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Biology and utilization of anadromous alosids: Annual progress report (October 1, 1967 - September 30, 1968)

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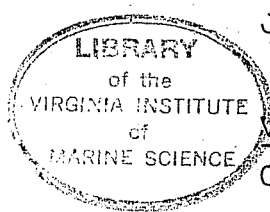
ANNUAL PROGRESS REPORT
ANADROMOUS FISH PROJECT

Project Title: Biology and Utilization of Anadromous Alosids
Project No: Virginia AFC-1-2
Project Period: October 1, 1967 - September 30, 1968

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ABSTRACT

Scales were collected from alewife, blueback, American shad and hickory shad in each tidal river system in Virginia at weekly intervals. Reading of alewife scales is complete to date and the alewife catch from the York and Rappahannock Rivers has been analyzed for sex composition and spawning history. Lack of catch records from the James and Potomac Rivers precludes analysis of these populations. Fishing effort in the major rivers during 1968 was equal to that of 1967. The catch of river herring increased approximately 4 million pounds over 1967 increasing catch per unit of effort to the highest level on record. Catch by pound nets in the upper Rappahannock River was estimated to be 1,654,015 pounds of river herring and 303,731 pounds of shad. In the upper York River, pound nets caught a minimum of 557,486 pounds of river herring and 129,702 pounds of shad with stake gill catch estimated at 221,124 pounds of shad. River herring spawn in all but a few smaller tributaries of the Rappahannock River between RA32 and RA93; in the Potomac River herring spawn in most Virginia tributaries between PT35 and PT90. Maryland tributaries were not investigated. Juvenile alosids in the Rappahannock River began seaward migration during October coincident with lowering river water temperatures.

PHASE 1

AGE COMPOSITION AND MORTALITY RATES

The spawning history of alewife in our weekly samples was determined by counting spawning checks on the scales. The catch in each two-week period was apportioned between the sexes and among the categories of spawning history (number of spawning checks). The numbers of fish in each category was determined by dividing the average weight of the fish in each category by the estimated catch in pounds from the commercial catch. The results are presented in Tables 1 and 2. The composition of the 1967 catch of alewife in the Rappahannock and York Rivers is shown in Figures 1 and 2. When data from succeeding years are available mortality rates will be calculated.

Although we have read alewife scales from the James River and Potomac River, we cannot calculate mortality rates at this time because we lack catch records. Catch records for the Potomac River will soon be in hand; however, we were unsuccessful in obtaining records from the James River. We have not completed our examination of scales of blueback and shad; however, we have accelerated our reading program so that we expect to have completed them as well as those collected in 1968 by the end of the next contract period.

Table 1. Estimated number of alewife in commercial catch of 1967 in the upper Rappahannock River *subdivided by two-week sampling periods and by sex and spawning history.

	March 16-31	April 1-15	April 16-30	May 1-15	Totals
No Spawning checks					
♂	88,320	195,727	28,450	153,628	466,125
♀	62,881	184,523	49,943	138,317	435,664
1 Spawning check					
♂	77,291	102,236	23,930	96,530	299,987
♀	57,041	69,696	246,289	65,215	438,241
2 Spawning checks					
♂	9,174	29,614	44,796	78,520	162,104
♀	6,658	28,571	-----	22,685	57,914
3 Spawning checks					
♂	5,896	5,003		-----	10,899
♀	3,538	22,656		33,359	59,553
4 Spawning checks					
♂	-----	-----		9,288	9,288
♀	5,578	-----		8,402	13,980
5 Spawning checks					
♂		-----			-----
♀		8,500			8,500
	<u>316,377</u>	<u>646,526</u>	<u>393,408</u>	<u>605,944</u>	<u>1,962,255</u>

* Estimates are based on catch in commercial nets above RA10 only so as to reflect spawning history of Rappahannock River spawners only.

Table 2. Estimated number of alewife in commercial catch of 1967 in the upper York River *subdivided by two week sampling periods and by sex and spawning history.

