indications are that proposed impoundments in the flood control project for the upper river would eliminate about 20 percent of the sport fishery and bar a sizable portion of the run from established spawning grounds, possibly eliminating the upper river's contribution to the fishery.

Hadley Falls Dam fish lift on the Connecticut River--1964: The fish lift was operated 38 days (May 12 to June 25). Passage of American shad was 35,397 fish--an increase of 18 percent over the number passed in 1963. On June 9, 3,606 shad were lifted--a record for any one day's passage. Numbers of other species using the fish lift were 1 sturgeon, *Acipenser* sp.; 13 alewives; 61 trout, *Salmo* sp.; 2 carp, *Cyprinus carpio*; 311 bass, *Micropterus* sp.; 98 yellow perch, *Perca flavescens*; and 9 walleyes, *Stezostedion vitreum*. More lampreys, *Petromyzon marinus*, were removed from the fish lift this year than in any previous operation--a total of 537. During lifting operations, the water temperature varied from 60° to 77° F., and a peak number of 11,118 shad were lifted at water temperatures from 67° to 70° F. during the 4-day period from June 9-12 (table 3).

Cooperative Susquehanna River fishway studies--1964: Together with the Bureau of Sport Fisheries and Wildlife, Maryland Department of Research and Education, Pennsylvania Fish Commission, and New York

Table 3.--Shad passed by fish lift, Hadley Falls Dam, Connecticut River, 1964

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

Date operated	Daily lift	Cumulative total	8 a.m. water temperature
	Number	Number	°F.
May 12..	571	571	62
13..	804	1,375	63
14..	31	1,406	62
16..	14	1,420	60
18..	184	1,604	61
19..	650	2,254	62
20..	37	2,291	61
21..	6	2,297	62
22..	399	2,696	62
23..	585	3,281	63
24..	1,503	4,784	64
25..	1,825	6,609	66
26..	576	7,185	64
27..	1,268	8,453	66
28..	883	9,336	65
29..	422	9,758	64
30..	2,677	12,435	64
31..	1,054	13,489	65
June 1..	1,925	15,414	66
2..	1,985	17,399	67
3..	1,084	18,483	65
4..	528	19,011	66
5..	415	19,426	64
6..	468	19,894	65
8..	3	19,896	66
9..	3,606	23,503	67
10..	3,371	26,874	68
11..	2,026	28,900	69
12..	2,115	31,015	70
15..	771	31,786	71
16..	625	32,411	71
17..	1,007	33,418	70
18..	472	33,890	70
22..	726	34,616	75
23..	227	34,843	76
24..	464	35,307	77
25..	90	35,397	77

[1] Trade names referred to in this publication do not imply endorsement of commercial products.

Conservation Department, we continued studies to determine suitability of the Susquehanna River for restoring runs of American shad.

Young shad hatched in spring 1963 in North Branch of the Susquehanna River and Juniata River successfully moved downstream through York Haven and Safe Harbor impoundments into Holtwood impoundment during their fall migration. In October, several thousand young shad were observed immediately upstream of the trash rocks at turbine intakes in York Haven Dam. None was observed in other downstream impoundments. Surface water temperatures in the impoundments ranged from 17.8° to 12.2° C. Oxygen concentrations at four sites on a transect 500 feet above the dams ranged from 7.0 p.p.m. at the surface to 4.5 p.p.m., in depths more than 60 feet. In November, young shad were seen in both York Haven and Holtwood impoundments. Limited numbers of fish that were feeding like shad were seen in the Conowingo impoundment near the dam. Surface water temperatures in the impoundments ranged from 15.5° to 8.9° C. From December 6-14, about 100 young shad, 95 to 175 mm. fork-length, were collected from rotating screens at Holtwood stream stations. In mid-December, ice formed over the impoundments, and observations were discontinued. If shad passed the two upper dams, similar passage would be expected at the lower dams.

