2-1975

Biology and management of river herring and shad in Virginia : Annual report, Anadromous Fish Project 1974

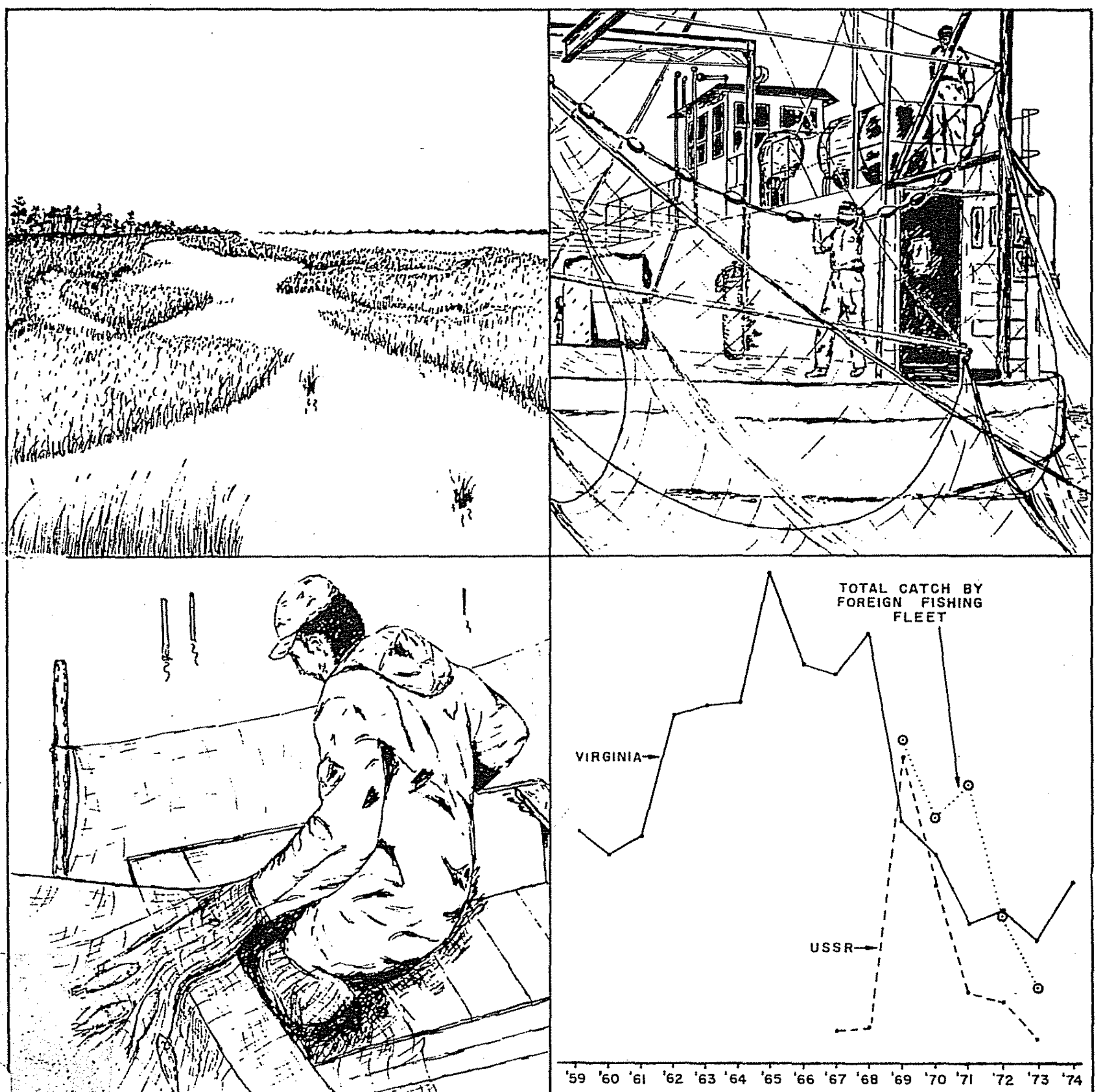
Walter J. Hoagman
Virginia Institute of Marine Science

John V. Merriner
Virginia Institute of Marine Science

William K. Kriete
Virginia Institute of Marine Science

Woodrow L. Wilson
Virginia Institute of Marine Science

Biology and Management of River Herring and Shad in Virginia



Annual Report, Anadromous Fish Project, 1974

Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

Annual Report 1974

Project Title on Contract: Biology and Management of River Herring and Shad

Project Number: Virginia AFC 8-1

Project Period: 16 October 1973 to 30 September 1974

Prepared By: Walter J. Hoagman, Ph.D.

John V. Merriner, Ph.D.

William H. Kriete, B.S.

Woodrow L. Wilson

This project was financed in part with Anadromous Fish Act (P.L. 89-304) funds through the National Marine Fisheries Service, Northeast Division.
Grant Number 04-4-043-410.

Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

February 1975

TABLE OF CONTENTS PAGE NUMBER

TABLE OF CONTENTS PAGE NUMBER

Preface

This annual report covers the period October, 1973 through September, 1974. It is the seventh report generated by the project, with 3-year completion reports prepared in 1970 and 1973. The project is continuing at VIMS and each year allows stronger conclusions to be made concerning trends in the basic population parameters studied.

The 1970-1973 completion report was widely distributed in Virginia, libraries at fishery science institutes, and throughout the National Marine Fisheries Service. The completion report analyzed data from the entire history of the project. In many cases the entire summarized data core for a particular segment was presented, e.g. mortality rates and age composition of the run since 1966. Some jobs were presented in final analysis form, because they were made inactive after 1973. The history of the foreign fleet activities was presented with an analysis of their effect on the anadromous alosids.

This annual report has the specific purpose of reporting progress on the jobs and objectives of one additional year. Thus, many of the tables, figures, and conclusions are not repeated here. It is difficult to make conclusions or propose directions of effort without such background, however, so where necessary some past data are presented. Overall, the 212 page completion report is the main reference document, and this annual report has been designed and written for brevity.

The project has been renewed for 1974-1975 and we anticipate renewal for 1975-1976. In 1976 we will draw together the last 3 years of data, combine them with the 1970 and 1973 documents, and again present full analysis and the summarized data bank.

The following jobs and objectives were proposed for our research program during 1973-1976 and inactive jobs for the 1973-1974 contract period are noted.

Job 1. Catch-Per-Unit-of-Effort

Objective 1. To measure fishing effort and estimate landings of adult *Alosa* spp.

2. To detect changes in the stock, and economics of the river fishery by comparison with former years.

Job 2. Population Dynamics of Adults

Objective To determine mortality rates, age specific sizes, times of spawning, and ratios of abundance for adult alewife, blueback herring, and American shad.

Job 3. Annual Index of Juvenile Abundance

Objective To determine annually an index of abundance for each species of juvenile *Alosa* in the four major spawning areas (James, York, Rappahannock and Potomac rivers) in Virginia.

Job 4. Feeding Energetics of Juvenile Alewife

Objective 1. To determine food selectivity and feeding periodicity of juvenile alewife in the nursery zone of the James River.

2. To derive a seasonal energy budget by integration of ingestion, egestion, respiration, and growth rates.

Job 5. Culture, Rearing and Experimental Study of River Herring

Objective 1. Development of culture methods for *Alosa* spp. from the egg through juvenile stages for the production of experimental animals.

2. (Conditional to No. 1). Conduct experiments with *Alosa* spp. on tolerance, preference, and optima for environmental parameters and effects of pollutants on various life stages.

Job 6. River Herring Population Estimates, Movements, and Resource Utilization Through a Tagging Program

This job was not contracted for by NMFS for the 1973-1974 contract year.

Job 7. Resident Fishes of the Nursery Zone

Objective 1. To determine biomass indices of the nonmigratory fish component of the freshwater nursery zones of the major rivers during midwinter.

2. To derive quantitative estimates of overwintering populations of juvenile alosids.

Job 8. Shallow Water Population Indices (A Pilot Program)

Objective 1. To determine the abundance of fishes in the beach zone of a prime alosid nursery area in the James River during the late summer.

2. To derive (if possible) an annual index of year-class strength of the alosids and other fishes independent of the late summer survey.

The major change from the 1970-1973 contracts was the reduction of Job 4 to exclude the productivity and zooplankton studies, and the addition of Jobs 7 and 8 to add balance to the basic monitoring program.

Job 1 was written by W. Wilson and J. Merriner, Jobs 2 and 3 by W. Hoagman, Job 4 by J. Weaver, Job 5 by J. Merriner, Job 7 by J. Merriner and W. Kriete, and Job 8 by W. Kriete.

Project Personnel, October 16, 1973 to September 30, 1974

Name	Position and Percent of Time Assigned to Project	Comments
Walter J. Hoagman, Ph.D.	Prin. Investigator, 75%	3 years on project
John V. Merriner, Ph.D.	Co-Investigator, 25%	4 years on project
William H. Kriete, B.S.	Asst. Mar. Sci., 50%	Joined project 1973
Woodrow L. Wilson	Lab. Specialist, 100%	7 years on project
James Bristow	Lab. Technician, 100%	7 years on project
Deane Estes	Lab. Technician, 100%	2 years on project
James Owens	Lab. Technician, 100%	Joined project 1973
Joice Davis	Lab. Technician, 100%	Joined project 1973
Jackson Davis, Ph.D.	Asst. Director, 10%	P.I. until 1972
Grad Students Weaver Cooke Byrne	Tech. Aides, 20 hrs/wk on project	Weaver has part of Job 4 as thesis
Summer Aides Starkey Zeigler Bruton	Full Time for Approx. 10 weeks each	

Job 1. Catch-per-unit-of-effort

Anadromous alosine fishes are subjected to an extensive domestic fishery in Virginia during their spawning migration. Pound nets, stake gill nets, and drift gill nets are the primary fishing gears used in the Virginia commercial fishery for river herring and shad. Pound nets are the primary devices in the fishery for river herring but they rank second to stake and drift gill nets in the American shad fishery. Overall, the fishery for alosine fishes in Virginia has declined since the late 1960's. The decline in the fishery and its probable causes are more fully discussed in Jobs 2 and 3 of this report and in Hoagman et al. (1973).

The pound net fishery operating in Chesapeake Bay and tributary rivers in Virginia was slightly larger in 1974 than in 1973 (Table 1.1). Aerial counts of active gear made twice monthly between February and June revealed an increase in effort for the Rappahannock River and Mobjack Bay. Effort in the Potomac River during 1974 was lower than in 1973 and all other areas showed little difference between the 1973 and 1974 fishing season. Pound net effort for alosine fishes generally increases through March and peaks in the latter half of April and first half of May (Table 1.1). A general decline in pound net effort has been noted since 1967 (Hoagman et al., 1973). Effort will probably continue to decline since we forecast lower stock abundance at least through 1978-79 (see Jobs 2 and 3).

The number of stake gill net stands, overall, was 10% higher in Virginia rivers during 1974 than in 1973 (Table 1.2), but the effort was not uniformly higher in each river. The net count was 34% higher in the James River, 7% higher in the York, but declined by 15% in the Rappahannock. The stake gill net fishery, like the pound net fishery, is most active in April and May. Stake gill nets are the principal gear in the American shad fishery and are also effective for hickory shad and striped bass. River herring (alewife and blueback) are not captured in appreciable numbers by the gill nets due to mesh size selectivity.

Drift gill nets are used extensively for American shad and hickory shad in Virginia but reliable records of catch and net effort are not available. Drift netting is a seasonal means of obtaining a secondary income and the times and places of gear use are irregular, at best.

Catch-per-unit-of-effort (c/f) data herein reported are derived from gear counts, selected log book records, and total catch, using methods detailed in Hoagman et al. (1973).

James River

Pound nets were not suitably positioned in the James during 1974 to provide indices of the spawning run of river herring and American shad.

Stake gill net catch of American shad between 6 March and 1 May 1974 was estimated at 1.5 million pounds (730,000 pounds female and 770,000 pounds male, Table 1.3). Daily catch of female American shad exceeded 3% of the total catch between 30 March and 8 April 1974. Male American shad were more abundant than females in the catch throughout the period of log book records. In previous years log books had not shown this since the males were usually discarded at the net rather than landed. The market for male American shad during 1974 remained firm through 13 April, thus reliable catch estimates for males from the James River were attained for the first time.

Total catch of female American shad and c/f/season during 1974 were higher in the James than in either the York or Rappahannock rivers. However, c/f for females declined by 49% and total catch of females declined by 22% compared to 1973 levels (Table 1.2). The 1974 estimated total catch of female American shad was only 46% of the average season catch for 1969 through 1972 despite 178% greater effort in 1974 over the season average for 1969 through 1972. Thus, American shad in the James River are becoming less abundant than in previous years of record.

York River

Pound nets in the York River were positioned too near the river mouth to provide reliable indices of the 1974 run of river herring and American shad.

Stake gill nets harvested an estimated 0.4 million pounds of American shad from the York River in 1974 (353,000 pounds female and 43,000 pounds male) and 19,000 pounds of hickory shad (Table 1.4). The American shad catch represents a decline of 19% from the 1973 landings (highest in the 8-year history of our studies) and female landings in 1974 were 140% higher than the average weight landed between 1969 and 1972. Daily catch, estimated from fisherman log books, revealed two major pulses in the American shad migration during 1974 (9-12 March and 29 March - 4 April, Table 1.4). Landings of male American shad were consistently lower than those of females and demonstrate the tendency of fishermen in the York River to discard male shad at the net due to their low market value.

Catch-per-unit-of-effort for female American shad (Table 1.3) declined by 24% compared to 1973 c/f but was equal to 96% of the 1969-1972 average c/f for the York River. Stake gill net effort in the York was 7% higher than in 1973 and was 1.5 times greater than the average gill net effort for 1969 through 1972. The above data indicate a slight decrease in the abundance of American shad in the York River system compared to 1969-1972 levels.

Rappahannock River

Stake gill net catch in the Rappahannock River during 1974 was estimated at 65,000 pounds of American shad (42,800 pounds female and 22,600 pounds male) and 21,300 pounds of hickory shad (Table 1.5). The peak of the run was less well defined than in the more southern rivers but was generally greatest during the last week of March and first week of April. Total catch and c/f were higher in 1974 than in 1973 by 17 and 38%, respectively, and there was a 15% decline in effort (Table 1.2). During 1974 stake gill net effort was 80%, c/f was 29.3% and total catch of female American shad was 24% of the mean levels during 1969-1972. Thus, stake gill net data show a decline in American shad abundance in the Rappahannock River compared to the 1969-72 period.

Pound nets in the Rappahannock River during 1974 yielded an estimated 30,000 pounds of American shad (13,000 pounds female and 17,000 pounds male) and 0.76 million pounds of river herring (475,000 pounds alewife and 287,000 pounds blueback) (Table 1.6). The catch of American shad during 1974 showed a slight increase over the 1973 catch of 24,000 pounds (12,500 pounds female and 11,500 pounds male). The catch of river herring declined from 0.86 million pounds (332,000 pounds alewife and 532,000 pounds blueback) in 1973 to 0.76 million pounds in 1974. The peak run of American shad occurred between April 16 and April 30. River herring catches peaked between April 1 and April 15. The number of active pound nets fishing in the Rappahannock River in 1974 during the peak run increased by 8% over 1973. Catch-per-unit-of-effort for American shad increased slightly from 476 pounds per net in 1973 to 535 pounds per net in 1974. Catch-per-unit-of-effort of river herring declined slightly from 15,000 pounds per net in 1973 to 13,600 pounds per net in 1974.

Potomac River

Stake gill nets in the Potomac River during 1974 caught 61,000 pounds of American shad (42,000 pounds female and 19,000 pounds male) and 59 pounds of hickory shad (Table 1.7). The peak of the run was during April. We do not make counts of stake gill nets in the Potomac River because the Potomac River

Fisheries Commission obtains catch records from all commercial fishermen. Our tables are compiled from their catch records.

Pound nets in the Potomac River during 1974 yielded 18,400 pounds of American shad (7,000 pounds female and 11,400 pounds male) and 3.52 million pounds of river herring (648,000 pounds alewife and 2.87 million pounds of blueback) (Table 1.8). There were no reported catches of hickory shad by pound nets. The catch of American shad during 1974 declined sharply from the 1973 catch of 204,000 pounds (158,000 pounds female and 46,000 pounds male). The catch of river herring, however, increased sharply from the 1973 catch of 1.39 million pounds (550,000 pounds alewife and 843,000 pounds blueback). During 1974 pound net effort was 21% below the 1973 effort during the peak fishing season. Catch-per-unit-of-effort of American shad declined from 4,427 pounds per net in 1973 to 512 pounds per net in 1974. Catch-per-unit-of-effort of river herring increased from 31,000 pounds per net in 1973 to 98,000 pounds per net in 1974.

References Cited

Hoagman, W. J., J. V. Merriner, R. St.Pierre, and W. L. Wilson. 1974. Biology and Utilization of Anadromous Alosids. Completion Report 1970-1973, Project No. VA AFC 7-1 to 7-3, 212 pages.

Table 1.1. Number of active pound net stands in Chesapeake Bay and its Virginia tributaries during spring 1974.

Area	Feb. 21	Mar. 4	Mar. 26	Apr. 11	May 7	May 24	Jun 10
James River	0	0	0	0	0	1	0
York River	2	2	4	8	9	9	6
Rappahannock River	14	33	51	61	56	32	16
Potomac River	1	4	15	24	36	36	27
Cape Henry-Willoughby Point	1	1	4	4	5	5	5
Old Point-Tue Marsh Point	0	2	5	7	7	7	4
Back River	2	6	6	7	7	5	6
Poquoson River	2	2	2	2	2	2	2
York Spit	0	0	2	2	2	3	3
Mobjack Bay	0	0	2	7	10	8	8
New Point-Stingray Point	3	3	8	17	17	23	22
Piankatank River	0	1	4	5	6	5	5
Windmill Point-Smith Point	6	7	24	30	38	33	24
Great Wicomico River	0	0	2	3	4	4	5
Eastern Shore-N. Hungar Creek	1	1	0	0	1	0	0
Eastern Shore-S. Hungar Creek	4	4	3	15	26	31	28
Total	36	66	132	192	226	204	161

Table 1.2. Number of stake gill net stands fished in Virginia river systems 1973-74, catch of female American shad per net per season, and total catch of female American shad (in pounds).