	March 1-15	March 16-31	April 1-15	April 16-30	May 1-15	Totals
No Spawning Checks						
♂	393	5,124	25,275	20,192	3,010	53,994
♀	110	1,981	27,564	14,071	1,932	45,658
1 Spawning Check						
♂	226	3,048	4,463	19,795	1,708	29,240
♀	87	1,420	4,633	4,574	809	11,523
2 Spawning Checks						
♂	184	853	3,422	5,954	2,116	12,529
♀	---	385	4,376	2,502	1,021	8,284
3 Spawning Checks						
♂	109	426	1,402	-----	904	2,841
♀	55	678	6,300	4,879	861	12,773
4 Spawning Checks						
♂	19	94	2,178		360	2,651
♀	---	469	2,251		671	3,391
5 Spawning Checks						
♂		80	760		-----	840
♀		-----	-----		598	598
6 Spawning Checks						
♂			-----			-----
♀			631			631
	1,183	14,558	83,255	71,967	13,990	184,953

* Estimates are based on catch in commercial nets above Y008 only so as to reflect spawning history of York River system spawners only.

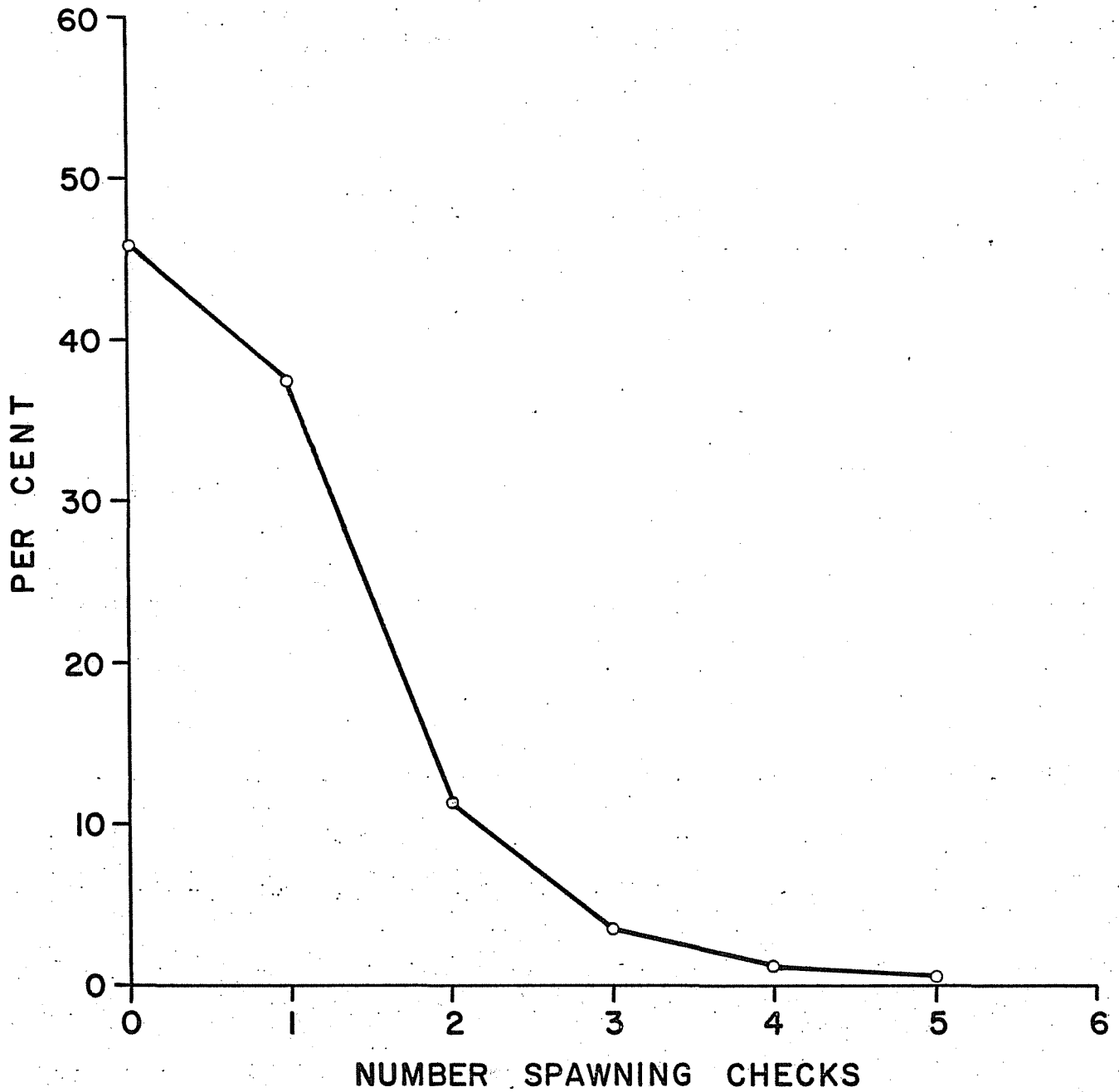


Fig. 1. Composition of 1967 catch of alewife in the Rappahannock River by spawning history based on numbers of fish.