From April 26 to May 11, studies were made on adult shad to determine the extent and nature of upstream and downstream movement of fish transplanted from Susquehanna Flats area to holding facilities in Conowingo impoundment. Of 760 adult shad from Susquehanna Flats, 689 (90.6 percent) survived transport to the holding facilities. Ultimately, 509 were released, of which 10 were marked with sonic tags[2] and 294 with Petersen tags. Limited recoveries (3.9 percent) of the Petersen tags indicated that the shad moved downstream after release (table 4). Tracking patterns from sonic tags suggested similar movement. We believe that the holding pens were not in a suitable location, however, and this may have contributed to this downstream movement. Next year we plan to use other locations for the holding pens to determine if locations have any effect on migration.

Table 4.--Recaptures from 294 American shad tagged in Conowingo impoundment, Susquehanna River, April 26 to May 11, 1964

Date recaptured	Location	Distance from release site	At liberty
		Miles	Days
April 27...	Whorton Point--Chesapeake Bay....	26	1
May 3...	Susquehanna Flats................	14	2
4...	Meeks Point--Chesapeake Bay......	26	2
4...	Whorton Point--Chesapeake Bay....	28	2
5...	Deep Creek--Lower Susquehanna R..	6	6
20...	Susquehanna Flats................	12	16
20...	do. do.................	14	11
20...	do. do.................	14	10
22...	Lower Susquehanna River..........	8	15
22...	Susquehanna Flats................	10	26
25...	do. do.................	16	26
June 6...	do do.................	12	32

Studies to determine suitability of the river above the impoundments for successful hatching of shad eggs and larval development were continued from May 15 to June 30. We obtained about 4 million fertilized eggs from the Susquehanna Flats area and 16 million from the Columbia River on the West Coast for the study. Survival of the eggs in transit to the hatching sites were 74 percent for Columbia River eggs, and 81 percent for Susquehanna Flats eggs. Fertilized eggs from both sources were distributed in Juniata River, North Branch of the Susquehanna River, and Clarks Ferry and Sunbury, Pa., on Susquehanna River. At the hatching sites the water temperature ranged from 18.9° to 26.7° C., pH from 7.1 to 8.4, dissolved oxygen from 5.8 to 9.2, total alkalinity from 32 to 93, acidity from 0.0 to 4.0, total iron from 0.04 to 1.5, and sulphates from 26 to 171. The number of experiments and average egg survival at each hatching site were: North Branch of the Susquehanna River, 6 with 76 percent; Juniata River, 4 with 59 percent; Clarks Ferry, 6 with 58 percent; and Sunbury, 5 with 65 percent. Preliminary conclusion was that water quality above the impoundments, at least in areas tested, was suitable for hatching shad eggs.

ATLANTIC COAST STRIPED BASS PROGRAM

Paul R. Nichols, Chief

Our studies of striped bass were continued in Albemarle Sound, N.C., in cooperation with William W. Hassler of the University of North Carolina, Raleigh, and in Maryland waters of Chesapeake Bay in cooperation with Chesapeake Biological Laboratory, Solomons, Md. In both areas, the striped bass fishery is an important, year-round activity involving several thousand sport and commercial fishermen. The average annual combined commercial catch is about 5 million pounds, worth more than $1 million.

[2]The sonic tag was a transparent plastic toroid, 1-15/16 inch long by 9/16 inch diameter, 0.6 ounce dry weight with attachment strap, and operated for 4 to 5 days. It emitted a signal of 2 to 5 pulses per second at 158 kilocycles when activated. Portable tube-type signal detector units were used for tracking.