River Systems	Number of Net Stands	
	1973	1974
York	130	139
James	115	154
Rappahannock	100	85
Total	345	378
	C/F/season	
York	3,365	2,542
James	9,383	4,787
Rappahannock	365	504
Total	13,113	7,833
	Total Catch of Female American Shad	
York	437,450	353,385
James	1,079,045	737,197
Rappahannock	36,500	42,806
Total	1,552,995	1,133,388

Table 1.3. Estimated catch of American shad by stake gill nets in the James River 1974 by sex (in pounds).

Date		Female	Male
March	6	2,106	4,212
	7	1,482	3,042
	8	2,964	3,978
	9	8,034	9,789
	10	11,310	15,483
	11	8,736	12,012
	12	7,878	7,020
	13	-	-
	14	7,176	9,165
	15	6,708	3,900
	16	7,722	6,045
	17	8,775	17,550
	18	-	-
	19	-	-
	20	16,965	19,149
	21	-	-
	22	13,533	26,130
	23	8,775	7,800
	24	10,725	11,934
	25	15,990	25,194
	26	18,681	18,408
	27	15,093	19,500
	28	12,246	12,675
	29	17,394	31,200
	30	39,000	48,945
	31	-	-
April	1	34,437	36,894
	2	25,935	26,832
	3	55,965	65,520
	4	41,925	45,552
	5	48,516	61,152
	6	54,444	74,100
	7	48,750	46,644
	8	22,035	29,757
	9	17,472	23,634
	10	29,133	29,445
	11	12,948	21,450
	12	-	-
	13	14,761	0
April	14	17,043	0
	15	10,374	0
	16	-	-
	17	11,934	0
	18	11,310	0
	19	2,379	0
	20	4,095	0
	21	-	-
	22	-	-
	23	2,925	0
	24	6,045	0
	25	2,262	0
	26	-	-
	27	3,705	0
	28	8,190	0
	29	3,120	0
	30	3,003	0
May	1	3,198	0
TOTAL		737,197	774,111

GRAND TOTAL 1,511,308

Table 1.4. Estimated catch of American and hickory shad by stake gill nets in the York River 1974.[1]

Date		American Shad Female	American Shad Male	Hickory Shad
Feb.	26	1,960	140	0
	27	490	210	0
	28	140	0	0
March	1	245	70	0
	2	350	455	0
	3	840	350	0
	4	1,845	595	0
	5	2,275	805	0
	6	3,045	1,400	0
	7	5,460	1,155	70
	8	9,380	910	0
	9	12,635	2,205	0
	10	11,200	2,345	0
	11	23,135	3,605	0
	12	10,570	1,190	140
	13	8,400	0	0
	14	6,685	595	140
	15	5,110	315	70
	16	5,285	385	280
	17	5,530	1,330	0
	18	9,905	945	490
	19	10,710	1,330	350
	20	8,575	2,030	490
	21	8,785	1,785	210
	22	-	-	-
	23	-	-	-
	24	-	-	-
	25	-	-	-
	26	12,215	875	560
	27	4,725	245	490
	28	5,320	175	0
	29	16,310	2,170	840
	30	21,280	3,780	1,540
	31	13,020	2,100	1,750
April	1	13,440	2,450	2,240
	2	10,605	840	1,960
	3	13,300	1,225	910
	4	14,000	0	1,750

Date		American Shad Female	American Shad Male	Hickory Shad
April	5	6,580	0	980
	6	3,675	0	910
	7	4,235	770	0
	8	1,890	105	0
	9	6,370	245	0
	10	6,195	805	560
	11	3,535	525	350
	12	2,030	210	0
	13	5,215	490	280
	14	9,100	630	210
	15	8,365	665	0
	16	11,445	350	700
	17	5,250	0	350
	18	2,730	0	280
TOTAL		353,385	42,805	18,900
GRAND TOTAL		396,190		

[1] Table entries in pounds, dash = no data for that day.

Table 1.5. Estimated catch of American and hickory shad by stake gill nets in the Rappahannock River 1974.[1]

Date		American Shad Female	American Shad Male	Hickory Shad
Feb.	18	34	470	0
	19	-	-	-
	20	-	-	-
	21	68	68	0
	22	-	-	-
	23	-	-	-
	24	68	119	0
	25	68	68	0
	26	-	-	-
	27	238	323	0
	28	68	136	0
March	1		102	0
	2	170	119	0
	3	-	-	-
	4	289	442	0
	5	0	255	0
	6	187	357	0
	7	153	476	0
	8	1,020	629	0
	9	238	816	0
	10	1,224	969	0
	11	1,122	1,445	0
	12	697	595	0
	13	-	-	-
	14	442	322	0
	15	510	646	0
	16	765	340	0
	17	-	-	-
	18	510	442	0
	19	1,309	561	0
	20	561	629	0
	21	1,989	646	0
	22	629	612	0
	23	918	918	0
	24	-	-	-
	25	1,734	1,139	765
	26	2,516	918	884
	27	918	340	357
	28	1,700	561	714
March	29	187	510	68
	30	1,207	731	918
	31	1,190	476	1,071
April	1	1,462	595	1,513
	2	1,139	476	1,003
	3	1,615	765	272
	4	1,224	459	969
	5	1,530	391	1,530
	6	833	272	1,207
	7	2,125	425	1,360
	8	1,037	238	1,853
	9	3,009	442	1,768
	10	-	-	-
	11	0	238	663
	12	-	-	-
	13	-	-	-
	14	1,632	391	1,717
	15	969	187	1,173
	16	850	306	153
	17	901	170	901
	18	1,751	102	425
TOTAL		42,806	22,637	21,284
GRAND TOTAL		65,443		

[1]Table entries in pounds, dash = no data for that day.

Table 1.6 . Estimated catch of alosine fishes by pound nets in the Rappahannock River above river mile 10 in 1974.[1]

			American Shad[2]				River Herring					
			Female		Male				Alewife		Blueback	
Date	Avg. No. of Nets	No. Days Fished	Avg. Catch Index Nets	Estimated Total Catch	Avg. Catch Index Nets	Estimated Total Catch	Avg. Catch Index Nets	Estimated Total Catch	Percent	Pounds	Percent	Pounds
Feb. 24-28	11	5	10.0	550	5.6	308	114	6,270	100	6,270		
March 1-15	23	7	10.8	1,739	37.3	6,005	636	102,396	95	97,276	5	5,120
March 16-31	37	6	10.8	2,398	8.3	1,843	617	136,974	95	130,125	5	6,849
April 1-15	40	6	7.8	1,872	4.2	1,008	1,300	312,000	53	165,360	47	146,640
April 16-30	40	6	15.5	3,720	28.8	6,912	692	166,080	42	69,754	58	96,326
May 1-10	34	5	16.2	2,754	5.0	850	230	39,100	17	6,647	83	32,453
TOTAL				13,033		16,926		762,820		475,432		287,388

[1]Only nets between RA-10 and RA-55 were sampled to represent fish assumed to spawn in the Rappahannock River system.

[2]Estimated total catch of American shad = 29,959

Table 1.7. Total catch by month of American and hickory shad by stake gill nets in the Potomac River 1974 (in pounds).

	American Shad		Hickory Shad
Months	Female	Male	
January	0	230	0
February	5	12	0
March	1,195	3,505	35
April	33,850	12,676	8
May	6,955	2,396	16
TOTAL	42,005	18,819	59
GRAND TOTAL	60,824		

Table 1.8. Total catch of *Alosa* by pound net per month in the Potomac River during 1974 (in pounds).

	American Shad		River Herring	
Month	Female	Male	Alewife	Blueback
February	0	0	153	0
March	334	909	38,832	0
April	4,907	4,015	411,742	874,952
May	1,721	4,881	194,479	1,966,395
June	25	1,633	3,129	31,637
TOTAL	6,987	11,438	648,335	2,872,984
GRAND TOTAL	18,425		3,521,319	

Job 2. Population Dynamics of Adults

A. A review of 1974 activities

Data presented in the 1970-1973 completion report revealed little need to take scale samples weekly during the spawning run and that to gather more than 50 scale samples per species each period was unnecessary. Accordingly, we adopted a 2-week sampling period in 1974 with 50 scale samples per species per river. The additional specimens of each species in the sample were weighed, measured and counted. The sequential nature of the alosine spawning run, however, often precludes obtaining the desired number of specimens of each species within a single sample during each semimonthly period.

Cooperating commercial fishermen in the James, Chickahominy, York, Rappahannock and Potomac rivers save catches for the sampling team. All samples are obtained from nets located above river mile 10 to insure that the fish analyzed have selected their spawning river.

The data bank accrued for this job was summarized and presented in the 1970-1973 completion report (Hoagman et al., 1973). Portions of it will be referred to in some comments and in developing conclusions within this presentation.

The alosine spawning run in 1974 was very erratic due to an unusually warm period in February. This triggered an early alewife run, and blueback were more abundant in many fish samples during March and April than in previous years. The American shad run had a boom and bust fluctuation throughout the spring. The data obtained in 1974 thus had several gaps relative to the designed coverage. Nevertheless, the low catches and age composition were similar to data from 1973. In all, 1,176 alewife, 2,066 blueback, and 205 American shad were collected in spring of 1974 for analysis (Table 2.1).

The 1974 landings of river herring (alewife and blueback combined) were 13.3 million pounds in Virginia and 6.2 million pounds in North Carolina (Table 2.2) and in 1973 were 8.9 and 7.9 million pounds, respectively. The combined inshore catch of river herring for these states was 16.8 million pounds in 1973 and 19.6 million in 1974. River herring landings in Virginia during 1974 were slightly greater than those of the last 3 years but were far below the 30 million pounds per year average of 1966-1969. This small increase in catches may be the result of the strong 1970 year class but the fishery, in general, has been depressed by overfishing since 1969. Dockside value of river herring was $431,164 to Virginia fishermen and $246,753 to North Carolina fishermen.

B. Analysis of the 1974 spawning run in Virginia[1]

The average length of alewife and blueback in the Potomac River declined again in 1974. Alewife averaged 246 mm fork length in 1973 and 238 mm in 1974. An overall decline in average length and weight of both species in the Virginia commercial catch has taken place since 1969 and it parallels the increase in catch by the foreign fleet off the Virginia Capes during winter and spring (Fig. 2.1). We believe the increased fishing pressure offshore has damaged the stock and reduced it significantly (see Hoagman, et al., 1973 for a fuller account).

The change in average length and weight of river herring from the Rappahannock River landings since 1965 has been similar but not as drastic as that cited for the Potomac River (Figs. 2.2 and 2.3). The Rappahannock River landings of river herring are typically a fraction of those in the Potomac (often as low as 10%). In 1974 fork length of alewife decreased but length of blueback increased from 238 mm in 1973 to 243 mm (Table 2.3). This increased length of blueback in 1974 does not mean that the alosine stock has had less fishing pressure because 1) the stocks of alosine fishes are mixed together at sea (Potomac and Rappahannock stocks for example) and 2) a minor fishery (Rappahannock) cannot be used to develop conclusive statements when fuller data sets (Potomac) show otherwise. Blueback from the Rappahannock River averaged 194 g in 1973 but weighed only 183 g in 1974 although our records showed an increase in average length of 5 to 8 mm. We can give no reason as to why blueback in 1974 were thinner in the Rappahannock than in the Potomac River.

The age composition of the 1974 spawning run showed an absence of 8-year-old alewife in the Potomac catch and a predominance of 4-year-old fish from the 1970 year class. Age four alewife made up 91% of the Potomac catch and age four blueback accounted for 83% of the catch (Table 2.4). This is far above the norm of 50 to 65% contribution to each year's catch by age four alewife and blueback. If this trend of reliance upon younger fish from fewer year classes continues and year-class strength remains low, then the fishery is certainly headed for greater instability. Three-year-old fish are never numerous in the landings. If the 1971 year class does not contribute at least 75% of the 1975 catch (four-year-old fish), then our prediction of decreasing yields for the next 3 years will be confirmed. The basis of our prediction is poor year classes after 1970.

The spawning run of river herring in the James River is not fished heavily. It has not been economical to transport them

---

(1) See Job 1 of this report for details on landings.

from the James River to the processing plants in the Northern Neck. Although some alewife and blueback are landed for roe and crab bait, the total poundage cannot be more than several thousand pounds. American shad, however, are actively fished and are the most important alosine fish in the James River.

We have evidence that the river fishery has not harmed the stocks independently, since the basic population parameters appear similar for river herring from each spawning river in Virginia. River herring from the James River and those from the Potomac and Rappahannock rivers would be decidedly different in basic population attributes, if the river fishing had harmed the stocks independently. Alewife averaged 246 mm in the James compared to 234 mm in the Potomac and 247 mm in the Rappahannock. Average length of blueback from the James was 240 mm compared to 238 mm from the Potomac and 244 mm from the Rappahannock. In the absence of heavy intrariver fishing pressure, river herring in the James River may be expected to be larger and heavier than those from rivers which have well developed commercial fisheries for river herring. We have demonstrated a decline in length and weight for several river herring stocks as the combined landings by the foreign fleet and river fishery repeatedly exceeded the calculated maximum sustained yield (Hoagman et al., 1973, Job 2); but we did not calculate a long term trend for the James.

The age composition of river herring during 1974 was generally similar amoung all rivers (Table 2.4). The river herring stock in the James was not dominated by middle-aged or older members, as one might expect in a lightly fished population. Four-year-olds were the most abundant age group, representing 57% of the alewife and 56% of the blueback sampled from the James. The age frequency distributions of alewife from the James River did have a greater proportion of older fish than the other rivers, but age groups 6-9 were in low abundance. Blueback showed a similar trend, with the James and Rappahannock having a greater abundance of older fish than the York and Potomac. Age frequency of blueback from the Chickahominy was atypical with strong second age frequency mode (1968 year class), which was not as noticeable for samples from the James River proper.

The James River has been the most productive river of any we have studied, typically producing 80% or more of the total river herring year class by numbers in the four major rivers which lie in or form the boundary of Virginia and are tributaries to Chesapeake Bay. Yearclass strength of river herring has been declining since 1970 in the James River as in other rivers (see Job 3 this report). The James River does not yet appear to be polluted beyond the tolerances of river herring. Indeed, river herring are more abundant in the James River relative to the York, Rappahannock and Potomac, when juveniles per 100 m^3 are compared.

We believe the river herring stocks are river specific for spawning but are all equally vulnerable to the foreign fleet at sea. This would explain the parallel changes in the unfished James stock over the last several years compared to the Potomac stock and the present set of observed population attributes. The Potomac fishery has declined drastically in the last 6 years and the major reasons are now apparent. The river herring fishery in the James River has not been active and no records are available to ascertain the size of the spawning run; but to produce the hundreds of millions of young-of-year we have observed in early fall, the spawning run of blueback and alewife must be great.

It is doubtful that the James River would provide stock to the other rivers through recruitment of spawning adults, even if it remains unfished for river herring. The major point is that even though river herring in the James River have been relatively unfished since 1968, their age composition and mortality rates indicate they have been subject to the same overfishing that decimated the Potomac River stocks and this fishing occurred while the fish were at sea.

A summary account of Virginia landings and their relationship to yearclass production is provided at the end of Job 3.

References Cited

Hoagman, W. J., J. V. Merriner, R. St.Pierre, and W. L. Wilson, 1974. Biology and Utilization of Anadromous Alosids. Completion Report 1970-1973, Project No. VA AFC 7-1 to 7-3, 212 pages.

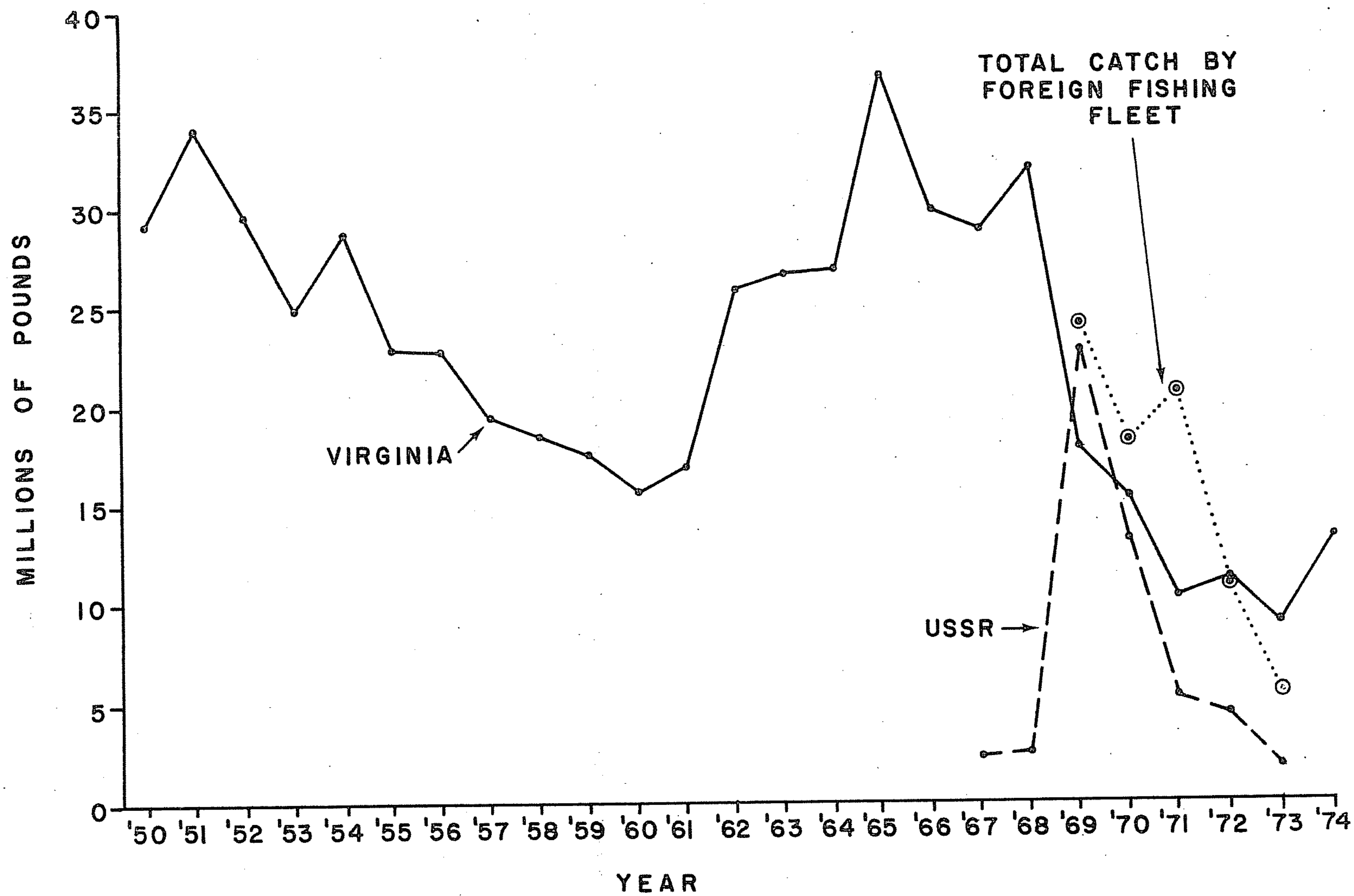


Fig. 2.1. Landings of river herring (alewife and blueback combined) in Virginia from lower Chesapeake Bay and tributaries, total foreign fleet catch and USSR catch in the Middle Atlantic Bight.