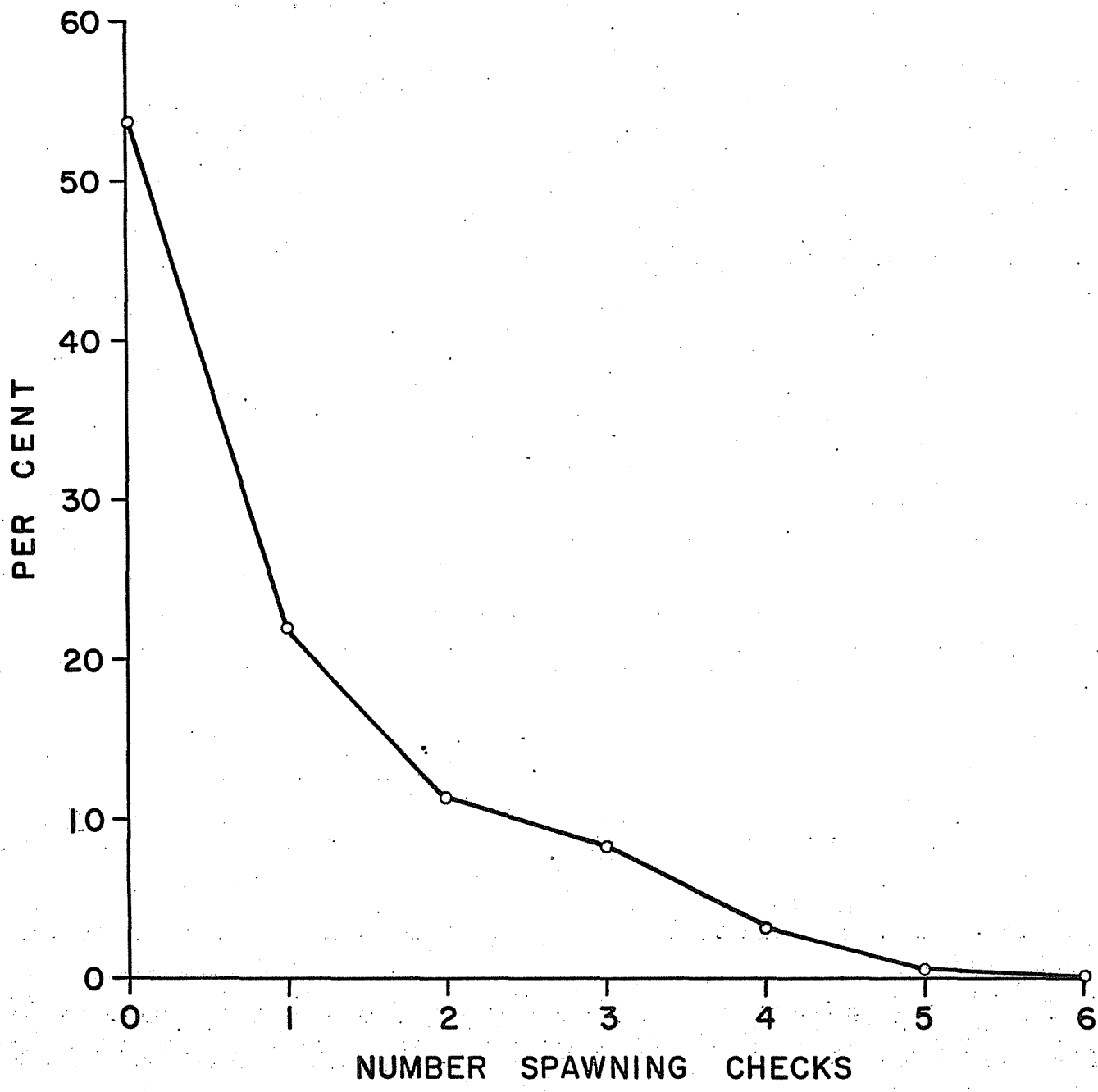


Fig. 2. Composition of 1967 catch of alewife in the York River by spawning history based on numbers of fish.