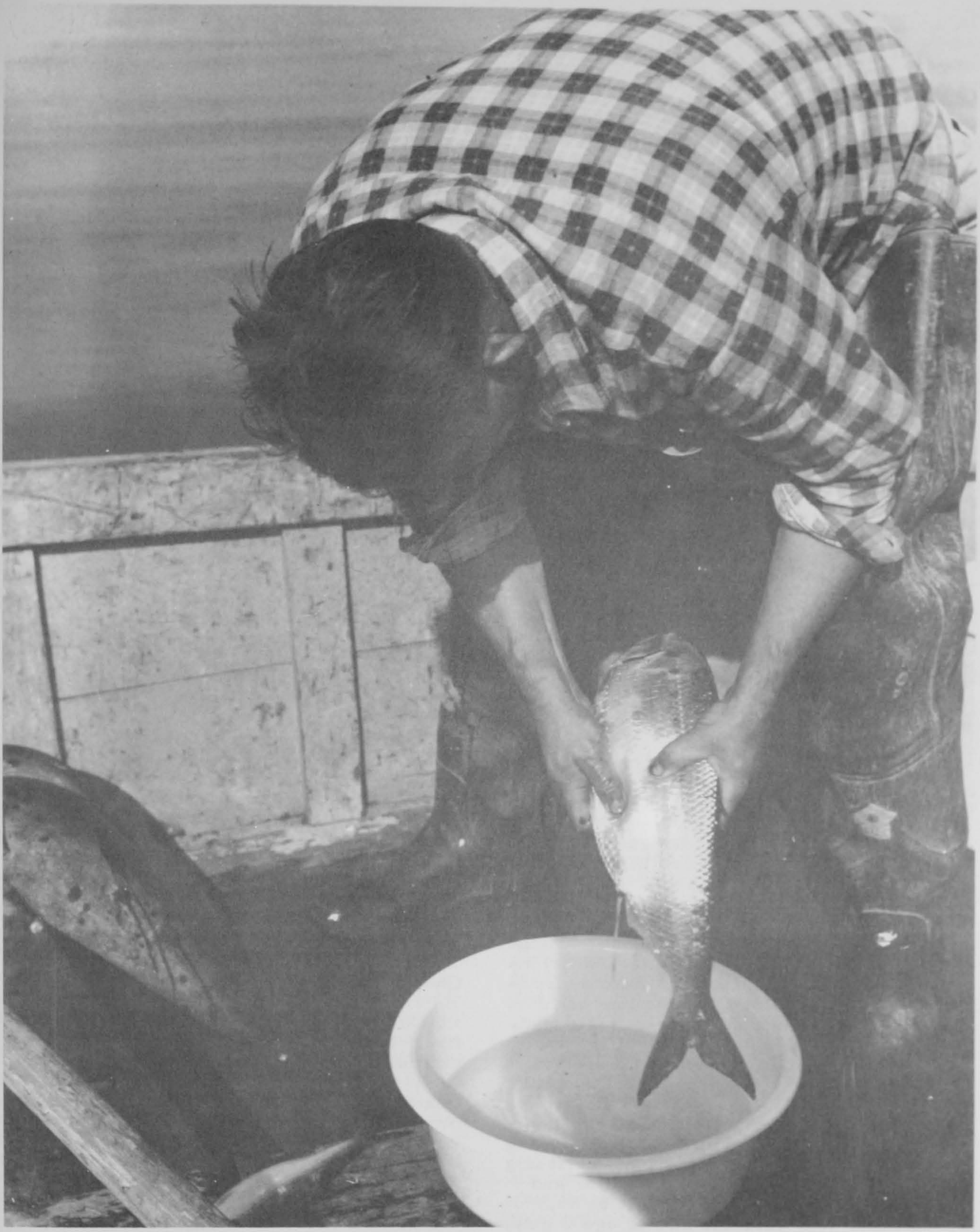

Figure 11.--Stripping female shad to obtain live eggs for hatching experiment.

Our striped bass research concerns primarily the population available to the commercial fishery in Albemarle Sound and seasonal movement of striped bass in Chesapeake Bay and its tributaries and their contribution to stocks of fish occurring along the northeast Atlantic coast.

Albemarle Sound Cooperative Study

Randall P. Cheek

Striped bass research included (1) trawling for young-of-the-year and sampling commercial catches for predicting relative year class strength and population size 1 year in advance of exploitation; (2) collecting catch-effort statistics for estimates of population size available to the fishery in Albemarle Sound; and (3) tagging studies and collecting catch-effort statistics for estimates of size of spawning population in Roanoke River and exploitation by the commercial fishery.