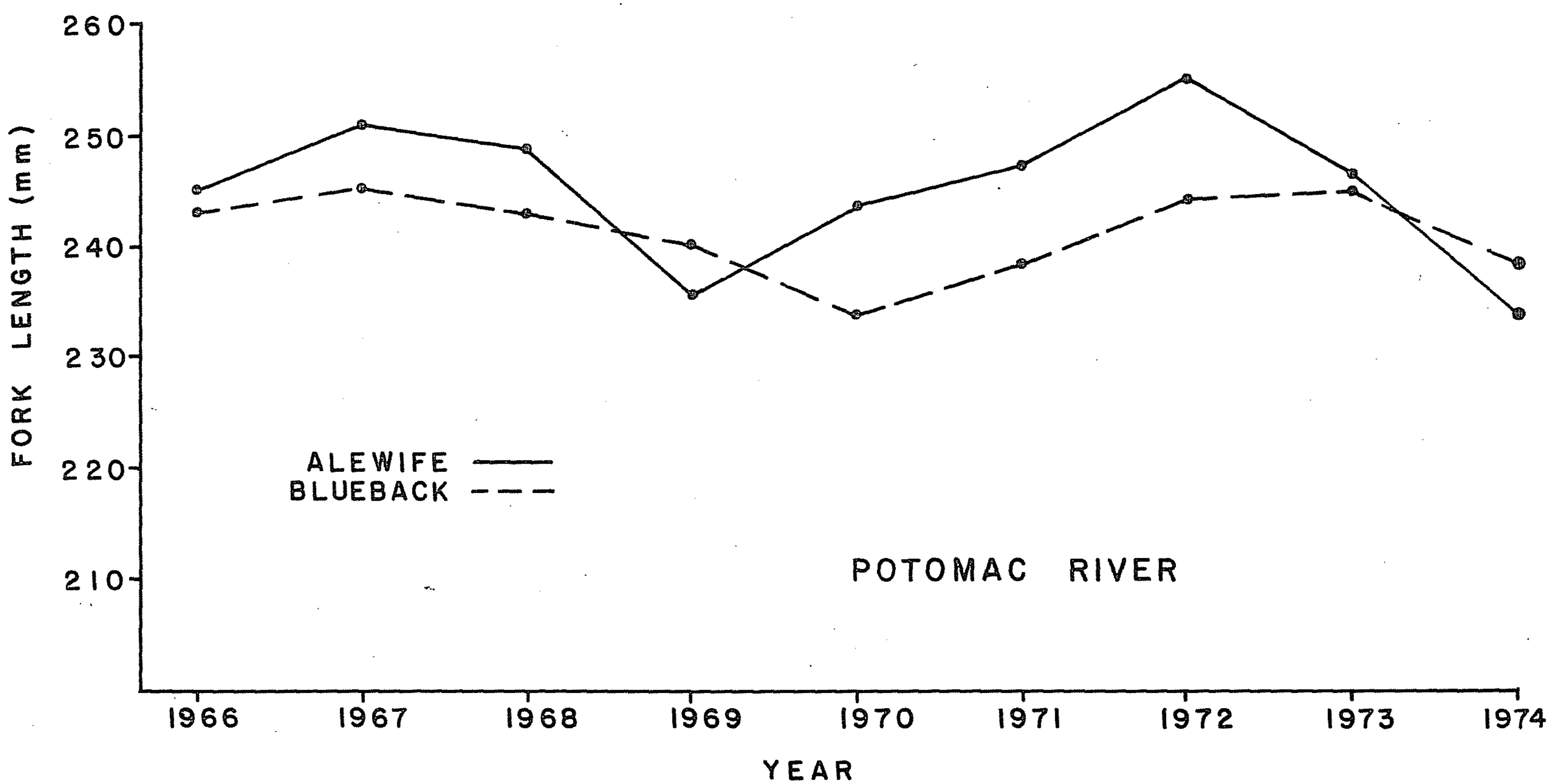


Fig. 2.2. Average fork length of sexes combined for alewife and blueback in landings from the Potomac River, 1966 to 1974.

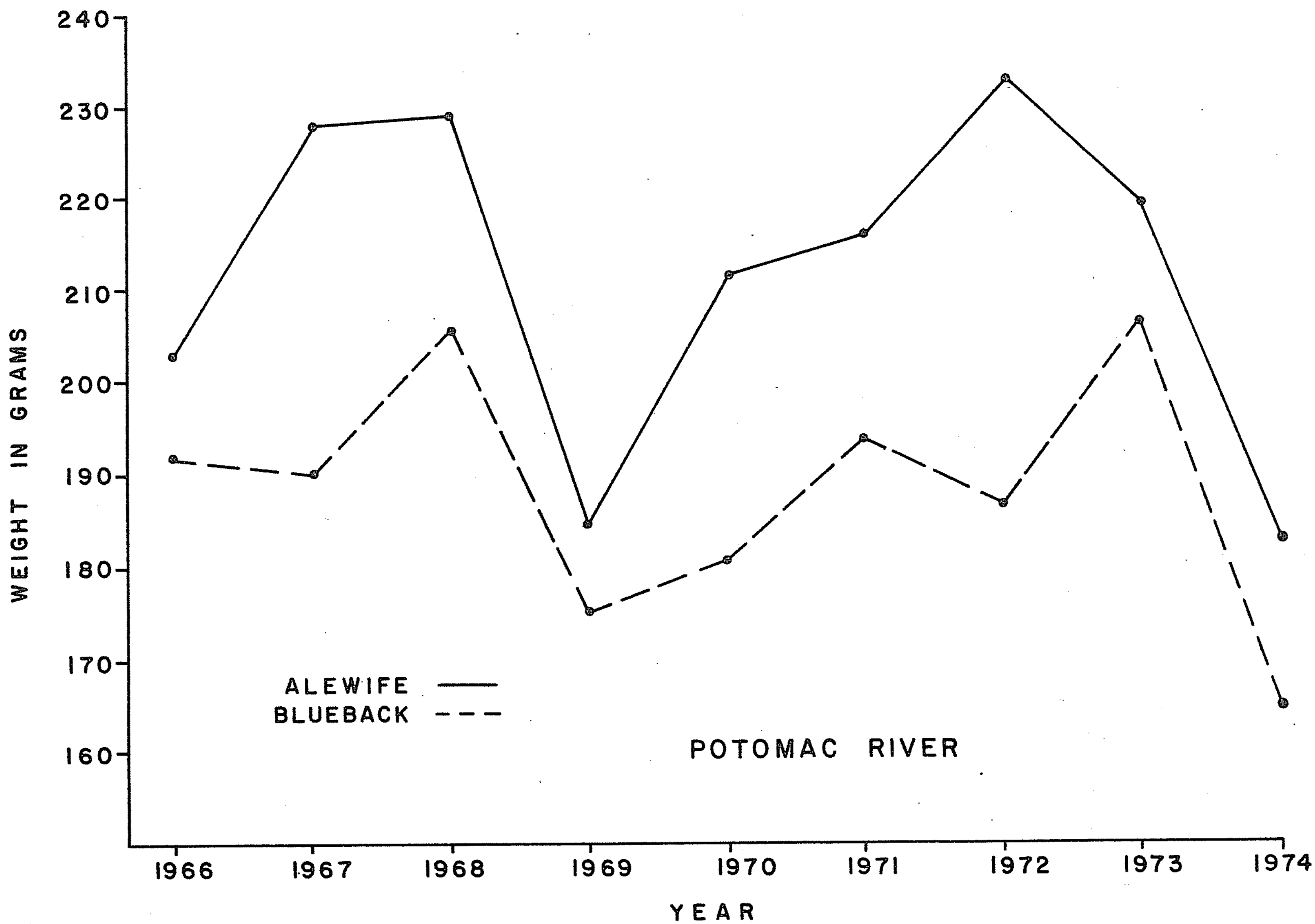


Fig. 2.3. Average weight, using combined data for season and sex, for alewife and blueback in landings from the Potomac River, 1966 to 1974.

Table 2.1. Summary of alosine collections[1] gathered by project personnel during the 1974 spawning run in major Virginia tributaries to Chesapeake Bay.

River and half month	Alewife		Blueback		American Shad	
	Males	Females	Males	Females	Males	Females
James						
April						
1st	181	51	39	38	24	26
2nd	167	15	24	14	19	31
May						
1st	52	36	34	39		
2nd	39	11	25	11		
Chickahominy						
April						
2nd	2		119	81		
May						
1st			103	85		
2nd			131	37		
York						
March						
2nd	44	38	13	4		
April						
1st	34	16	23	17		
2nd	7		49	65		
Rappahannock						
March						
2nd	113	80	10	1		
April						
2nd	48	51	90	45	29	21
May						
1st	25	20	156	44	24	26
2nd	18	14	65	78		5
Potomac						
April						
2nd	32	31	108	57		
May						
1st	12	12	170	91		
2nd	13	14	125	75		
Totals	787	389	1,284	782	96	109

[1]Includes only fish from which biological data were taken.

Table 2.2. Catch of river herring (alewife and blueback) in the inshore fishery and in ICNAF subarea 6 by various countries. Catch is in thousands of pounds, round weight.

	INSHORE			OFFSHORE						
	Virginia	North Carolina	Total U.S.A.	U.S.S.R.	East Germany	Bulgaria	Poland	Total Foreign	Total All Countries	Foreign Catch As Percent of Total Catch
1966[1]	29,061	12,522	46,689						46,689	
1967	28,166	18,489	48,944	2,163				2,163	51,107	
1968	32,326	15,529	52,137	2,370	278	0		2,648	54,785	5
1969	30,454	19,766	53,686	22,884		1,257		24,141	77,827	31
1970	15,051	11,523	32,822	13,126		1,645		14,771	47,593	31
1971	10,287	12,665	26,012	5,015	12,773	1,160	1,806	20,765	46,777	44
1972	11,175	11,197	23,389	4,515	5,227	322	897	10,961	34,350	32
1973	8,942	7,901	16,843[2]	1,764	2,284	615	745	5,408	22,251	24
1974	13,342	6,210	19,552[2]							
1966-1969 Average	30,002	16,576	50,364							
1970-1973 Average	11,364	10,822	24,766							
1966-1971 Average									54,130	

[1] First year of subarea 6 ICNAF statistics

[2] Landing records incomplete, use Virginia plus North Carolina as a first approximation for U.S.A. (NMFS Current Fisheries Statistics)

Table 2.3. Basic population attributes of the anadromous alosids in ~~the major~~ tributaries from the 1974 spawning run. (Fork length in millimeters and weights in grams)

	Alewife						Blueback						American Shad					
	Male			Female			Male			Female			Male			Female		
	Mean Length	Mean Weight	Number Sampled	Mean Length	Mean Weight	Number Sampled	Mean Length	Mean Weight	Number Sampled	Mean Length	Mean Weight	Number Sampled	Mean Length	Mean Weight	Number Sampled	Mean Length	Mean Weight	Number Sampled
James																		
Apr. 1-15	237.7	199.1	180	253.3	246.3	51	233.1	166.1	39	241.2	159.2	38	444.2	1603.7	24	459.0	1861.9	26
Apr 16-30	242.9	192.4	167	249.9	223.6	15	233.7	175.1	24	251.4	214.9	14	444.9	1417.1	19	456.7	1739.2	31
May 1-15	246.3	201.6	52	248.8	212.9	36	229.5	172.1	34	238.3	190.5	39						
May 16-31	241.9	197.5	39	251.9	239.2	11	242.4	183.8	25	250.5	215.5	11						
Males and Females Combined	246.1	213.8	551				239.8	184.6	224				450.8	1655	100			
Chickahominy																		
Apr 16-30	231.5	172.0	2		No Fish		237.2	187.4	119	249.9	232.4	81		No Fish			No Fish	
May 1-15	-						239.9	178.6	234	251.6	216.5	122						
Males and Females Combined							244.3	203.5	556									
York																		
Mar 16-31	241.6	215.5	44	259.2	284.9	38	236.4	180.2	13	246.8	219.8	4		No Fish			No Fish	
Apr 1-15	240.3	196.9	34	255.6	258.2	16	238.7	191.7	23	245.8	217.5	17						
Apr 16-30	241.6	175.6	7				233.4	181.8	49	241.0	204.0	65						
Males and Females Combined	247.5	226.3	139				240.2	199.4	171									
Rappahannock																		
Mar 16-31	237.2	207.0	113	250.7	255.5	80	229.1	170.7	10	238.0	153.0	1						
Apr 16-30	239.9	193.2	48	253.8	243.2	51	240.3	185.7	90	250.2	222.6	45	390.8	946.7	29	459.7	1435.9	5
May 1-15	241.6	165.6	25	256.9	193.6	20	240.5	152.4	156	252.5	184.2	44	388.6	819.7	24	456.5	1417.3	26
May 16-31	241.1	156.4	18	254.4	198.3	14	246.4	182.3	65	254.9	219.3	78				482.6	1920.0	5
Males and Females Combined	246.7	201.3	369				243.8	183.4	489				429.4	1308	89			
Potomac																		
Apr 16-30	231.2	177.3	32	225.3	202.2	31	235.7	172.5	108	242.7	185.5	57		No Fish			No Fish	
May 1-15	213.1	183.3	12	247.2	186.1	12	229.8	156.6	170	241.1	169.3	91						
May 16-31	242.7	179.2	13	246.5	167.5	14	235.0	143.8	125	246.0	162.8	75						
Males and Females Combined	234.3	182.5	101				238.2	164.7	625									

Table 2.4. Age composition of alosine fishes sampled from the commercial fishery of Virginia in spring 1974.

River	Alewife								Blueback									American Shad						
	Number at Age							Total	Number at Age								Total	Number at Age						Total
	3	4	5	6	7	8	9		3	4	5	6	7	8	9	10		4	5	6	7	8	9	
James	1	316	125	50	43	13	1	549	2	115	33	34	12	9		1	206	46	17	23	7	3	2	98
Chickahominy		2						2		176	71	158	79	34	14	2	534							
York		99	23	15	1		1	139		145	23	1					169							
Rappahannock	1	225	100	32	2	9		369	1	206	167	75	22	6		1	478	67	23	5	4	1	1	101
Potomac		96	10	3	2			111		454	67	22	8	3			554							
Species Grand Total								1,170									1,941							199

Job 3. Annual Index of Juvenile Abundance

A. Yearclass strength in 1974

A fifth annual index of yearclass strength for juvenile alosids was obtained from a trawl survey in the major tributaries between August 12 and September 27, 1974. The 1974 index was the lowest of any recorded to date by the project. Methods and sampling assumptions are detailed in Hoagman et al., 1973. The shallow draft sampling vessel was used on the James River but became inoperable for the other rivers. R/V Langley took all tows in the York, Rappahannock and Potomac rivers for the 1974 juvenile abundance index.

The standard data analysis developed from earlier years used pooled information from two vessels to derive the surface index, which was in turn averaged with the midwater index. In most cases the shoal water samples reflected nearly equal population abundance compared to channel samples, thus its absence this year may not have been critical to developing the general river index. However, in some years and rivers there was wide disparity in average c/f of the two vessels. We assume the 1974 index represents the true situation because we made a compensatory increase in sampling effort by the R/V Langley in the York, Rappahannock and Potomac rivers and because the two vessels reflected equivalent abundance in the James.

Towing effort was increased to derive a better annual index for juvenile alosids in 1974. The James received 1,660 min of towing effort compared to 1,150 in 1973 and the Rappahannock received 1,060 min effort in 1974 compared to 800 min in 1973 (Table 3.1). The York and Potomac rivers were sampled at previous effort levels or slightly greater. The effort at midwater depth during 1974 was boosted in every river, and now represents approximately one third of the total sampling effort.

The steady increase in towing effort since the beginning of the annual index represents our attempt to better quantify the relative and absolute abundance of alosines and other pelagic fishes associated with them. Effort expended in the rivers probably will not be increased in 1975, but we may sample several of the larger tributary streams in the 1975 survey.

The surface and midwater c/f estimates for 1974 (Table 3.2) were extremely poor with no alewife caught in the Mattaponi and no American shad taken in the Potomac. The proportions of each species in the catch were not drastically different from previous years with blueback predominating. The c/f estimates, stratified by two depths, did not suggest an atypical distribution in 1974. Surface c/f for the R/V Brooks was 137.7 blueback, 0.7 alewife, and 5.1 shad in the James. These c/f estimates for blueback and shad were double those of the R/V Langley. Past surveys (Hoagman et al., 1973, Table 3.6) have shown that the R/V Brooks does not consistently outfish the Langley but rather the shoal distribution (abundance) varies by river, year, and perhaps sampling week.

The 1974 c/f index of yearclass strength was the lowest of any recorded by the project (Table 3.3). Blueback c/f index for the James fell from 560 in 1973 to 87 in 1974, for the York-Pamunkey from 164 to 3.7 in 1974, for the Rappahannock from 558 to 3.8 in 1974, and for the Potomac from 4.5 to 1.4 in 1974. Alewife c/f index for the James fell from 7.3 in 1973 to 1.6 in 1974, the York from 18 (average of both branches) to 0.7 in 1974, the Rappahannock from 36 in 1973 to 1.2 in 1974, and for the Potomac from 0.8 to 0.4 in 1974. American shad c/f index for the James fell from 11 in 1973 to 4.9 in 1974, for the York from 15 to 3.4 in 1974. American shad c/f index for the Rappahannock increased from 0.8 in 1973 to 2.1 in 1974. No American shad were captured in the Potomac despite nearly a hundred tows at all depths between mile 65 and 95.

The 1974 c/f index for alewife and blueback combined was about 10% of the 1973 index. The 1974 American shad index was about 40% of the 1973 index. The 1974 yearclass strength for all species in every river was the lowest we have measured and continues the steady decline in estimates of juvenile production since 1970 (Fig. 3.1).