PHASE 2

CATCH PER UNIT OF EFFORT

The number of pound nets operating in 1968 (Table 3) differed only slightly from that of 1967. In 1968 somewhat fewer nets were fished in the section of Chesapeake Bay between Windmill Point and Smith Point, but in the major rivers and other sectors of the bay, effort was similar in 1967 and 1968.

The catch of river herring in 1968 was about 4 million pounds greater than in 1967 (32,404,496 lb. in 1968, 28,107,494 lb. in 1967). Since fishing effort was nearly the same, the catch per unit of effort (catch/net/season) increased somewhat to the highest level on record. Fig. 3 illustrates trends in catch and effort in Virginian waters. Although the Potomac River is Maryland territory, the herring caught there are, for the most part, landed and processed in Virginia. Fig. 4 illustrates trends in the fishery of the lower Chesapeake Bay Region (the bay and its tributaries from the Potomac River south to Cape Henry). We have counted pound nets in the Potomac River only since 1965. The increase in catch per net per season indicates that the fishery is in healthy condition and is being efficiently prosecuted.

Our efforts to estimate total catch in each river system were again only partly satisfactory. Despite extensive and diligent effort, we have been unable to obtain catch records from the James River. There is little or no market for herring along the James River and most of the herring caught in the few pound nets are discarded. The fishery in the James

Table 3. Numbers of pound nets in Chesapeake Bay
and tributaries, spring 1968.

Area	2-15-68	3-3-68	3-18-68	4-6-68	4-20-68	5-6-68	5-20-68	6-3-68	6-19-68
James River	0	3	5	6	6	6	3	1	4
York River	4	7	15	18	18	19	19	16	13
Rappahannock River	2	17	42	51	51	47	26	11	5
Potomac River	1	3	15	66	82	86	84	71	3
Cape Henry to Willoughby Point	0	8	10	11	10	11	11	6	6
Old Point to Tue Marsh Point	2	12	15	11	16	14	12	5	0
Back River	0	7	7	10	8	7	6	1	1
Poquoson River	2	2	2	3	3	3	3	3	3
York Spit	0	0	4	6	7	8	10	9	8
Mobjack Bay	0	4	6	7	8	8	7	7	4
New Point to Stingray Point	1	14	25	25	28	25	21	13	10
Piankatank River	0	2	4	4	4	4	3	0	0
Windmill Point to Smith Point	10	20	31	41	45	47	50	18	7
Great Wicomico River	0	0	0	1	3	5	4	2	0
Eastern Shore-N. Hungar Creek	No*	No*	0	1	4	4	5	4	3
Eastern Shore-S. Hungar Creek	No*	No*	5	8	16	23	29	29	25
Totals	22	99	186	269	309	317	293	196	92