Albemarle Sound--1964: Our information on the stocks is based on the results of tagging and sampling. The estimated fishable population weighed 1,692,386 pounds, the fishing rate was 22.4 percent, and the catch 379,560 pounds. Age composition of the commercial catch was 95.8 percent in ages 2 and 3 and 4.2 percent in age 4 and older. The catch was 28.7 percent less than the 7-year average of 532,359 pounds. The estimated fishing rate was 22.7 percent less than the 7-year average of 29.0 percent. Predicted age composition derived from regressions calculated prior to the fishing season showed that the catch should consist of 88.8 percent in ages 2 and 3 combined. The estimated percentage of these ages in the catch was 95.8 percent.

Regressions have been designed to yield estimates of the number of fish in the catch of ages 2 and 3 separately. These regressions indicated that age 2 should comprise 50.6 percent of the catch. The observed percentage was 51.5. These regressions indicated that the percentage composition of age-3 fish in the catch should be 38.2 percent, while the estimated percentage based on sampling was 44.3 percent. Regressions designed to yield estimates of the combined weight of age-2 and -3 fish in the population resulted in a prediction of 1,581,300 pounds, compared to an estimated 1,621,306 pounds of age-2 and -3 fish in the population based on catch-effort data.

Based on regression analyses, the following predictions are made for the 1964-65 fishing season: (1) the percentage of age 2 and 3 combined in the population should be 86.3; of age 2 only, 46.0 percent; and of age 3 only, 40.3 percent; and (2) the total fishable population of striped bass should weigh about 1,573,170 pounds.

Roanoke River--1964: Roanoke River in North Carolina produces young striped bass that grow to maturity in Albemarle Sound. In the river, sport and commercial fisheries for adults on their spawning migration have made annual catches in recent years ranging from 15,000 to slightly over 44,000 striped bass.

The catch in 1964 was 44,208 fish--an increase of 121.7 percent over the previous season. A total of 557 striped bass were tagged and released during their spawning run in Roanoke River in 1964. Based on tag recaptures, the fishing rate was 10.2 percent--a decrease of 56.8 percent from the previous season. The preliminary population estimate is 431,997 fish.

Chesapeake Bay Cooperative Study

Paul R. Nichols

A major activity was striped bass tagging during wintering and spawning seasons in the Maryland part of Chesapeake Bay and its tributaries to obtain information on seasonal movement of the tagged fish, particularly of those that left the bay. Analyses of data from large-scale tagging programs during wintering, spawning, and feeding seasons in Potomac River, 1959-61, contributed to our knowledge.

The seasons of tagging and recapture were designated in terms of striped bass activity in Maryland waters as follows: wintering season, November-March; spawning season, April-June; and feeding season, July-October.

Chesapeake Bay and tributaries--1964: Fifteen hundred striped bass were tagged and released during February and March (wintering season) in the Maryland part of Chesapeake Bay and 1,376 fish from April to June (spawning season) in the bay tributaries. Subsequent recaptures have totaled 893 tagged fish. Preliminary results indicate that most of the recaptured fish were taken in Maryland waters and only three of the tagged fish were recovered outside Chesapeake Bay. No recaptures have been reported in the Virginia part of Chesapeake Bay.

Prior to release, we obtained lengths, weights, and scale samples from the tagged fish. Mature fish were sexed by manually extruding eggs or milt, and immature fish were sexed by removing a piece of gonadal tissue through the oval opening with special forceps and examining the tissue under a microscope. The fish were tagged with (a) a Nylon streamer with a trailing plastic disk, threaded through the back of the fish and securely knotted, and (b) Petersen red plastic disks, attached by means of a nickel pin inserted directly through the back of the fish.