The 1974 year class will do nothing to replenish losses we have observed from overfishing by the combined domestic and foreign fisheries over the last several years. In previous reports we have predicted that the alosine fishery in Virginia between 1975 and 1977 can expect poor catches. With the poor 1974 year class, adult catches in 1978 and 1979 are now expected to be even lower. The production of juveniles is vital to sustaining any fishery and it now appears that this link is dissolving and may result in a perilously small spawning run in the foreseeable future.

Lengths of juveniles at capture were identical to other years and no diseases were apparent. There was an increased incidence of spinal deformity noted for all species in the James River. The run of spawning adults was sporadic but information from Jobs 1 and 2 indicates that the Potomac and Rappahannock had spawning runs at least equivalent to 1973. The spring of 1974 was for the most part "normal" within the context of factors which conceivably could affect yearclass strength. Prolonged cold snaps, low river flow, and extreme spring run-off were absent during early 1974. However, there was an unusually warm period during February which appeared to trigger an earlier run of alewife and blueback. The commercial fishery in Virginia usually captures the majority of its catch before the fish spawn, but this fraction is probably "constant" in years of scarcity as well as abundance. We know of no change that would have allowed the commercial fishery to reduce the spawning potential in Virginia by taking a greater fraction of the run in 1974.

We believe the low yearclass success of all species in 1974 to be the result of several factors which periodically interact synergistically to yield far greater negative effects than when acting separately. This situation is typical for many fish stocks and often results in some cyclic function. The mechanisms of interaction may never be resolved, but if the negative factors converge on an already depressed population, the effects are far more apparent.

Year classes usually vary by factors of 3 to 10 when the stock is healthy and reproductive potential (including the environment) is adequate. Thus a year class ten times the norm or a year class one-tenth the norm is very unusual. As the general stock declines, the variability in yearclass potential remains the same, creating a situation where a one-tenth normal year class is barely measurable. Similarly, a year class several times normal, under depressed population conditions, may not be as large as a normal year class under former conditions. Yearclass variability usually increases at very low stock levels, thereby creating a real potential for stock extinction (Ricker, 1958).

We are not predicting stock extinction for the Virginia anadromous alosines; indeed, they may never become extinct in the literal sense. If the fishery fails completely because of lack of fish, then this parallels the meaning of extinction to most interests. The central idea is that the situation is close to the point where irreversible outcomes are possible by a combination of natural factors. The alosine stocks are depressed and are subject to greater damage due to the lack of "reserve." In some cases, perhaps here, density dependent effects of natural population regulation may improve the alosine stocks faster than anticipated, i.e. historical recovery of other fisheries. However, the danger is catastrophic mortality which is density independent and causes an equal percentage death at both low and high densities. When the stock is abundant it can absorb these, when low it cannot.

B. <u>Summary of yield and parent-progeny relationship</u>

The anadromous fish project on alosine fishes has generated data which is useful in the determination of several aspects of population dynamics for blueback, alewife and American shad. This information has been presented in annual reports, but was not always synthesized in journal format. With five years of yearclass strength data and yield data by species by river for even longer, we now have the basis for summation and generalization of important relationships and possible causes. The following manuscript brings together and extends the data gathered within several jobs of the project. It is presented here to allow use before its appearance in a scientific journal.

References Cited

Hoagman, W. J., J. V. Merriner, R. St.Pierre, and W. L. Wilson. 1974. Biology and Utilization of Anadromous Aloside. Completion Report 1970-1973, Project No. VA AFC 7-1 to 7-3 212 pages.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Bull. No. 119. Fish. Res. Bd. Canada. Ottawa, Ontario. 300 pages.

The Production of Juvenile Clupeids in Relationship to Size of Spawning Stock in Virginia Estuaries

by

Walter J. Hoagman and Jackson Davis

Abstract

Year class strength estimates of alewife, blueback herring and American shad were compared to landings and catch-per-effort estimates of the parents in the major freshwater nursery zone of the James, York, Rappahannock and Potomac rivers of Chesapeake Bay. There was no direct parent-progeny relationship for any species in any river, although adult landings of shad (females) below 150,000 pounds per season usually coincided with weak year classes.

The James River was the most productive for young alosines over the period of record. The density of juveniles in the James River exceeded the other rivers by 15 to 70 times depending on year and species. The Potomac, with far less density, produced more young alosids than in the more productive York and Rappahannock because of its large nursery zone. Over the last five years the total estimated number of juvenile alosids present in early fall ranged between 73 and 1969 million for all rivers.

Introduction

The anadromous alosines constitute an important biological and economic resource to Chesapeake Bay and the middle Atlantic. Each spring the adults of alewife, *Alosa pseudoharengus* (Wilson), blueback herring, *Alosa aestivalis* (Mitchill), and American shad, *Alosa sapidissima* (Wilson) ascend the freshwater tributaries to spawn (Massmann, 1952; Walburg and Nichols, 1967). An intensive fishery exists for these species from the Chesapeake Bay mouth to the final spawning areas in fresh water. Adults again run the gear gauntlet after spawning and return to the Atlantic Ocean.

The young hatch from March through June and become the dominant pelagic planktivore of the freshwater zones (Massmann, 1953). Here they spend their first half year and then migrate to sea in mid-fall as the water temperatures decline. They are exploited by the offshore fishery, mature within five years and return to their river of origin to complete the cycle. After their initial spawning they return yearly.

The Virginia Institute of Marine Science under the Anadromous Fish Act (Public Law 89-304) has been studying this group intensively since 1965. This paper summarizes the yearclass strength estimates, compares them to parent stock, and demonstrates the relative importance of the James, York, Rappahannock and Potomac rivers.

Methods and Materials

Young fish sampling

The juvenile alosines were sampled in August and September in the freshwater zones of the major rivers (Fig. 3.2). A 5 x 5 ft Cobb trawl was towed for 10 minutes at the surface or midwater without relation to tidal flow. Trawl effort was divided between a shallow draft vessel which worked the shoals (R/V *Brooks*) and a larger vessel which towed mainstream (R/V *Langley*). Effort was concentrated in the most productive stretch of each river and generally consisted of 2 to 4 tows per river mile. Catch-per-unit-of-effort was calculated from the grand average catch of both vessels in the defined nursery zone and the midwater and surface tows combined. Midwater (3 to 7 m) catches were incorporated because of the heterogenous vertical distribution of some species in some years (Hoagman et al., 1973). All tows were made between two hours after sunrise and two hours before sunset. This program has been carried out for five years (1970-1974) in all rivers and six years in the James.

Adult sampling

Total yield by species was available for the Potomac through the Potomac River Fisheries Commission. In the Rappahannock, log books were placed with fishermen operating 18% of the total pound nets and 10% of the stake gill nets. Yield for the Rappahannock above river mile 15 was extrapolated from these index nets. Yield of shad from the York River was obtained from log books providing 75% coverage of the stake gill nets. Yield of shad from the James River was extrapolated from log book data which included 35% of the stake gill nets. In the York and James, alewife and blueback were not fished commercially from 1969-1973. Shad are further separated into females and males because males are often discarded at the net, which would bias the parent stock estimates for comparison with young. Full details of the run and program are in Davis et al. (1971 and 1972) and Hoagman et al. (1973).

Juvenile Catch Comparison

The catch-per-unit-of-effort (c/f) of juveniles was highest in the James from 1970-1974, even though catch per tow declined from 2,273 to 87 for blueback, 164 to 2 for alewife, and 41 to 5 for shad (Table 3.3). In 1970 the blueback catches (c/f) ranked by river were James, Potomac, York and Rappahannock; for 1971 it was James, York, Rappahannock and Potomac; in 1972 it was James, Rappahannock, Potomac and York; in 1973 the James led again but the Potomac was last. The Rappahannock had doubled its blueback production nearly every year but crashed to a c/f of four in 1974. In general, when blueback catches were low in any river for a given year, alewife and shad numbers were also low. The Potomac and Rappahannock yielded low numbers of juvenile shad in every year despite high yields of adults during the spawning runs.

The percent contribution that each species made to the total juveniles captured (Table 3.4) was similar in every river and across the river width. Blueback made up from 80.4 to 97.5% of the catch in the James, 60.7 to 91.9 in the York, 85.9 to 95.4 in the Rappahannock, and 83.3 to 93.7 in the Potomac. Blueback were dominant in the same rivers in 1951 and 1952, (Massmann, 1953) ranging from 81 to 91% of total clupeids captured with surface trawls and minnow seines. Warinner, et al. (1969) reported 95% blueback in the Potomac in 1968 and included trawls at three depths for several stations from June through October. Davis and Cheek (1966) reported 73% blueback in surface water of the Cape Fear system in North Carolina during July through November. In Virginia waters the use of surface tows alone biases catches in favor of blueback (Hoagman et al., 1973).

Adult and Juvenile Relationship

Yield of spawning stock by weight can be compared with experimental catches of juveniles by number if ova production is proportional to weight and yield is proportional to stock. The relationship between ova production and weight was linear for York River shad (Nichols and Massmann, 1963), for Altamaha River shad (Vaughn, 1967) and for blueback in Georgia (Street, 1969). During years of high yield, our adult c/f estimates are high, so we are fairly certain yield is proportional to spawning stock by year.

By comparing the percentage composition of the juvenile catch in late summer to the percentage catch of spawning stock in spring, the parent-progeny relationship is tested. Rappahannock and Potomac stocks were tested this way and the 27 available XY point (all species) showed no significant relationship between composition of adult catch and composition of juvenile catch in late summer. The Potomac with adult blueback percentages of

65-90 approached the 83 to 93% juvenile catch but we feel these data are misleading because the Potomac fishermen set their nets too late in most years to take appreciable quantities of the earlier running alewife.

A comparison of yield and juvenile c/f for each species, keeping rivers separate, similarly failed to show any positive relationship. No species fit the expected pattern better than any other even though blueback numbers are the most reliable.

A comparison of roe shad alone (Table 3.5) with the juvenile c/f of shad by river and combined showed no relationship. A comparison of adult shad c/f (Hoagman et al., 1973) with juvenile shad c/f similarly showed no relationship. At very low stock sizes (150,000 pounds or less of females per year) juvenile production does seem to falter however. The juvenile shad in the Rappahannock show this for 1972 and 1973, the York in 1970, and the Potomac in 1970.

For the Rappahannock and Potomac, the percentage of juveniles of each species does not resemble the percentage of adult yield by species. For any particular species, the fluctuation in yearclass strength had no relationship to the yield of mature adults that previous spring. In the York and James, estimates of blueback and alewife are unavailable because an active commercial fishery for these does not now exist. The percentage of each species as juveniles however, is practically identical with the other rivers, so they must have very substantial spawning runs. The yield estimates are possibly in error for the Rappahannock, but records are nearly complete for the Potomac River in which, through the Potomac River Fisheries Commission regulations, all fishermen report landings.

Estimates of Juvenile Stocks

The relative density of juveniles in the nursery zone can be determined from Table 3.3. The absolute density can be approximated by dividing the water strained (1062 m^3) into the grand c/f, but the results would merely reduce the size of the numbers. A minimum estimate of stock size can be calculated by comparing size of nursery zones and the rivers can thus be compared on an absolute basis. The final estimates may not be as precise as desired but do serve to rank the rivers and are helpful in determining their importance to alosine stocks.

Cronin (1971) provided volumetric and areal statistics of the Chesapeake Bay tributaries. His accumulated mean low water areas for various regions are given in Table 3.6. The nets used in this investigation strained 1062 m^3 in 10 minutes at 2 kn and were towed randomly in relation to tide. The grand average c/f for each nursery zone included zones of high and low abundance, midwater and nearsurface depths, shoal and deep water areas, and can be used directly as the river average. The intertidal volume is usually a small fraction of the total volume and the additional space provided for alosines at high tide is small compared to total volume. The midwater tows are made at a fishing depth 4 to 6 m and few juveniles are often very dense. To account for shoals and other areas that are less than 5 m, and since juveniles are captured at 5-8 m over deep water, we will assume the entire nursery zone resembles a box only 4 m deep. This should provide a conservative estimate because several of the rivers have steep sides and the actual nursery zone extends down to 5-7 m to both shores. We computed total number of juveniles from the expression

$$N = \frac{\text{Vol. of Nursery Zone}}{\text{Vol. of Tow}} \times \text{Grand c/f}$$

for each species and river.

In every year the James had far more juvenile alosines in late summer than any other river, ranging from 1633 to 62 million blueback, 117 to 2 million alewife and 30 to 4 million American shad (Table 3.6). The second most important river was the Potomac because of its large nursery zone. The York and Rappahannock produce juveniles in fair density (Table 3.3) but the small water volumes in these rivers from 0-4 meters puts them far below the others in total contribution. The James led the Potomac by an average density factor of 70 for blueback, 27 for alewife and 59 for shad in 1970 through 1974. It has led the York and Rappahannock by factors of 72 and 88 for blueback.

In 1972 juvenile blueback production in the Rappahannock was up three-fold compared to 1970 and 1971 and then it doubled again in 1973. James production was down by 80% in 1972, but it still produced nine times the number of blueback as did the Rappahannock. In 1973 the James increased two-fold over 1972 production, as did the Rappahannock. American shad yield (adults) in the James has averaged 4 to 10 times that of the Rappahannock, yet the young present in late summer average over 70 times the total number present in the Rappahannock. In 1974 all rivers produced extremely poor year classes despite spawning runs that were similar to several earlier years. Shad runs in all rivers have been holding well over the last several years. It seems very doubtful that the low numbers of young shad produced in the York, Rappahannock and Potomac could support a yield of 200 to 500 thousand pounds per year. Our initial estimates of absolute juvenile production may be in error, but they serve to distinguish the relative importance of the major tributaries to Chesapeake Bay.

Comparison of total number of young produced (Table 3.6) and the size (weight) of the spawning run did not show any direct relationship between parents and progeny.

Overall, 1972 was a bad year for every species; 1973 showed some recovery but 1974 broke all low records. Hurricane Agnes which flooded the Virginia rivers in June of 1972 may have contributed to the poor year class but definite proof is lacking. The 1974 year class will do little to bolster the sagging Virginia fishery. We can suggest no reason at this time why 1974 was such a poor year.

Literature Cited

Cronin, W. B. 1971. Volumetric, areal and tidal statistics of Chesapeake Bay estuary and its tributaries. Chesapeake Bay Inst. Spec. Rep. No. 20. 135 p.

Davis, J. R. and R. P. Cheek. 1966. Distribution, food habits, and growth of young clupeids, Cape Fear River system, North Carolina. Proc. S. E. Assoc. Game and Fish Comm. 20:250-260.

Davis, W. J., J. V. Merriner, W. J. Hogman, R. A. St.Pierre, and W. L. Wilson. 1971. Biology and utilization of anadromous alosids. Annu. Prog. Rep., Virginia AFC-7-1. Virginia Inst. Mar. Sci. 105 p.

Davis, W. J., W. J. Hogman, J. V. Merriner, R. A. St.Pierre, and W. L. Wilson. 1972. Biology and utilization of anadromous alosids. Annu. Prog. Rep., Virginia AFC-7-2. Virginia Inst. Mar. Sci. 119 p.

Hoagman, W. J., J. V. Merriner, R. St.Pierre, W. L. Wilson, and W. J. Davis. 1974. Biology and management of river herring and shad in Virginia. Completion Rep. 1970-1973. Virginia AFC 7-1 to 7-3, Anadromous Fish Act, NMFS. 212 p.

Massmann, W. H. 1952. Characteristics of spawning areas of shad *Alosa sapidissima* (Wilson) in some Virginia streams. Trans. Amer. Fish. Soc. 81:78-93.

Massmann, W. H. 1953. Relative abundance of young fishes in some Virginia streams. Trans. 18th N. Amer. Wildl. Conf. 439-449 p.

Nichols, P. R. and W. H. Massmann. 1963. Abundance, age, and fecundity of shad, York River, Va., 1953-1959. Fish Bull. 63(1):179-187.

Street, M. W. 1969. Fecundity of the blueback herring in Georgia. Contrib. No. 17, Mar. Fish. Div., Georgia Game and Fish Comm. 15 p.

Vaughn, T. L. 1967. Fecundity of the American shad in the Altamaha River system. Contrib. No. 3. Mar. Fish. Div. Georgia Game and Fish. Comm. 9 p.

Walburg, C. H., and P. R. Nichols. 1967. Biology and management of the American shad and status of the fisheries, Atlantic coast of the United States, 1960. U. S. Fish and Wildl. Serv. SSR-Fish. No. 550. 105 p.

Warinner, J. E., J. P. Miller, and W. J. Davis. 1969. Distribution of juvenile river herring in the Potomac River. Proc. 23rd Conf. S. E. Ass. Game and Fish. Comm. 23:384-387.