* Not Observed

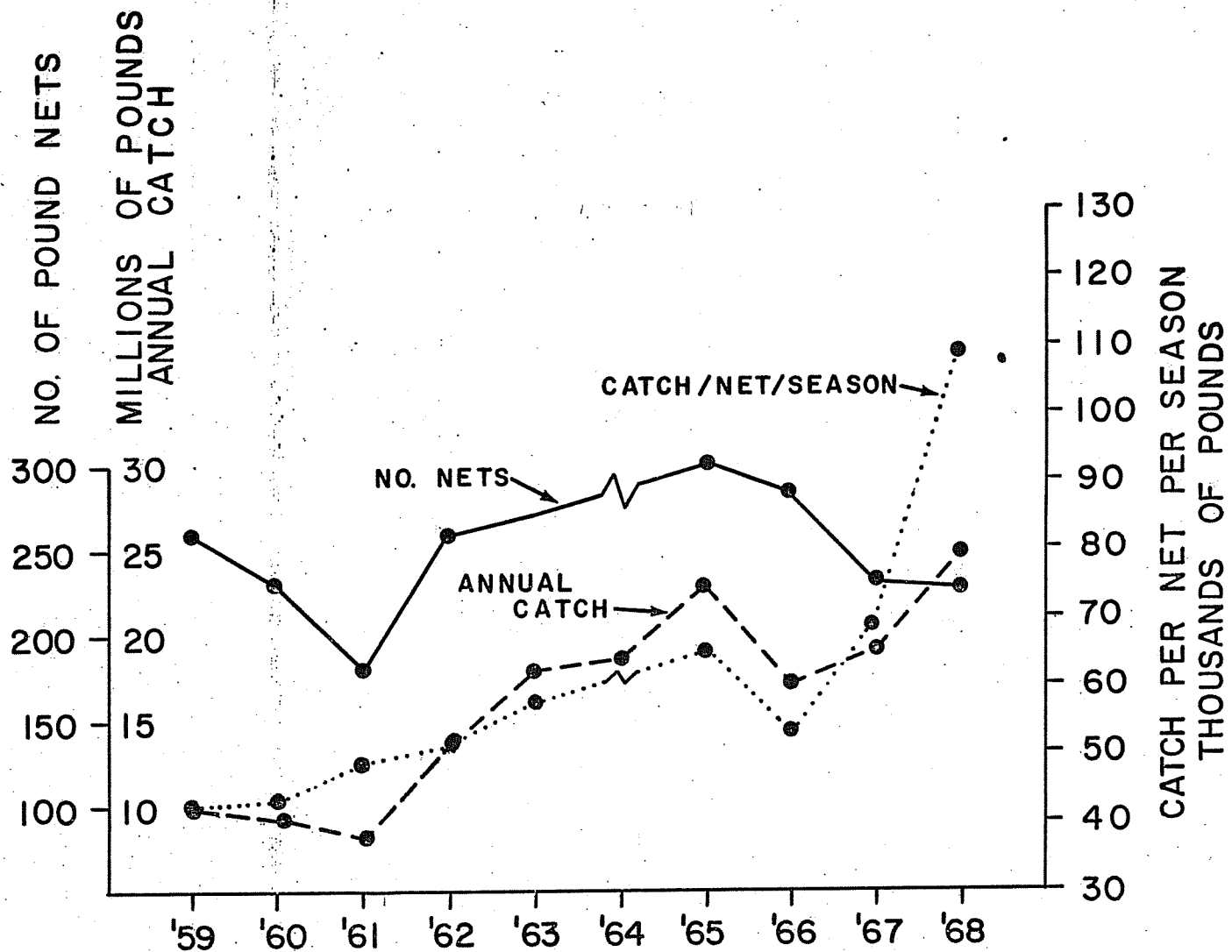


Fig. 3. Fishing effort and catch rate in the river herring fishery of Virginia exclusive of the Potomac River.