Preliminary results from tagging and releasing 1,500 striped bass during the wintering

Figure 12.--Sampling "jumbo" striped bass from haul seine fishery on Outer Banks, N.C.

season in the bay indicated that (1) within the season of release, 357 (62 percent) of the tagged fish recaptured were taken near the release site and 63 (11 percent) were recovered in the tributaries; (2) during the spawning season, 84 (15 percent) of the tagged fish were recaptured in the bay and 43 (8 percent) were taken in the tributaries; and (3) in the following feeding season 20 (3 percent) of the tagged fish were recaptured in the bay, 1 (less than 1 percent) was taken in the tributaries, and 1 was taken in Housatonic River, Conn.

Preliminary results of tagging and releasing 1,376 striped bass during the spawning season in the tributaries indicate that (1) within the season of release, 47 (14 percent) of the tagged fish recaptured were taken in the tributaries; (2) late in the spawning season and early in the feeding season, 273 (84 percent) of the tagged fish recaptured were taken in the bay, and 2 (less than 1 percent) were recaptured outside Maryland waters. Of the two outside recaptures, one was taken May 31 at Bowers Beach in Delaware Bay, and the other on July 31 off Warren Point, R.I.

Although most recaptures were made near the release site, some fish traveled great distances within Chesapeake Bay and tributaries, and a small number traveled greater distances outside Maryland waters.

Analyses are continuing on coastal migration and seasonal movement of tagged fish by size and age classes and by sex within Chesapeake Bay and tributaries. As far as we know, this is the first attempt to sex immature striped bass before tagging and release; therefore, the study should contribute much to our knowledge of movements of sexually immature fish and of the life history of the species. The relative fishing intensities in different localities will have to be considered in the final analysis of these tag returns.

Potomac River--1964: Results of our tagging and releasing 8,973 striped bass during wintering, spawning, and feeding seasons from 1959 to 1961, with subsequent recapture of 3,348 tagged fish, indicated that most recaptured fish were taken in the Maryland part of Chesapeake Bay and its tributaries (table 5). Less than 1 percent of the recaptured fish were taken in the Virginia part of Chesapeake Bay and its tributaries, and only 1.6 percent of the recaptures occurred outside Chesapeake Bay. The 52 outside recaptures were made north of Chesapeake Bay from Delaware to Nova Scotia.

In general, recaptures indicated the following seasonal movement: (a) the bulk of the fish tagged during the wintering season remained in the Potomac River for the spawning season; (b) during the latter part of and immediately after the spawning season, most tagged fish moved downstream into the bay, but some individuals stayed in the Potomac for the feeding and wintering season; (c) during the feeding season, tagged fish were widely dispersed throughout the upper bay and its tributaries; and (d) following the feeding season, there was some evidence of concentration of the tagged fish in the bay and in the Potomac.

Preliminary analyses show that only 68 (2 percent) of the recaptured fish were taken outside the Maryland part of Chesapeake Bay and its tributaries: 16 in the Virginia part of Chesapeake Bay and its tributaries; 3 in Delaware Bay; 8 off New Jersey coast; 12 off Long Island; 2 in Connecticut waters; 6 off Rhode Island; 15 along the Massachusetts coast; 3 in Maine waters; and 3 off the coast of Nova Scotia. Fish in age groups 2 and 3 made up 93 percent of the tagged fish recaptured outside the bay. These data indicate that the Potomac River probably is an important contributor to stocks of striped bass in age groups 2 and 3 occurring along the northeast Atlantic coast.

Analyses of the recapture data are continuing in order to determine the exchange of striped bass between the Potomac River and Chesapeake Bay and its other tributaries, and to observe movements of tagged fish by size and age classes. Also, we expect these studies to provide information on whether spawning fish return to the same spawning area each year.