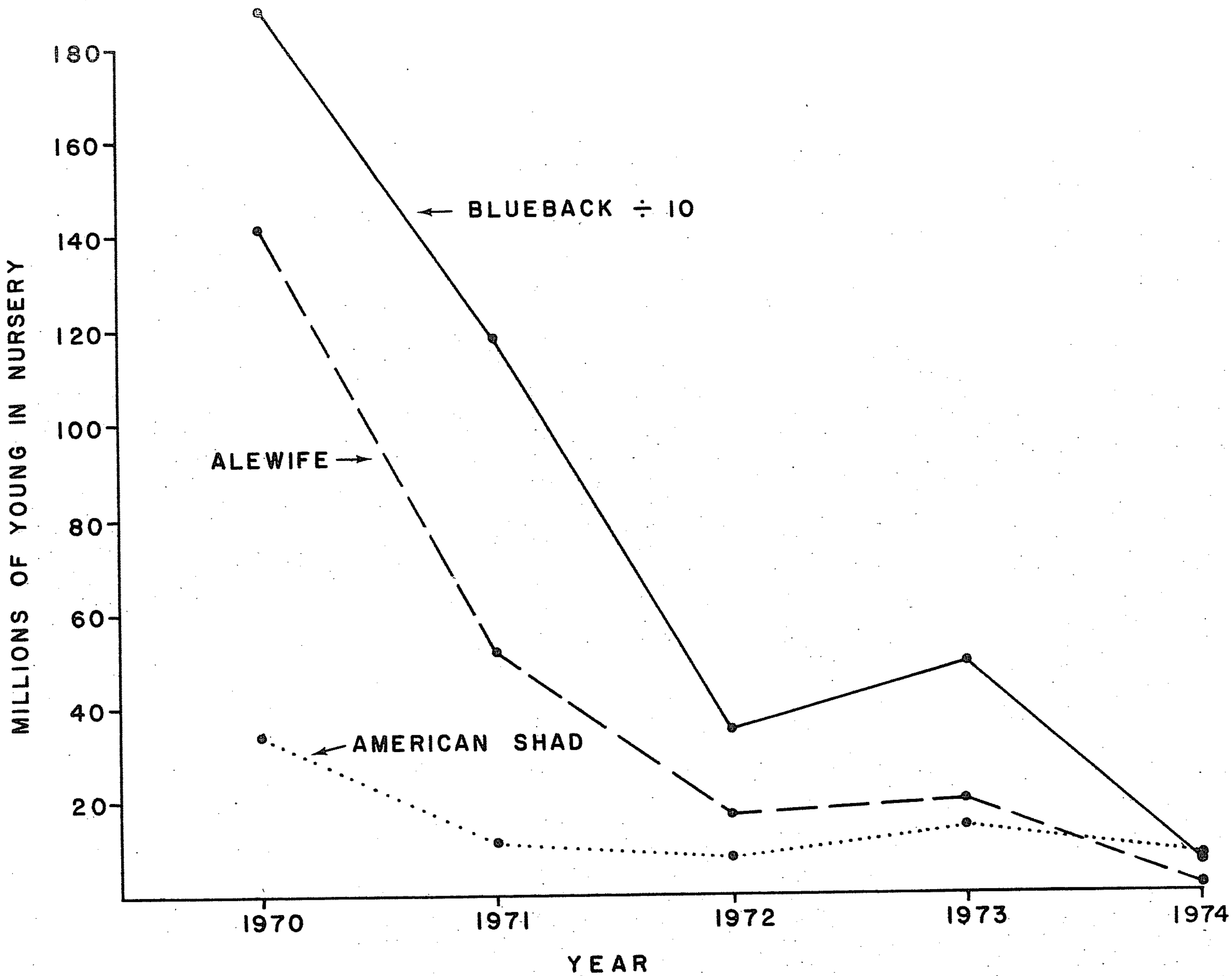


Fig. 3.1. Yearclass strength of alewife, blueback herring, and American shad expressed as total estimated number of young (Aug.-Sept.) in all major nursery zones (Fig. 2.2) for 1970 to 1974. Data from Table 3.4.

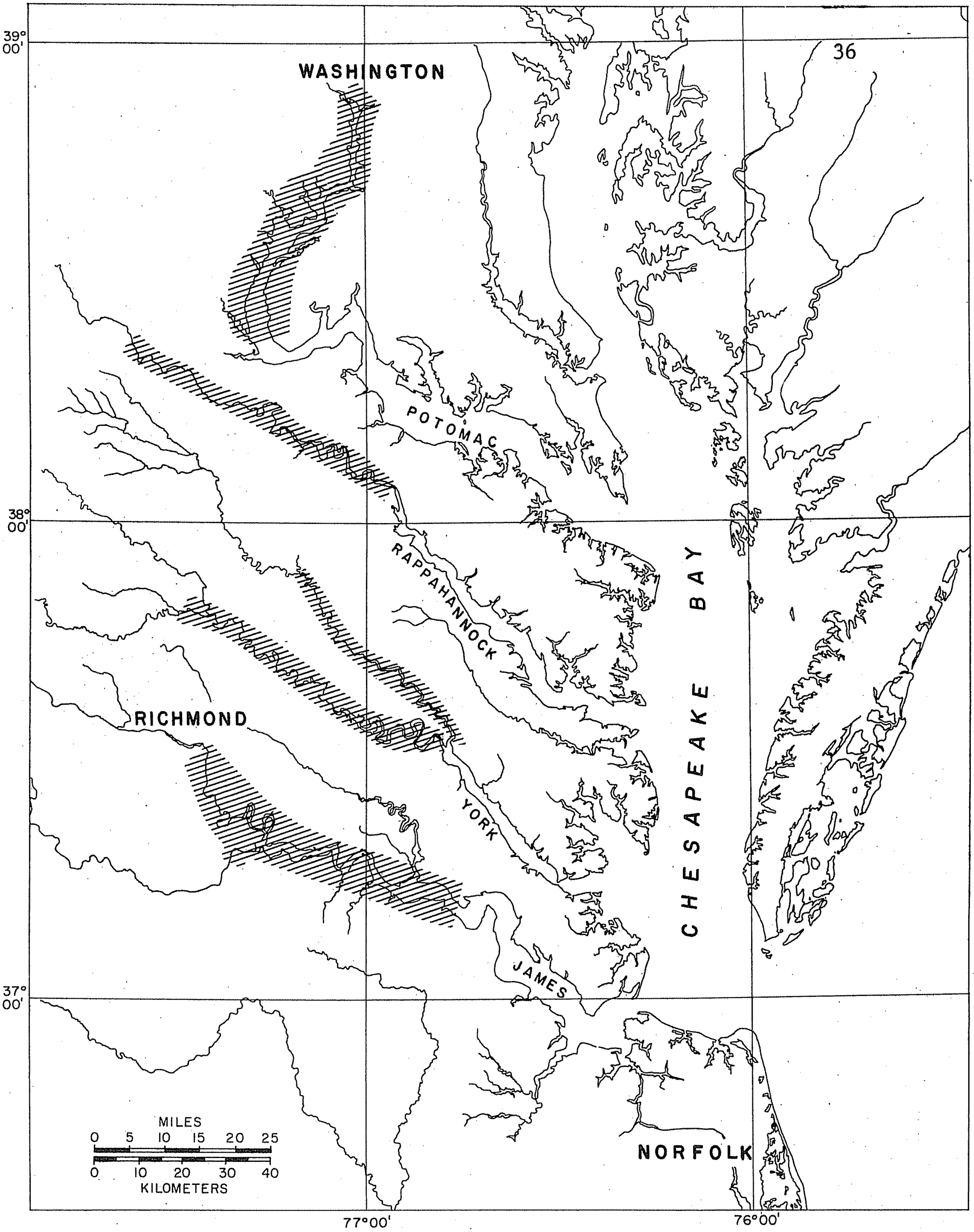


Fig. 3.2. Location chart of the major alosid nursery zones in Virginia and their relation to the entire estuarine and Chesapeake Bay system. Shaded portions are freshwater nursery zones.

Table 3.1. Trawling effort with pelagic trawls for juvenile alosids in Virginia rivers. (Five-min tows in 1969-1972 and 10-min tows in 1973 and 1974.)

	R/V Langley				R/V Brooks[a]		Total Towing Time
	Surface		Midwater		Surface		Surface &
	Tows	Minutes	Tows	Minutes	Tows	Minutes	Midwater
James							
1969	20	100	10	50			150
1970	46	230	10	50	38	190	470
1971	46	230	10	50	40	200	480
1972	92	460			73	365	825
1973	33	330	16	160	66	660	1,150
1974	60	600	32	320	74	740	1,660
York-Pamunkey							
1970	30	150	3	15	35	175	340
1971	21	105	5	25	30	150	280
1972	42	210			66	330	540
1973	14	140	14	140	52	520	800
1974	60	600	20	200			800
York-Mattaponi							
1970	25	125	4	20	25	125	270
1971	21	105	3	15	21	105	225
1972	44	220			50	250	470
1973	10	100	10	100	42	420	620
1974	60	600	20	200			800
Rappahannock							
1970	31	155	5	25	26	130	310
1971	31	155	7	35	31	155	345
1972	62	310			62	310	620
1973	19	190	25	250	36	360	800
1974	66	660	40	400			1,060
Potomac							
1970	31	155	7	35			190
1971	31	155	7	35	30	150	340
1972	62	310			62	310	620
1973	22	220	21	210	62	620	1,050
1974	70	700	35	350			1,050

(a) Brooks used only in James River in 1974 because of mechanical breakdown.

Table 3.2. Average c/f estimates in surface and midwater tows for juvenile alosids in major Virginia rivers during 1974. (Two vessels in James River and only R/V *Langley* in other rivers).

River and Miles Used	Blueback	Alewife	American Shad	Total Tows Within Miles
James, 35-80				
Surface c/f	79.7	0.7	3.4	100
Midwater c/f	93.7	2.4	6.4	60
Average	86.7	1.6	4.9	
Percent	93.0	1.7	5.2	
York-Pamunkey, 30-55				
Surface c/f	2.7	1.2	2.2	40
Midwater c/f	4.7	1.6	4.2	20
Average	3.7	1.4	3.2	
Percent	44.6	16.9	38.6	
York-Mattaponi, 30-50				
Surface c/f	8.2	0	6.0	40
Midwater c/f	1.5	0	1.5	20
Average	4.8	--	3.7	
Percent	56.5	--	43.5	
Rappahannock, 50-80				
Surface c/f	1.5	1.3	1.6	63
Midwater c/f	6.1	1.2	2.6	39
Average	3.8	1.2	2.1	
Percent	53.5	16.9	26.6	
Potomac, 65-95				
Surface c/f	1.0	0.3	0	60
Midwater c/f	1.8	0.4	0	30
Average	1.4	0.4	--	
Percent	77.8	22.2	--	

Table 3.3. Annual index of yearclass strength for all species in all rivers using the combined data of two vessels and the midwater and surface samples. Figures are average c/f defined as a 10-min tow with the 5x5' Cobb trawl.

River and Year	Total Tows	Blueback	Alewife	American Shad	Average Blueback and Alewife[a]	Average of all Species[a]
James						
1969	30	263.0	39.0	25.0	101.3	63.5
1970	94	2,273.0	164.0	41.0	610.6	248.2
1971	96	1,591.0	63.0	12.0	316.6	106.3
1972	165	368.0	4.6	4.9	41.1	20.2
1973	115	560.0	7.3	11.0	63.9	35.6
1974	166	86.7	1.6	4.9	11.8	8.8
York-Pamunkey						
1970	68	128.0	12.0	3.6	39.2	17.7
1971	56	251.0	52.0	2.3	114.2	31.1
1972	108	15.0	5.5	4.2	9.1	7.0
1973	80	164.0	8.5	6.0	37.3	20.3
1974	80	3.7	1.4	3.2	2.3	2.6
York-Mattaponi						
1970	54	89.0	7.1	5.8	25.1	15.4
1971	45	11.0	23.0	6.6	15.9	11.9
1972	94	17.3	8.3	5.7	12.0	9.4
1973	62	15.0	27.0	24.0	20.1	21.3
1974	80	4.8	0.0	3.7	2.0	1.2
Rappahannock						
1970	62	108.0	10.0	0.6	32.9	8.7
1971	69	44.0	1.9	0.2	9.1	2.5
1972	124	234.0	38.1	0.2	94.4	12.1
1973	80	558.0	36.0	0.8	141.7	25.2
1974	106	3.8	1.2	2.1	2.1	2.1
Potomac						
1970	38	169.0	27.0	0.5	67.5	13.2
1971	68	8.9	0.4	0.2	1.9	0.9
1972	124	54.0	5.5	1.0	17.2	6.7
1973	105	4.5	0.8	0.1	1.9	0.7
1974	105	1.4	0.4	0.0	0.6	0.4

[a] Geometric mean.

Table 3.4. Percentage distribution of the juvenile alosids from the combined c/f of the R/V Langley and R/V Brooks, surface and midwater.

River and Year	Blueback	Alewife	American Shad
James			
1969	80.4	11.9	7.7
1970	91.7	6.6	1.7
1971	95.5	3.8	0.7
1972	97.5	1.2	1.3
1973	96.8	1.3	1.9
1974	93.0	1.7	5.2
York-Pamunkey			
1970	89.1	8.4	2.5
1971	82.2	17.0	0.8
1972	60.7	22.3	17.0
1973	91.9	4.8	3.3
1974	44.6	16.9	38.6
York-Mattaponi			
1970	87.3	7.0	5.7
1971	27.1	56.7	16.2
1972	55.3	26.5	18.2
1973	22.7	40.9	36.4
1974	56.5	0	43.5
Rappahannock			
1970	91.1	8.4	0.5
1971	95.4	4.1	0.4
1972	85.9	14.0	0.1
1973	93.8	6.1	0.1
1974	53.5	16.9	26.6
Potomac			
1970	86.0	13.7	0.3
1971	93.7	4.2	2.1
1972	89.3	9.1	1.6
1973	83.3	14.8	1.9
1974	77.8	22.2	0

Table 3.5. Yield by commercial gear of adult clupeids in Virginia rivers 1967-1973 and their percentage contribution to the catch. Yield is in thousands of pounds.

River and year		Species: Blueback Yield	Blueback Percent of Total	Alewife Yield	Alewife Percent of Total	American Shad Yield of both Sexes	American Shad Yield of Females	American Shad Percent of Total	All Species, Yield
James	1969	-		-		1569	1435	100	1569
	1970	-		-		1962	1619	100	1962
	1971	-		-		1961	1718	100	1961
	1972	-		-		3003	1683	100	3003
	1973	-		-		1901	1075		1901
	1974	-				1511	737		1511
York	1967	76	14	184	35	274	201	51	534
	1968	340	37	217	24	351	204	39	908
	1969	-		-		174	169	100	174
	1970	-		-		159	147	100	159
	1971	-		-		435	371	100	435
	1972	-		-		355	322	100	355
	1973	-		-		490	438		490
	1974	-				396	353		396
Rappahannock	1965			995					
	1966			632					
	1967	2833	57	1932	39	204	103	4	4969
	1968	406	19	1248	59	469	263	22	2123
	1969	374	23	842	50	454	254	27	1671
	1970	103	14	363	49	268	156	37	734
	1971	445	32	430	31	518	378	37	1393
	1972	295	33	441	49	147	96	16	778
	1973	532	46	332	35	80	49	8	944
	1974	287	33	475	56	95	56	11	857
Potomac	1965	6723	65	4169	31	346	-	4	13328
	1966	9166	81	1943	17	177	-	2	11268
	1967	7043	80	1617	18	212	130	2	8772
	1968	6048	75	1629	20	393	249	5	8070
	1969	2838	75	637	17	298	204	8	3773
	1970	5676	90	473	7	170	111	3	6319
	1971	5065	82	790	13	354	300	5	6209
	1972	3105	60	1618	31	421	360	9	5144
	1973	834	53	550	35	194	157	12	1578
	1974	2873	80	648	18	79	49	2	3600

Table 3.6. General estimates of yearclass strength and estimates of numbers of young alosids in Virginia rivers in August and September.

River and Miles Included	Area in Nursery Zone, $10^6 m^2$	Volume in Nursery Zone, $10^6 m^3$	Volumes Equated to Smallest Zone	Species	Estimated Number Present in Early Fall, in Millions. 1970	1971	1972	1973	1974
James	190.8	763.2	15.97	Blueback	1633.2	1143.3	264.5	402.4	62.3
35-80				Alewife	117.8	45.3	3.3	5.2	1.2
				American Shad	29.5	8.6	3.3	7.9	3.5
York-Pamunkey	25.6	102.4	2.15	Blueback	12.3	24.2	14.4	15.8	0.4
30-60				Alewife	1.2	5.0	5.3	8.1	0.1
				American Shad	3.5	2.2	4.0	5.7	0.3
York-Mattaponi	11.9	47.8	1.00	Blueback	4.0	0.5	0.8	0.7	0.2
30-50				Alewife	0.3	1.1	0.4	1.2	0
				American Shad	0.3	0.3	0.3	1.1	0.2
Rappahannock	32.4	129.4	2.71	Blueback	13.2	5.4	28.5	68.0	0.5
50-80				Alewife	1.2	0.2	4.6	4.4	0.1
				American Shad	0.07	0.02	0.02	0.09	1.5
Potomac	206.2	824.8	17.26	Blueback	131.3	6.9	42.0	3.5	1.1
65-95				Alewife	21.0	0.3	4.3	0.6	0.3
				American Shad	0.4	0.2	0.8	0.07	0

Table 3.6. (Continued)

River and Miles Included	Area in Nursery Zone, $10^6 m^2$	Volume in Nursery Zone, $10^6 m^3$	Volumes Equated to Smallest Zone	Species	Estimated Number Present in Early Fall, in Millions. 1970	1971	1972	1973	1974
			Total						
				Blueback	1794.0	1180.3	350.2	490.4	64.5
				Alewife	141.5	51.9	17.9	19.5	1.7
				American Shad	33.8	11.3	8.4	14.9	7.2

Job 4. Feeding Energetics of Juvenile Alewife

Job 4 formerly contained the productivity, nutrient, zooplankton, feeding and community aspects of the alosine nursery zones. These general aspects were reported in the 1973 completion report. An in-depth study of alewife became the dissertation research project of James Weaver and will require one more year to complete the laboratory phase and write-up. To indicate progress made, the work performed to date by Weaver is summarized below.

"Food selectivity, feeding chronology, and energy transformations in juvenile alewife (Alosa pseudoharengus) in the James River at Hopewell, Virginia"

The objectives of the research are two-fold: (1) describe the food, feeding selectivity, and feeding chronology of juvenile alewife and (2) establish a seasonal energy budget for a "typical" alewife by estimating ingestion rates (daily ration), egestion rates, respiration rates, and growth rates in a combined field and laboratory program.

A 12-min tow at surface and midwater (5 m fishing depth) for juvenile alewife in the James River near Hopewell, Virginia was made with a 1.5 m x 1.5 m Cobb trawl every 3 hr during a 24-hr period in the months of July, August and September, 1972, and June, July, August and September, 1973. Replicate 3-min surface and midwater plankton samples were taken with a Clark-Bumpus sampler equipped with a #20 (0.076 mm pore) mesh net every 3 hrs concurrently with the trawls. Flow meter readings were recorded to quantify plankton abundance and samples were preserved in 5% formalin for laboratory examination.

Five alewife from each surface tow and five from each mid-water tow were preserved in 10% formalin. Each fish was measured (fork length $\pm$ 1 mm) and weighed ($\pm$ 0.1 g). Stomach contents from each fish were weighed ($\pm$ 0.1 mg) and examined under a dissecting scope to identify and enumerate the prey species eaten over a 24-hr period. Plankton samples were examined under a dissecting scope, the species were identified, and enumerated. Feeding selectivity was calculated by relating percent of each prey species in the plankton to percent in the stomach by Ivlev's Index of Electivity:

$$E = \frac{r_i - p_i}{r_i - p_i}$$

where: E = electivity

r_i = percentage in stomach

p_i = percentage in plankton

The examination of the stomach contents and the anlysis of feeding selectivity will be completed during the 1974-1975 contract year.

Up to 25 alewife from each surface and midwater tow were frozen on dry ice in sealed plastic bags and returned to the laboratory. Wet weight was obtained on each fish and stomach contents were removed. Ten fish were selected from each monthly sampling period and the dry and ash weights were measured. Caloric content of replicate samples from these fish were determined with a Phillipson microbomb calorimeter utilizing standard techniques and corrections. Monthly growth rates of alewife expressed as changes in length, wet and dry weight, and caloric content are presently under study and will be completed this year.

Wet weight ($\pm$ 0.1 mg) of the stomach contents were obtained for each fish and feeding chronology was determined by following the changes in these weights over each 24-hr period. The stomach contents from fish captured in both surface and midwater tows were pooled for each 3-hr sample period and dry weights obtained. Ash weights were measured on a sample of the pooled contents and caloric value determined for replicate samples. Daily ration for alewife will be estimated by a model utilizing the mean wet and dry weight as well as mean caloric value of stomach contents from each 3-hr period with appropriate corrections for average stomach evacuation rates between each 3-hr period as determined by laboratory studies. Stomach content analyses have been completed and the daily ration model will be developed and tested this year.

Live alewife, collected by 30 m beach seine at Jamestown Beach on the James River from August through November, 1973, were returned to the laboratory for determination of respiration, stomach evacuation and ingestion rates.

Respiration rates were determined by a recording spirometer on individual fish held in a 4.8 liter container submerged in a constant temperature bath at 20, 25, and 30 C. At the conclusion of each experiment, length, wet weight, and dry weight were determined for each of eight fish used at each temperature. The analysis of respiration rates has been completed.

Stomach evacuation and egestion rates at 20, 25, and 30 C were based on single-meal experiments. Fish that had fasted for 48 hr were allowed to feed for 30 min on natural live plankton at each temperature, and uneaten plankton was then removed by water filters. Eight fish were immediately sacrificed, and lengths, wet weights, and dry weights determined. Wet and dry weights of stomach contents were recorded. Eight fish were then sacrificed every 1.5 hr, and stomach contents weighed, until digestion of the meal was completed. Ash weights and caloric values were determined on pooled samples of stomach contents obtained at each sacrifice interval. For egestion rates, feces from remaining live fish at each temperature were collected by pipette from tank bottoms during the next 48 hr. Wet and dry weights were determined on pooled samples of feces collected at each temperature. Ash weights and caloric values were also obtained on these samples. Stomach evacuation and egestion rate analyses have been completed.

The 1974-1975 contract year will be used for final data analysis, interpretation, and completion of the final document for inclusion in the 1975 progress report.

Job 5. Culture, Rearing and Experimental Study of River Herring

Development of techniques to rear alosine fishes from the egg through juvenile stages would allow experiments on the fish at several ontogenetic stages. These experiments would be uniform among replicates and stages tested in that the test animals would be from the same source and be exposed to the same environmental conditions until the time of testing. A documented series of each species would be obtained to allow description of larvae, aid in identification of field collections of larvae, and help in the recognition of hybrids in nature.

Progress toward the fulfillment of these goals has been achieved, but we have not been able to allocate either the manpower or the funds to this job that we feel are required to make a breakthrough in the culture of alosine fishes from egg to juvenile stage. This is due to budget limitations and personnel requirements for our other contracted objectives.

1974 Studies

Adult fish in spawning condition were captured by gill net and dip net in tributaries of the James River on three occasions. Egg taking and fertilization techniques were described in Hoagman et al., 1973. Plankton netting was placed in the bottom of the fertilization pans in all trials.

Fertilized eggs and netting were transferred to aerated aquaria in the laboratory for incubation and were monitored for development and mortality during incubation. Incubation water used in the 10, 20, and 30 gal aquaria was obtained from the site of adult fish collection. The netting (0.5 mm pore) retains the eggs (0.9 to 1.1 mm diameter) during incubation; after hatching larvae pass through the pores and do not become entangled in fungus on the dead eggs; and after all hatching, the dead eggs and fungus are easily removed from the aquaria. A fungicide (Wardley's Fungus Remedy) was added to the incubation aquaria (2 tbs/10 gal) to control fungus growth but this was not fully successful.

Food for the larvae was obtained from two nearby freshwater ponds. Plankton from approximately 150 gal of pond water, retained by 0.035 mm netting, was added to each aquarium daily. Rotifers were the most abundant food items (*Keratella* and *Brachionus*). A sample of larvae was examined with the aid of a dissecting microscope to inspect for feeding and growth, and a reference series of fish was preserved.

Alewife x Alewife

We did not capture both sexes of alewife in spawning condition on any collection trips in 1974.

Blueback x Blueback

Series A - Adult bluebacks were collected from Diascund Creek, a tributary of the Chickahominy River on May 8th. Eggs were stripped and fertilized at 1145 hr EDT. The water temperature was 18.2 C. The fertilized eggs arrived at the culture facility at 1630 hr and were placed in aquaria and in a large circular fiberglass tank containing a gravel filter system and well water. Subsamples of the egg lots were examined and fertilization was near 100%.

Observations at 22 hr after fertilization indicated high mortality (75+% in some cases). Water temperature had dropped to 15.5 C, suggesting fluctuation in water temperature during incubation as the cause of mortality.

Approximately 1500 live eggs were manually removed from the dead egg and fungus masses and were placed in four large fingerbowls. The embryos were examined (at 28 hr development) and found to be at the early tail-bud stage. The remaining live eggs and fungus mats were returned to the aquaria to complete incubation.

At 46 hr, the embryo's tails were free from the yolk and some movement was noticed. Approximately 10% mortality was noted in the fingerbowls. Temperature in all aquaria was 16 C and the water was changed in the fingerbowls. At 52 hr the water in the fingerbowls was again changed. Replacement water was obtained at the collection site and retained in an aerated aquarium in the laboratory.

At 62 hr, hatching had begun and the water temperature was 18 C.

At 86 hr, hatching was complete and larval density estimates in the aquaria were made (9,300 larvae present). These estimates later proved too unreliable and were discontinued. No larvae were found in the circular tank.

Concentrated plankton was added to the aquaria on the morning of day 6. A sample of larvae taken four hr after offering food revealed no food in their guts.

On day 7 food was again added and a sample of larvae was examined later, but no food was present in the gut. Similar results were obtained on day 8.

On day 9 some dead larvae were observed in the aquaria as plankton was added. The subsequent sample of larvae revealed two fish with what appeared to be partially digested food present in their guts. These "food" items however were digested beyond identification.

No food was added for the next two days and water samples from the aquaria revealed high densities of rotifers. On day 12 no live fish were observed in the aquria and examinations of the culture water revealed marginal densities of food organisms.

Series B - Adult bluebacks in spawning condition were collected on May 29, at Walker's Dam on the Chickahominy River (water temperature 25.5 C). Eggs were fertilized at 1430 hr EDT and arrived at VIMS at 1600 hr EDT. Spawning fish were not abundant at the collection site; as a result, one live female and one freshly dead female were fertilized with sperm from only one live male. The condition of the eggs was not optimal in this test due to the state of the adults used and high water temperature.

Fertilized eggs were placed in aquaria as before. Some egg mortality was evident as aquarium incubation was started and percent fertilization was not high.

At day 1, very high mortality was noted and the water temperature was 21.5 C. Approximately one thousand live embryos were removed from the netting and placed in fingerbowls for incubation. Embryos were in the late neural stages at the time of sorting. Water was changed in the fingerbowls after 6 hr.

At day 2, (43 hr after fertilization) the embryos were in the tail free stage and quite active. Hatching had begun in the fingerbowls by 50 hr after fertilization and larvae were observed in the aquaria.

At day 3, hatching was complete in the fingerbowls and these larvae were transferred to a 20 gal aquarium. Hatching had not been completed in the aquaria with egg mat netting. On day 4 hatching was completed in all aquaria and the netting was removed.

On day 5, all larvae were consolidated into one 30 gal aquarium and plankton was added. On days 6, 7, 8 and 9 plankton was added and live larvae were present. On day 8 a one-quart sample from the aquarium contained 3 live larvae.

On day 10, three one-gal samples from the aquarium contained a total of one larva. No plankton was added since the density of the plankton was equivalent to densities after feeding.

On day 11, no live larvae were found in the aquarium and plankton density was equal to that on day 10.

A collection trip to Walker's Dam on June 4 yielded no spawning bluebacks.

Hybrid Alosines

Alewife and blueback of opposite sex in spawning condition were not obtained during our field collections, thus hybrid crosses were not possible during 1974.

References Cited

Hoagman, W. J., J. V. Merriner, R. St.Pierre, and W. L. Wilson. 1974. Biology and Utilization of Anadromous Alosids. Completion Report 1970-1973, Project No. VA AFC 7-1 to 7-3 212 pages.

Job 6. River Herring Population Estimates, Movements, and Resource Utilization through a Tagging Program

This program element was inactive during the contract period 1973-1974.

Job 7. Resident Fishes of the Nursery Zone

Alosine fishes are present in the estuaries throughout most of the year at different life stages. Thus, most co-exist with, compete with, or are preyed upon by resident fishes in the estuary. Resident fishes are those present in the estuaries during the entire year. Migratory species, on the other hand, only contribute to the biomass of the system for a portion of the year. Fishes such as striped bass, Morone saxatilis are both resident and migratory. Adults enter the estuary in the spring, spawn, and leave; but juveniles remain in the system until they are two to three years old.

To estimate the resident population, a survey is conducted during the winter months. At this time, fishes have moved from the shallow creeks and flats into the deep holes in the channel and metabolic rates are much reduced. Thus, the resident population is best assessed during this time of relative concentration and immobilization.

The winter survey was conducted during January and February 1974. All major rivers of Virginia including the Potomac were sampled from river mouth to the upstream limit of navigation by R/V Langley. Four 1/4 mile tows, spaced 1 1/4 miles apart were taken with a 30' semi-balloon trawl per five-mile block (0-5, 5-10, 10-15, etc.) in each river. Length frequencies, total weights and total counts were recorded for each fish species taken on each tow. These data were pooled by five-mile blocks and assigned to the five-mile increment beginning the five-mile block (mile 0-4.9=0, mile 5-9.9=5, mile 10-14.9=10, etc.). All tows in a given river were made in one direction, either up-stream or down-stream, depending upon the direction of travel of the vessel, regardless of tide stage.

During the survey 73,954 specimens weighing 1519.41 kg were taken in 256 tows (Table 7.1). The Potomac River produced the lowest number of specimens (13,310) but had the greatest biomass (484.8 kg). The York River produced the greatest number of specimens (23,022) but ranked third in biomass (311.5 kg). The James River fish fauna had the greatest diversity with 37 species and diversity decreased progressively in each river to the north (Potomac = 25 species). Five species accounted for 84% of the biomass and 48% of the total number (Table 7.1) taken during the survey: white perch, Morone americana, (39.5%); brown bullhead, Ictalurus nebulosus, (14.9%); hogchoker, Trinectes maculatus, (11.3%); channel catfish, Ictalurus punctatus, (11.0%); white catfish, Ictalurus catus, (7.4%). All five prey on some life stage of alosine fishes. Gizzard shad, Dorosoma cepedianum, and spottail shiner, Notropis *hudsonius* are the main competitors, other than alosines themselves, during the warmer months when the juveniles are still in the nursery zone. In fall, when migration begins, bay anchovy, *Anchoa mitchilli*, Atlantic menhaden, *Brevoortia tryannus* and Atlantic croaker, *Micropogon undulatus* become the major competitors of the alosine fishes until they leave the bay. These five competitor species represent 44% of the total number of specimens but only 9% of the biomass (Table 7.1).

All surveyed river systems have basically the same ichthyofauna with the only variations being in the abundance of certain species by river system. Therefore, each system is presented to emphasize intersystem differences.

Potomac River

The Potomac River had the greatest total biomass of the four rivers sampled. This total would possibly be even higher save the fact that it is impossible to sample the area from mile 20 to 45. This 25 mile portion is a restricted area (the naval firing range at Dahlgren) and therefore is untrawlable. The combined biomass of white perch for miles 15-20 and 45-49 is 33% of the total white perch biomass for the river.

In the trawlable portion of the river, three species, white perch, brown bullhead and gizzard shad accounted for 97% of the biomass (Fig. 7.1). White perch dominated the river both in biomass (53.1%) and total numbers (71.9%) captured (Fig. 7.1). The remaining 22 species accounted for only 3% of the biomass. Hogchoker, *Trinectes maculatus*, white catfish and channel catfish, which normally represent large percentages of the biomass in other systems were taken in very small quantities in the Potomac. The Potomac is a highly productive river in terms of biomass even though most of this biomass is produced by only three species.

Rappahannock River

White perch were the leading contributor to biomass in the Rappahannock River (56.6%) (Fig. 7.1). Hogchoker, white catfish, channel catfish, and brown bullhead, together with white perch comprise 92% of the biomass in the Rappahannock River. Alosine fishes accounted for 8% of the total numbers and 2% of the biomass in the Rappahannock. This indicates there were still a fair number of alosine fishes remaining in the system as late as January. The Rappahannock had the lowest catch-per-unit-of-effort (c/f) and the lowest average biomass per tow of the rivers sampled even though it ranked second in total biomass taken per river (Table 7.1). The lower 75 miles of the river yielded 94% of the biomass. Only 20 g of white perch were taken in the upper 16 miles of the river and 98% of the hogchoker biomass (Fig. 7.1) occurred from mile 25 to 60.

York River

The York River ranked third in biomass captured in the winter survey and first in total number of fish (Table 7.1). This was due to the capture of large numbers of croaker and bay anchovy. Together these two species account for 58% of the total number of fish, but only 54% of the biomass in the York system. The Mattaponi and Pamunkey rivers produced almost identical biomass (68.6 kg and 71.6 kg, respectively), yet the Pamunkey produced almost twice as many specimens. Together they produced 45% of the biomass but only 32% of the total number of fish in the York system. Predator species, white perch (103.5 kg), hogchoker (90.2 kg), and white catfish (69.8 kg), represented 85% of the biomass.

Normally dominant predator species, such as gizzard shad and spottail shiner, present little competition for alosine fishes in the York where these fishes were replaced by species such as croaker and spot. Alosine fishes themselves only accounted for 1% of the total number and 1% of the biomass taken in the York River system.

James River

The James River ranked second in number of specimens (Table 7.1) and fourth in biomass captured. The average biomass per tow was also the lowest of all rivers surveyed, 4.3 kg/tow (1.5 kg below the average for all rivers) (Table 7.1). Unlike other systems, channel catfish had the greatest biomass, 123.2 kg (40.7% of the total) (Fig. 7.1) with brown bullhead second, 43.6 kg. The third ranked species by biomass was croaker which was very unusual for the winter months. Croaker ranked first in total number taken and was even more numerous than the next two most abundant species combined (Fig. 7.1).

The biomass is fairly evenly distributed from the James River mouth to the upper stations although the species composition changes with salinity. This statement is somewhat misleading until the oxbows (Turkey Island and Jones Neck) are examined. The upper 20 miles of the river yielded approximately 8% of the total biomass when only the mainstream stations were considered. Channel catfish comprise 85% of the biomass. Therefore, the oxbows must be examined to realistically describe the biomass and numbers of fishes in the area above Hopewell.

Turkey Island and Jones Neck Oxbows

The oxbows were cut off when the city of Richmond was improved as a seaport. The meandering James River was straightened by digging a channel across a short neck of land, eliminating the long bends at Turkey Island and Jones Neck. Recent sampling demonstrated extremely high productivity within the oxbows both in terms of fish abundance and biomass. Together they produced 20% (4,203) of the number of specimens and 24% (71.1 kg) of the biomass taken in the entire James River survey. More importantly, when the c/f and average biomass per tow in the oxbows are compared to the mainstream area, the oxbows produced 4.1 times as many fish (c/f) and 3.3 times as much biomass. Comparison of the "mainstream" stations adjacent to the oxbows with the oxbows themselves (Table 7.2) revealed 3 times as many species in Turkey Island Oxbow as at JA65-69, 5.2 times as many specimens and 4.3 times as much biomass. Jones Neck Oxbow produced 3.3 times as many species as JA70-74, 78.3 times as many specimens and 62.8 times as much biomass. The production, both in terms of numbers and biomass, of the oxbows thus resembles the mainstream production below Hopewell more closely than it does the mainstream area adjacent to the oxbows.

Resident populations are best sampled during the winter months when the fish move out of the creeks and shallows into the deep holes in the channel. The presence of croaker, *Micropogon undulatus*, spot, *Leiostomus xanthurus* and tautog, *Tautoga onitis*, indicates a mild winter and therefore the resident population may not have been fully concentrated in the deeper waters. We can only assume that the resident fishes moved to the deep holes because no samples were taken in shallow water during the survey. An attempt to correct this will be instituted in the 1975 winter survey.

All rivers are similar ecologically, yet each system is inheremtly different from the next; the Potomac River has a large population of white perch, but in the James River this species declined to the point of virtual non-existence. The James has a large population of channel catfish whereas the Potomac produced only 2.6 kg of channel catfish.

To fully assess the resident population of fishes, surveys of the type discussed herein must be a continuing effort so that data from one year may be compared to others.