Life History Studies

Paul R. Nichols

Origin of stocks: We continued cooperative tagging studies with the States of New Jersey,

Table 5.--Summary of recaptures from 8,973 striped bass tagged during the wintering, spawning, and feeding seasons in the Potomac River, Md., 1959-61

Season and year released	Number of fish tagged	Fish recaptured outside of Chesapeake Bay		Fish recaptured in Maryland part of Chesapeake Bay and tributaries		Fish recaptured in Virginia part of Chesapeake Bay and tributaries		Total fish recaptured	
	Number	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Wintering:									
1959.......	1,445	4	0.9	422	98.4	3	0.7	429	29.7
1959-60....	2,545	19	1.9	998	97.9	2	.2	1,019	40.0
1960-61....	2,207	20	1.7	1,139	97.5	10	.8	1,169	53.0
Total.....	6,197	43	1.6	2,559	97.8	15	.6	2,617	42.2
Spawning:									
1959.......	749	3	1.9	154	98.1	0	0.0	157	20.9
1960.......	631	4	1.7	232	98.3	0	.0	236	37.4
1961.......	474	0	.0	165	99.4	1	.6	166	35.0
Total.....	1,854	7	1.2	551	98.6	1	.2	559	30.2
Feeding:									
1959.......	922	2	1.2	170	98.8	0	0.0	172	18.6
Total.....	922	2	1.2	170	98.8	0	.0	172	18.6
Grand total.	8,973	52	1.6	3,280	98.0	16	.4	3,348	37.3