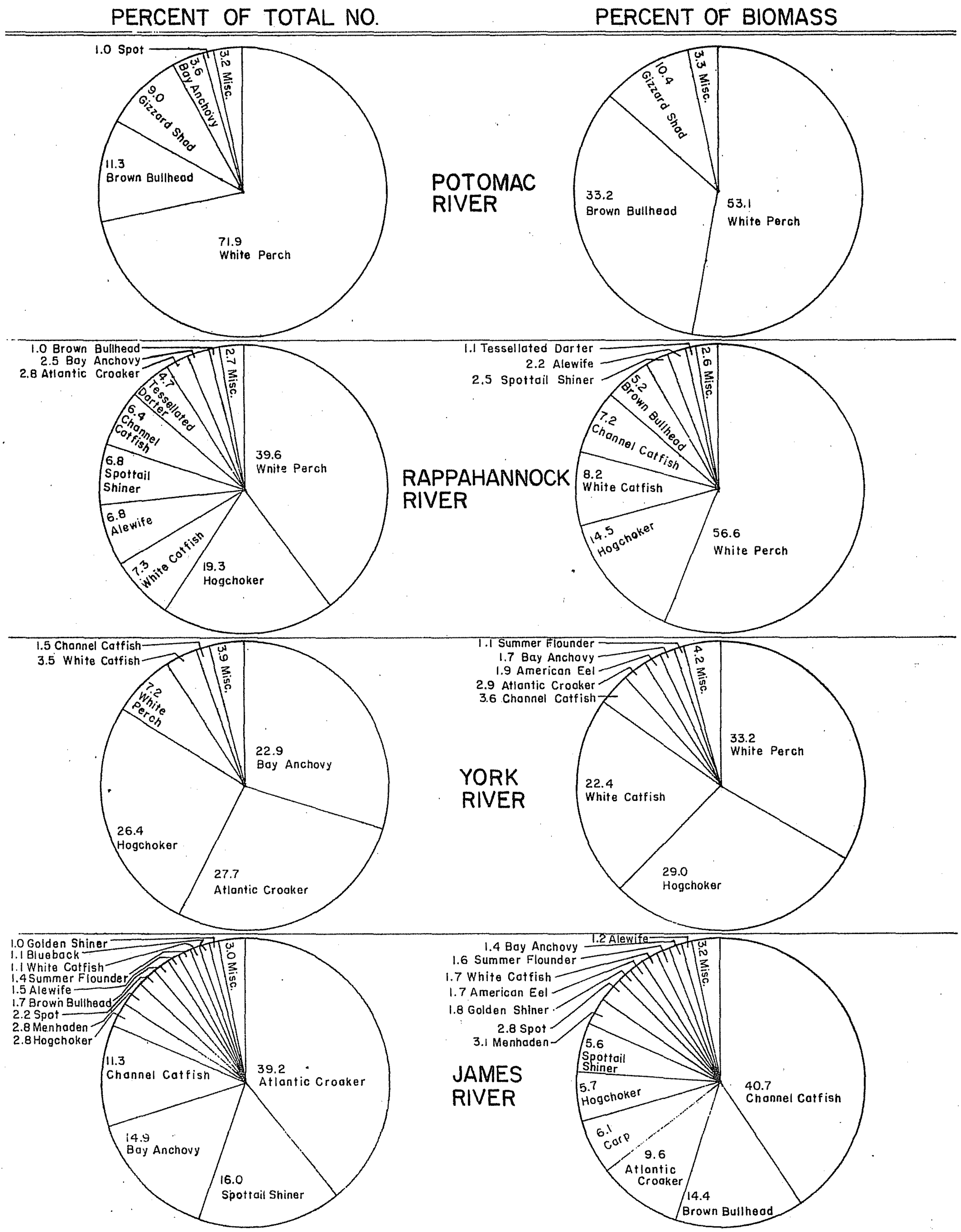


Fig. 7.1. Percent composition of trawl collections during winter 1974 by river.

Table 7.1. Comparison of river systems and major predator and competitor species in Virginia rivers during winter 1974.

	Total No. Specimens	Total Biomass (kg)	No. Tows	c/f No.	c/f Biomass (kg)	No. Species
Potomac	13,310	484.8	60	233.5	8.5	25
Rappahannock	17,176	420.1	76	218.6	5.7	27
York	23,022	311.4	54	426.3	5.8	30
James	21,446	303.1	71	302.1	4.3	37
Total	73,954	1,519.4	256			
c/f for survey				288.9		
Avg. biomass/tow					5.9	

Major predator species (ranked by biomass)

	Total No. Specimens	Total Biomass (kg)
White perch	17,675	600.0
Brown bullhead	2,015	227.0
Hogchoker	9,868	171.6
Channel catfish	3,929	167.2
White catfish	2,308	113.1
Total	35,795	1,278.9

Major competitor species (ranked by biomass)

	Total No. Specimens	Total Biomass (kg)
Gizzard shad	1,278	54.5
Atlantic croaker	15,262	38.3
Spottail shiner	4,595	28.2
Atlantic menhaden	692	11.7
Bay anchovy	10,968	10.0
Total	32,975	142.7
Alosa sp.	2,114	18.6

Table 7.2. Comparison of Turkey Island Oxbow (TIO) and Jones Neck Oxbow (JNO) to the adjacent mainstream in the James River during winter 1974.

	Total Number				Biomass			
Species	TIO	JA 65-69	JNO	JA 70-75	TIO	JA 65-69	JNO	JA 70-75
Channel catfish	17	531	185	10	4600	7470	5760	420
Tessellated darter	32	6	19	1	135	55	65	5
Spottail shiner	2264	14	928	5	10250	130	5120	45
Shorthead redhorse		1				90		
Hogchoker	2	1	2		5	40	10	
Gizzard shad	7		9	1	400		590	130
Brown bullhead	96		145		10200		15340	
Golden shiner	222		2		5460		30	
Blueback	188		5		430		25	
Eastern Silvery minnow	2				20			
Creek Chubsucker	2				40			
White perch	16		18		420		390	
Threadfin shad	7		8		60		80	
Pumpkinseed	14		2		330		70	
Carp	1		7		920		10190	
Yellow perch	2				170			
White catfish			1				60	
Total	2872	553	1331	17	33440	7785	37700	600
c/f	957.3	138.3	443.7	4.3				
wt/tow					11147	1946	12567	150

Job 8. Shallow Water Population Indices - Pilot Program

The 1974 beach seine program was designed as a pilot program to determine the extent to which shoal and beach areas in the nursery zone are utilized by alosine fishes. It was also designed to determine the extent of lateral and vertical movement by these fishes during daylight and darkness. A section of the nursery zone was selected and sampled simultaneously from shore zone to mid-channel over a 25-hr period.

The beach seine survey was conducted on 19, 20 and 21 August, 1974 in the James River in an area of high alosine abundance within the nursery zone (mile 30 through 84, Fig. 3.2). This area was divided into two sampling zones: one between mile 49 and 52 ("B" station) and one between mile 56 and 58 ("A" station) (Fig. 8.1). Each zone had four sampling sites, two on either shore. Bottom types were either sand or sand gradually becoming gravel as one moved offshore at each site. Each zone was sampled continuously for 25 hr.

Two methods of sampling were employed simultaneously to meet the goals of the program (beach seining and trawling). Two tows were made at each station with a 100' x 6' x 1/4" beach seine. Two repetitions were employed since DeLacy and English (1954) reported no significant data improvement from additional repetitions. Each beach seine swing originated at a point on shore, from which the net was stretched in a straight line to the full length of the net, or as deep as possible (limited to wader height). The "deep-end" was pulled parallel to the shore until the net was stretched to its full length. The "deep-end" was then turned toward shore and landed approximately 15 ft from the "shallow-end" of the net.

Directly offshore from each beach seine station, three ten-min tows were made with a 5' x 5' Cobb trawl: one surface and one midwater tow in the channel and one surface tow in shoal water (less than 15 ft of water).

The fish from each tow were weighed and measured either in the field or later in the lab. The 5' x 5' Cobb trawl strained an average of 7.6 times more water per tow than did the beach seine (3186.00 m^3 vs. 4192.23 m^3), respectively.

Unfortunately, the pilot program did not yield the anticipated results due to the low abundance of the 1974 year class of alosine fishes. Data are presented first as total community structure for the beach seine and trawling segments and secondly, as abundance of alosine fishes. Results presented are pooled data from "A" (miles 56 through 58) and "B" stations (mile 49 through 52). The results are divided into six time frames: pre-dawn darkness, 0000-0359; dawn, 0400-0600; morning daylight, 0601-1200; afternoon daylight, 1201-1814; dusk, 1815-2010; evening darkness, 2011-2400.

Beach seine

A total of 8,040 specimens representing 33 species were taken in 64 beach seine tows during the 50 hr period covered in the survey. The largest catch-per-unit-of-effort (c/f)(effort=one swing) occurred between 2011-2400 hr and the smallest c/f occurred between 0601-1200 hr. Spottail shiner, *Notropis hudsonius* accounted for 58% of the total number of specimens taken and was the most abundant species captured in each time frame. As expected the lowest c/f for spottail shiner (33.7) occurred in the morning (0601-1200) and the highest c/f (132.9) occurred in the evening darkness (2011-2400). The next most abundant species, banded killifish, *Fundulus diaphanus*, channel catfish, *Ictalurus punctatus* and golden shiner, *Notemigonus crysoleucas*, accounted for 19% of the total specimens caught. All exhibited greatest c/f during daylight hours when c/f of spottail shiner is at its lowest (Fig. 8.2). The satinfin shiner, *Notropis analostanus*, accounting for 6% of the total specimens caught, occupied the beach zone at the same time as the spottail shiner. The remaining 16% of the specimens taken, representing 27 species, appeared only as incidental species except for white perch, *Morone americana* and pumpkinseed, *Lepomis gibbosus* which moved into the beach zone during dusk and evening (Fig. 8.2).

Beach seine, Alosa species

Only 17 alosine fishes were taken in the beach zone during the entire sampling period. Therefore, little can be said about their involvement within the beach zone community. Of the 17 alosine fishes taken, 16 were taken from dusk to dawn at the "A" station. The absence of alosine fishes in the beach zone may be attributed to the extremely small year class produced in 1974 (Job 3, this report).

Trawling (5' x 5' Cobb Trawl)

A total of 44,888 specimens representing 22 species were taken in 94 trawls during this program. Surface channel trawls accounted for 26% of the total; midwater channel trawls, 35%; and surface trawls, 39%. The greatest species diversity occurred in the afternoon (1201-1814 hr) at surface channel stations. The surface channel stations had the greatest species diversity overall with midwater channel stations second and surface shoal stations last.

Surface channel (34 tows)

Spottail shiner dominated the trawl catch in three of the time frames 0000-0359, 0400-0600 and 1815-2000, while blueback dominated the remaining time frames (Fig. 8.3). Demersal fishes were taken in fair numbers only during the pre-dawn and dawn time frames. In all other time frames these species were replaced by either pelagic or non-predator species.

Midwater channel (34 tows)

Spottail shiner dominated midwater trawl catches in five of the six time frames (Fig. 8.3). They represented 45% of the fishes taken in the midwater trawl. Blueback accounted for 25%, ranking second; and bay anchovy, 18%, ranked third. These species were dominant in all time frames except pre-dawn (0000-0359) when threadfin shad displaced bay anchovy.

Surface shoal (25 tows)

Although the largest number of specimens were captured in shoal trawls this area had the lowest average number of species. Four species (blueback, threadfin shad, bay anchovy and spottail shiner) represented 99% of the specimens, taken in shoal trawls. Blueback dominated four of the six time frames (from dawn through dusk) with threadfin shad and spottail shiner each dominating the 2011-2400 and 0000-0359 time frames, respectively (Fig. 8.3). Insufficient water depth for trawling at two stations in the "B" transect reduced the number of tows in the shoal zone.

Trawling, Alosa species

The distribution of juvenile alosine fishes by time frames illustrated both lateral and vertical movement (Table 8.1). Blueback were evenly distributed in all depths during darkness but congregated in shoal areas at dawn and dusk, probably to feed. During the daylight hours they were more abundant in the upper levels of the water column, moving out of midwater depths. Alewife, on the other hand, were evenly distributed at all depths during pre-dawn hours but were concentrated in midwater during daylight hours. Alewife moved to shoal areas at dawn and dusk but during early evening hours returned to the channel, remaining on the surface. American shad followed a similar pattern except that they were not evenly distributed in the pre-dawn hours. They moved from midwater to shoal areas at dawn and returned to midwater in morning light. At dusk their movement was again toward shoal areas. They returned to the channel in evening darkness, remaining near the surface, as did alewife.

Although our beach seine program did not yield the anticipated results, Schuler (1971) reported beach seining was an effective method of sampling juvenile alosine fishes in the nursery area. The trawling portion yielded realistic and meaningful numbers which demonstrated both lateral and vertical movement of alosine fishes. Our program did provide useful data on the community structure within the nursery zone during daylight and darkness.

References Cited

DeLacy, Allan C. and Thomas S. English. 1954. Variations in beach seine samples caused by net length and repeated trawls. Ecology 35(1):18-20.

Schuler, Victor J. 1971. An ecological study of the Delaware River in the vicinity of an artificial island. Progress Report for the period January - December 1970, Part I. Ichthyological Associates, Delaware Prog. Rep. 3 (Pt. I). 384 p.

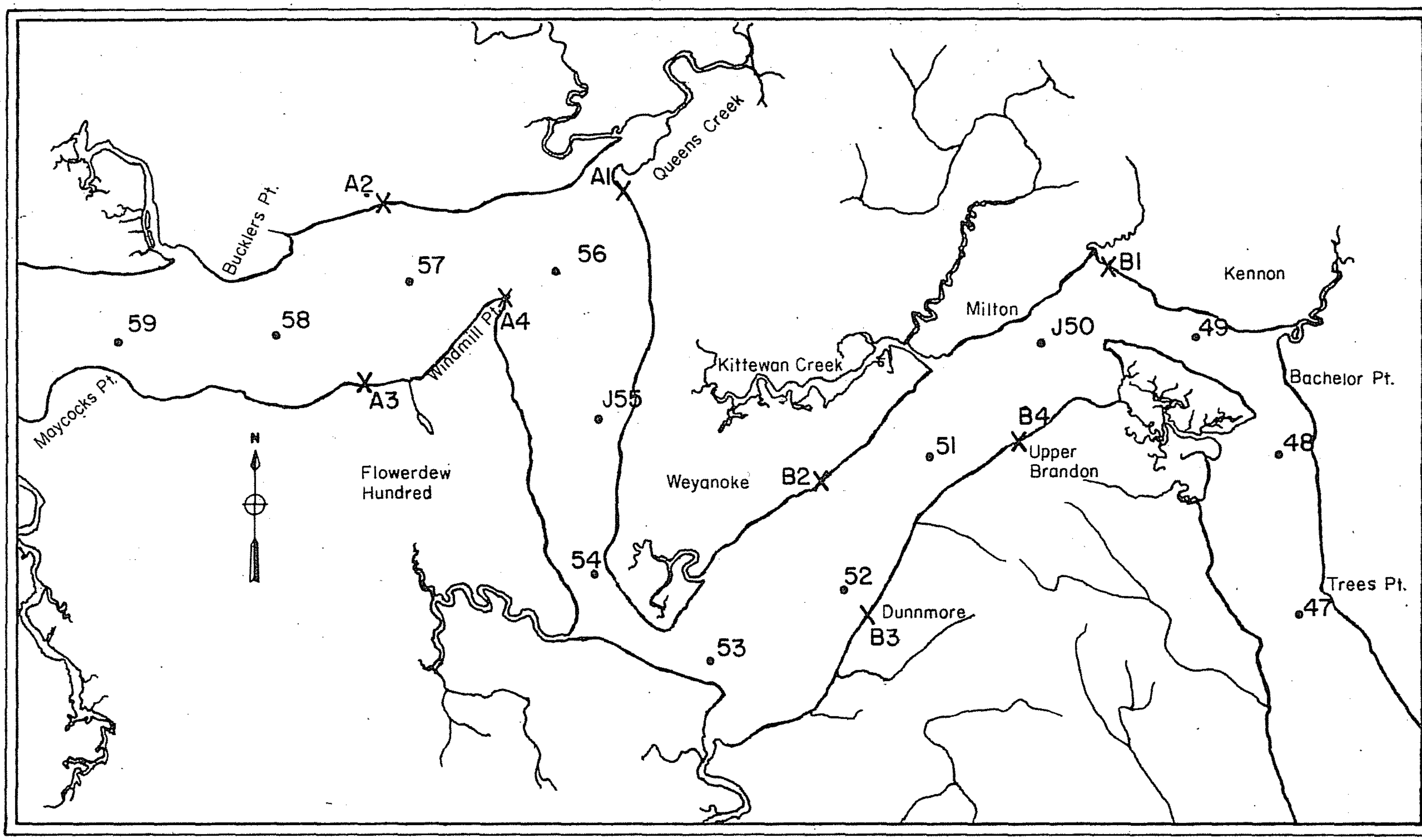


Fig. 8.1. Station locations in the James River nursery area for 24-hr beach seine program.

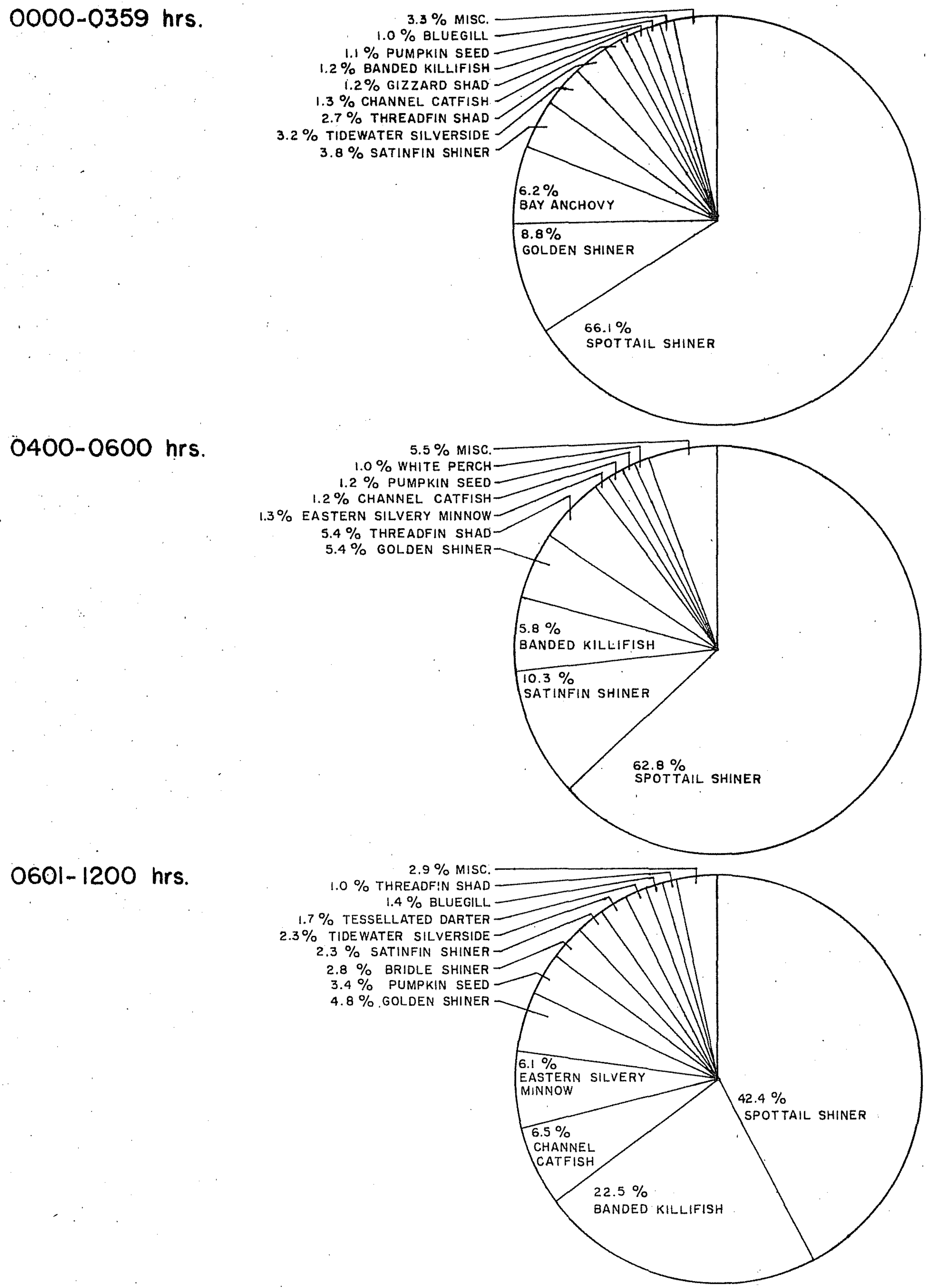
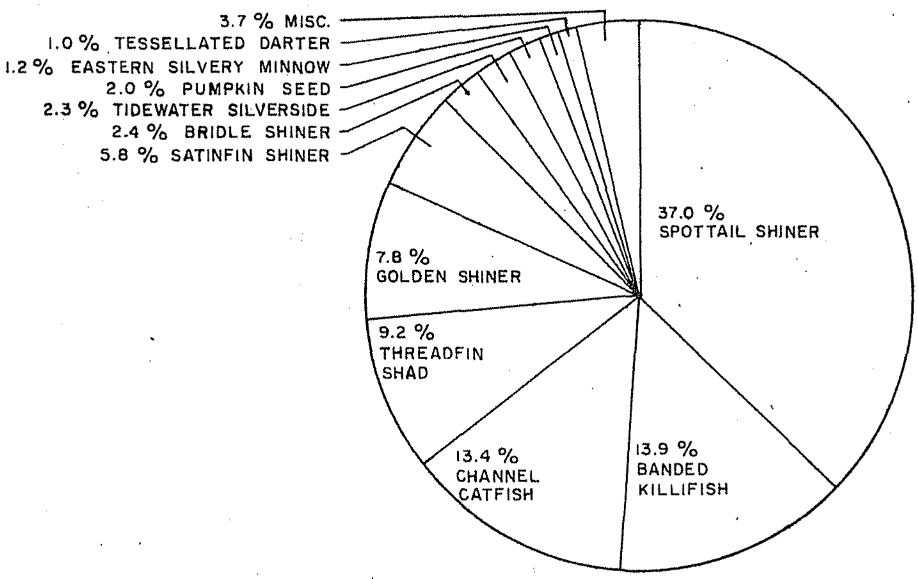
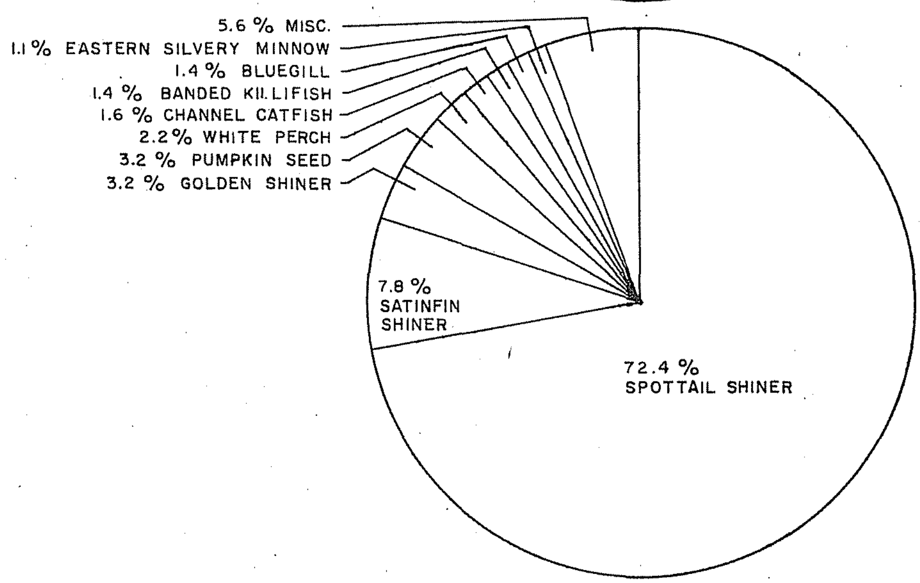


Fig. 8.2. Percent composition of beach seine fish collections by time frame.

1201-1814 hrs.



1815-2010 hrs.



2011-2400 hrs.

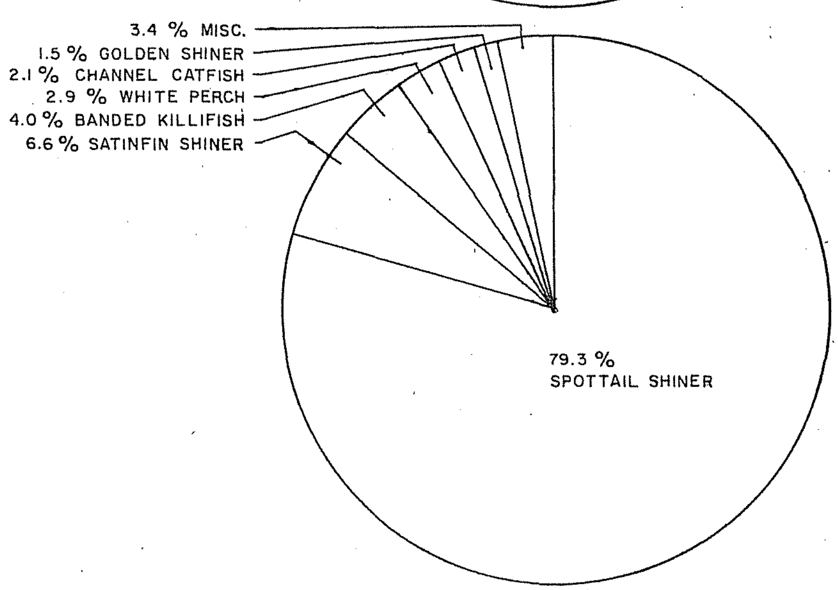


Fig. 8.2. (continued)

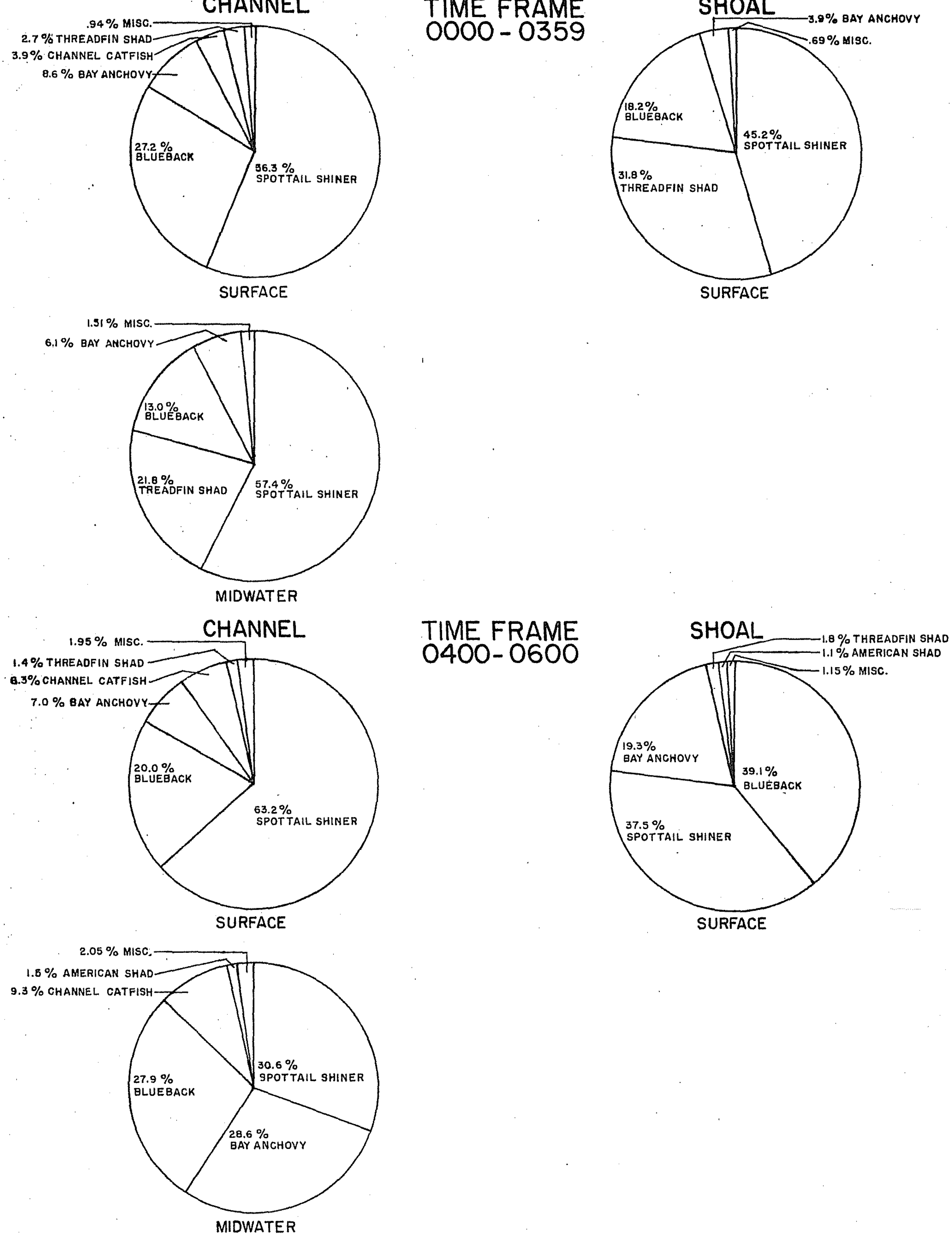


Fig. 8.3. Percent composition of 5' x 5' Cobb trawl fish collections by time frame and water depth.

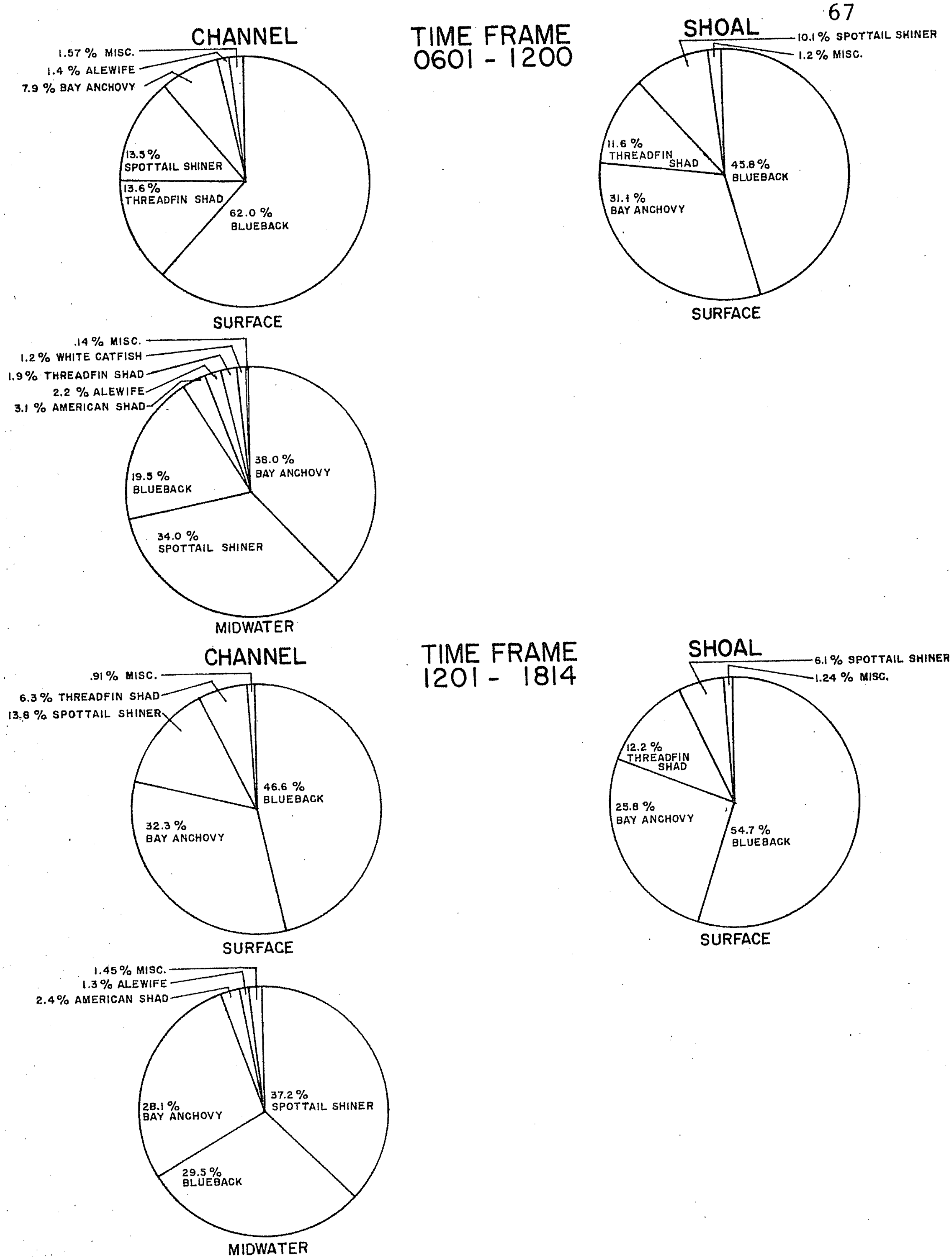


Fig. 8.3. (continued)

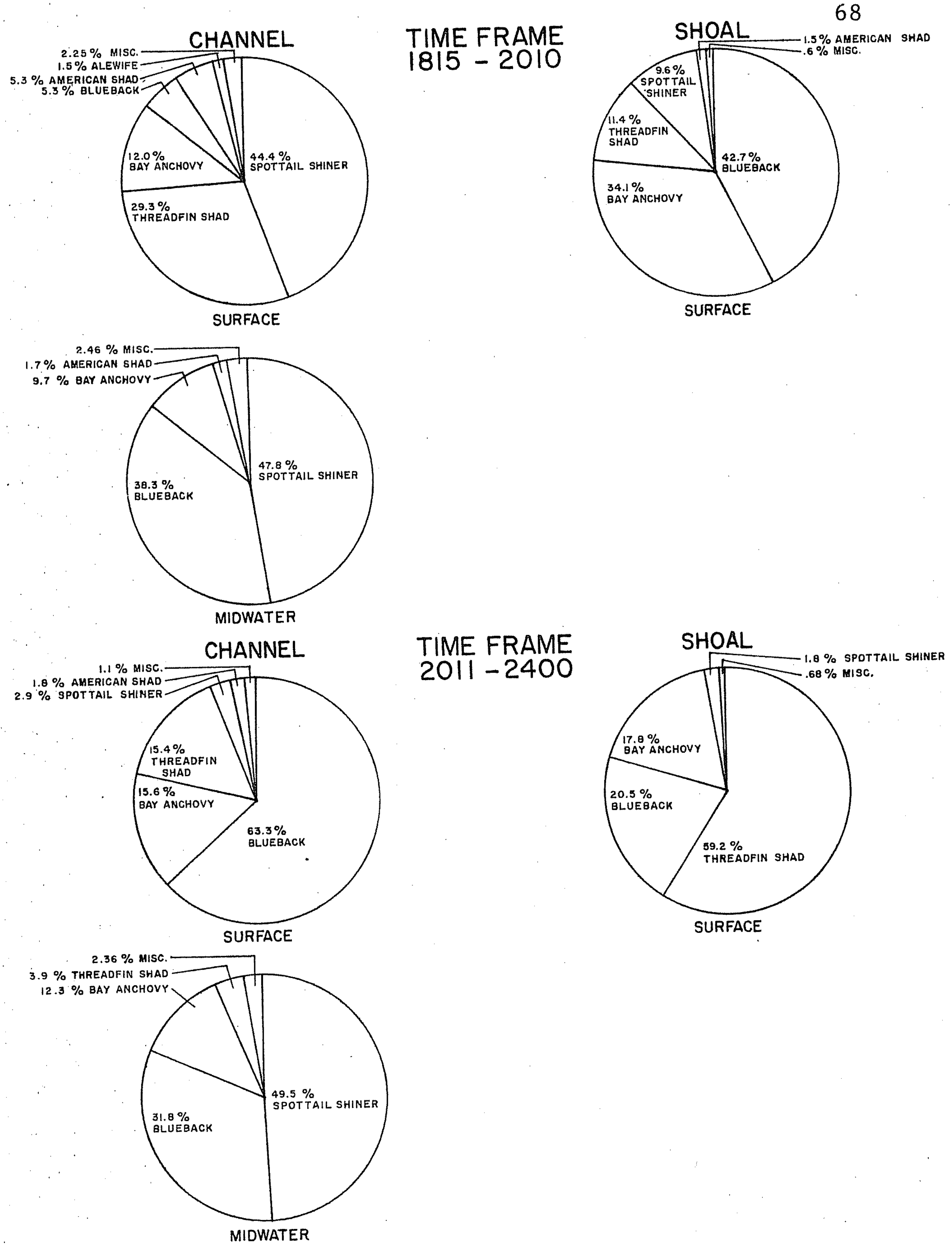


Fig. 8.3. (continued)

Table 8.1. Catch per unit of effort (c/f) of alosine fishes with a 5' x 5' Cobb trawl for 6 time frames by fishing depth by species.

	Time Frame					
	0000-0359	0400-0600	0601-1200	1201-1814	1815-2010	2011-2400
Blueback						
Surface, channel	183.40	33.25	198.80	141.80	1.75	332.75
Midwater, channel	142.75	91.00	55.80	86.00	154.25	253.25
Surface, shoal	184.50	378.50	279.25	167.80	373.25	240.50
Alewife						
Surface, channel	3.00	0.25	4.30	0.45	0.50	4.25
Midwater, channel	4.00	1.80	6.20	3.80	2.50	2.75
Surface, shoal	3.75	4.50	2.25	0.44	2.00	1.50
American shad						
Surface, channel	1.60	1.50	1.50	0.70	1.75	9.25
Midwater, channel	6.00	5.00	9.00	7.00	6.75	6.00
Surface, shoal	1.00	11.00	2.50	1.90	13.00	3.50