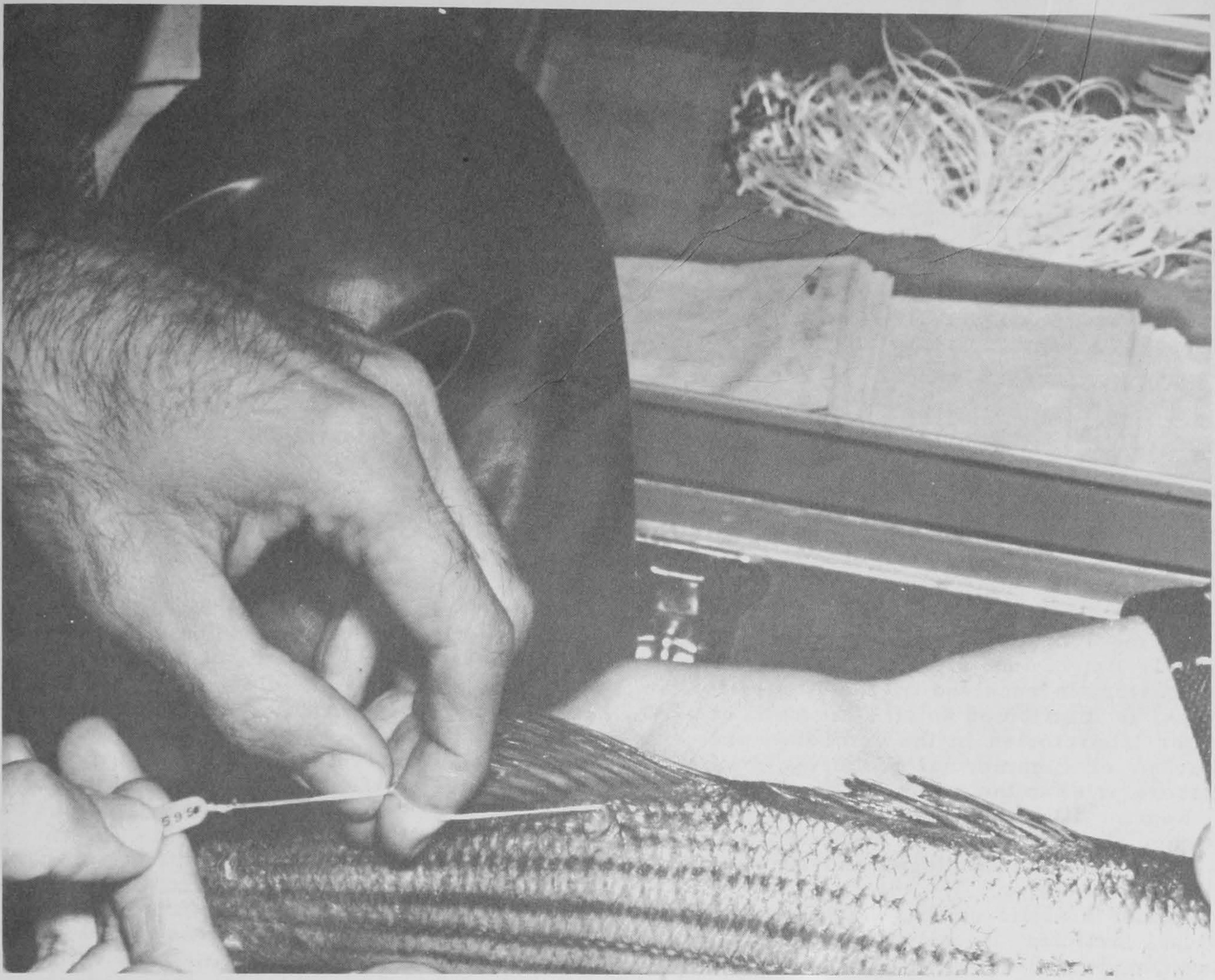

Figure 13.--Applying streamer tag on striped bass.

New York, Connecticut, and Massachusetts on the origin and migration of striped bass stocks occurring along the New England coast.

Results of tagging and releasing 168 striped bass in the Cape Cod area off the Massachusetts coast in mid-May 1963, with subsequent recapture of 30 tagged fish, indicated that most recaptured fish were taken in Massachusetts waters during summer and early fall and then there appeared to be a southward coastal movement (table 6). Recaptures in Massachusetts waters were 15 in the summer and fall following release in spring, and 5 in the summer and fall 1 year after release.

The preponderance of local recaptures of tagged fish suggested that the stocks of immature striped bass along the New England coast in spring remain in the area during summer and early fall and that a significant number remain in the area through the following summer.

Preliminary observations suggest that most of the migratory stocks of immature striped bass along the New England coast are produced in Delaware and Chesapeake Bays and that most of these coastal migrants are immature females. Large-scale tagging studies and sexing by biopsy could verify the origin of these stocks and the hypothesis that most are immature females. This study is being coordinated with the Chesapeake Bay tagging project.

Table 6.--Recaptures made outside Massachusetts waters from 168 striped bass tagged and released in the Cape Cod area, Mass., May 13-31, 1963

Number recaptured	Date released	Date recaptured	Locality	Fork length at time of tagging
1..........	May 31, 1963	July 7, 1963	Hampton River, N.H.	12.2
1..........	May 22, 1963	August 22, 1964	Niantic Bay, Conn.	12.3
1..........	May 20, 1963	November 16, 1963	Shinnecock Inlet, L.I., N.Y.	12.3
1..........	May 18, 1963	December 5, 1963	Mecox Bay, L.I., N.Y.	10.8
1..........	May 22, 1963	May 17, 1964	Off Staten Island, N.Y.	11.7
1..........	May 20, 1963	March 26, 1964	Hudson River, N.Y.	11.8
1..........	May 19, 1963	April 30, 1964	Off Island Heights, New Jersey Bay	11.8
1..........	May 21, 1963	June 11, 1964	Sandy Hook Bay, N.J.	12.7
1..........	May 27, 1963	March 6, 1964	Kitts Hummock, Delaware Bay	11.4
1..........	May 21, 1963	March 1, 1964	James River, Va.	12.5

LIBRARY

Anna F. Hall

During 1963, the library began to publish a weekly list of acquisitions. This list, showing all materials received by the library for the week, is distributed to all staff members and other laboratories in the immediate area and Bureau of Commercial Fisheries Biological Laboratories in the region.

Reprint files for both the Biological and Radiobiological Laboratories were organized. All reprints are cataloged and cards filed in the main catalogs.

Author analytic cards, which catalog individual articles in selected journals, have been made and added to the catalog. Viewed as a long-range project, these cards become a bibliography which will enable laboratory personnel to locate an author's works owned by the library.

The library cooperated with Duke Marine Laboratory and North Carolina Institute of Fisheries in compiling a Union List of Periodicals received on a regular basis. This checklist also shows holdings.

Current issues of 61 periodicals and numerous articles of special interest are displayed on two special racks. In addition, several unclassified publications of current interest are displayed on shelves 6 months to 1 year before being discarded.

Materials secured on interlibrary loan again showed an increase. One hundred and ninety-seven items were borrowed from other libraries, and 8 were lent. Almost 2,500 items were used in the library, and 380 volumes were lent for periods longer than overnight. Lists of publications by staff members were exchanged with 133 individuals and institutions. In response to requests from persons on the mailing list, 277 reprints were distributed.

SEMINARS

The Bureau of Commercial Fisheries Biological and Radiobiological Laboratories cooperated with Duke University Marine Laboratory in the following seminar program:

"Parasitic copepods as research animals." R. J. Shields, Department of Zoology, City College of New York, N.Y.

"Carbohydrate metabolism in a shrimp." W. Dall, Department of Zoology, University of Queensland, Brisbane, Australia.

"Status of experimental research on influence of temperature on meristic structures in developing marine fishes." W. E. Fahy, Institute of Fisheries Research, University of North Carolina, Morehead City, N.C.

"Radiobiological studies." T. R. Rice, Director, Bureau of Commercial Fisheries Radiobiological Laboratory, Beaufort, N.C.

"Morphological implications in systematics of marine fungi." T. W. Johnson, Jr., Department of Botany, Duke University, Durham, N.C.

"Combining under-water photography and quantitative sampling." R. J. Menzies, Duke University Marine Laboratory, Beaufort, N.C.

LITERATURE CITED

BOX, G.E.P., and P.V. YOULE.
1955. The exploration and exploitation of response surfaces: An example of the link between the fitted surface and the basic mechanism of the system. Biometric 11(3):287-323.

BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, BEAUFORT, N.C.
1964. Annual report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C, for the fiscal year ending June 30, 1962. U.S. Fish Wildl. Serv., Circ. 184, ii + 40 p.
1964. Annual report of the Bureau of Commercial Fisheries Biological Laboratory, Beaufort, N.C., for the fiscal year ending June 30, 1963. U.S. Fish Wildl. Serv., Circ. 198, ii + 26 p.

PUBLICATIONS

BONNER, RUPERT R., JR.
1963. A method of transporting striped bass. Progr. Fish-Cult. 25(4): 217.

CHAPOTON, ROBERT B.
1964. Surface trawl for catching juvenile American shad. Progr. Fish-Cult. 26(3):143.

HENRY, KENNETH A.
1964. Aging fish from their scales. Sci. Teach. 31(4):58-59.

JUNE, FRED C., and THEODORE R. RICE.
1963. Biological Laboratories, Beaufort, North Carolina. Amer. Zool. 3(3):365-366.

NICHOLS, PAUL R., and PEGGY M. KENEY.
1963. Crab larvae (Callinectes), in plankton collections from cruises of M/V Theodore N. Gill, South Atlantic Coast of the United States, 1953-54. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 448, ii + 14 p.

NICHOLS, PAUL R., and WILLIAM H. MASSMANN.
1963. Abundance, age, and fecundity of shad, York River, Va., 1953-59. U.S. Fish Wildl. Serv., Fish. Bull. 63: 179-187.

REES, GEORGE H.
1963. Edible crabs of the United States. U.S. Fish Wildl. Serv., Fish. Leafl. 550, 19 p.
1963. Progress on blue crab research in the South Atlantic. Proc. Gulf Carib. Fish. Inst., 15th Annu. Sess.: 110-115.

REINTJES, JOHN W.
1963. An initial inquiry into a photoelectric device to detect menhaden marked with fluorescent pigments. Int. Comm. Northwest Atl. Fish., North Atlantic Fish Marking Symp. Spec. Publ. 4: 362-368.
1964. The importance of the occurrence of menhaden in the coastal waters and estuaries of peninsular Florida. Proc. Gulf Carib. Fish. Inst., 16th Annu. Sess.: 108-113.

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