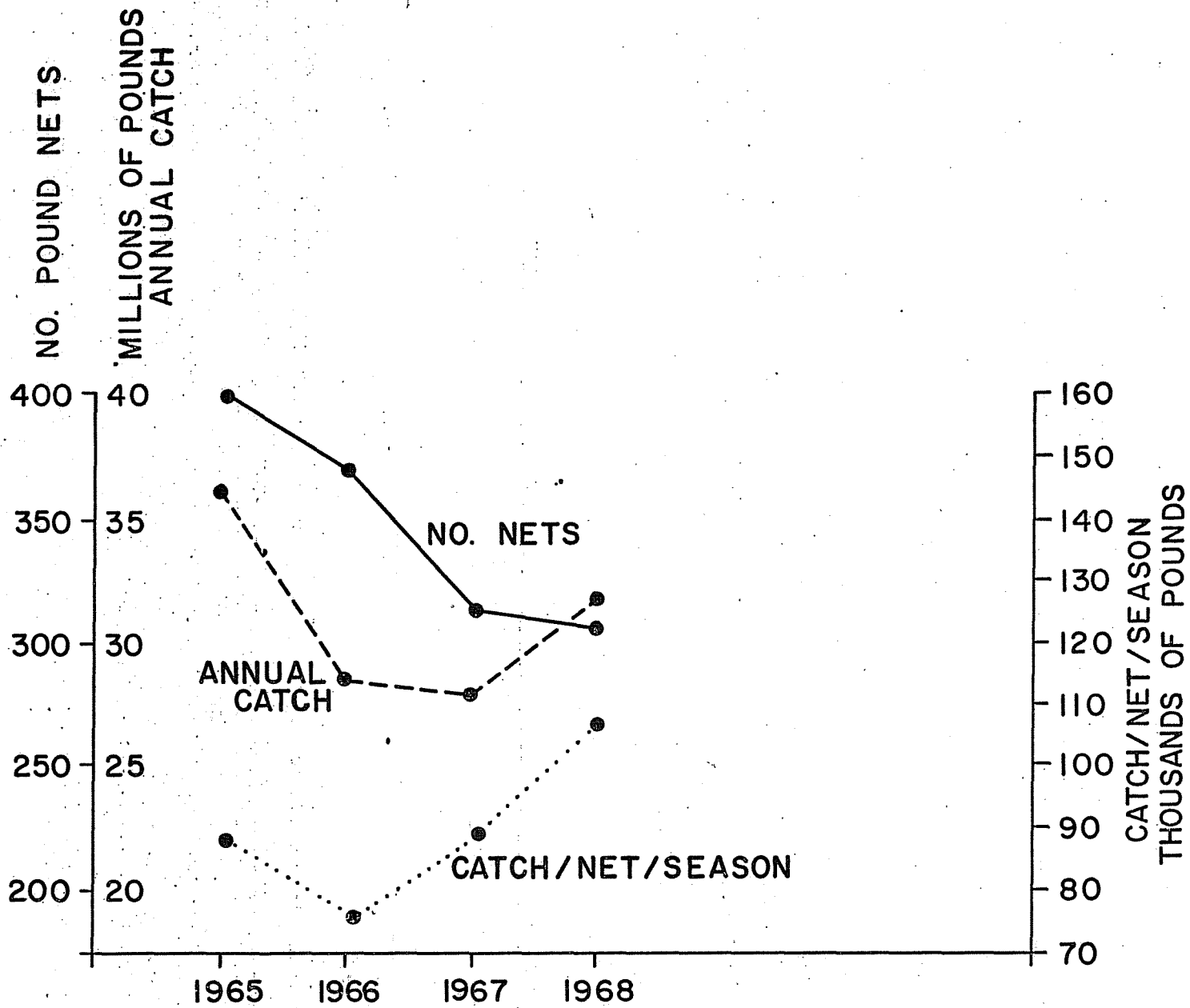


Fig. 4. Fishing effort and catch rate in the river herring fishery of Virginia and the Potomac River.

River is primarily for shad, herring being an underutilized resource.

Records from rivers other than the James are good or satisfactory. Daily catch records were obtained from 5 pound nets and 54 stake gill nets in the Rappahannock River. These records represent about 16% of the upper river pound nets located between RA10 and RA50 and about 36% of the stake gill nets. We have not included the pound nets below RA10 in our estimates since we are attempting only to estimate spawners indigenous to the Rappahannock. No gill nets are fished below RA10. Expansion of the catch of the index pound nets (Table 4) indicates a catch of 1.7 million pounds of river herring (1,247,628 pounds of alewife and 406,387 pounds of blueback herring) and about 304,000 pounds of shad in the period March 11-May 7. The index pound nets were removed from the water after May 7 and, although some nets continued fishing (Table 3) we have no record of their catches. We estimate that the catch of shad in 1968 exceeded that of 1967 by 49%, that the catch of alewife was the same in the two years, and that the catch of blueback herring declined in 1968, being only 14% of the level in 1967. These estimates are based on the assumption that random samples of 50 pounds of "run-of-the-catch" river herring obtained weekly reflect the species composition of the total catch.

Catch of shad in the Rappahannock River by stake gill nets during the period March 15-April 30 was estimated at 165,614 pounds, of which only 27,000 pounds was bucks (Table 5). Since bucks and roes were caught in equal quantities by pound nets, which probably are not selective for size, the disparity of sexes in the gill net catch probably reflects size selectivity of the gear and market demand. Total catch of shad in the Rappahannock River in 1968 by pound nets and stake gill nets was estimated at 469,345 pounds. Stake gill nets took an estimated 22,866 pounds of hickory shad, probably mostly females because bucks, having no market, are usually discarded at the net.

Table 4. Catch by pound nets in the upper Rappahannock River, 1968*

Date	Ave. No. of Nets	No. of Days Fished	SHAD				RIVER HERRING					
			Roe		Buck		Alewife			Blueback		
			Ave. Catch Index Nets	Estimated Total Catch	Ave. Catch Index Nets	Estimated Total Catch	Ave. Catch Index Nets	Estimated Total Catch	Per Cent	Pounds	Per Cent	Pounds
March 11-15	30	5	2.9	435	9.3	1,395	1,477	221,550	100	221,550	0	0
March 16-31	47	12	35.5	20,022	62.4	35,194	853	481,092	100	481,092	0	0
April 1-15	51	10	107.1	54,621	121.4	61,914	835	425,850	95	404,558	5	21,292
April 16-31	49	9	81.8	36,074	137.6	60,682	873	384,993	31	119,348	69	265,645
May 1-7	47	5	56.3	13,231	85.8	20,163	598	140,530	15	21,080	85	119,450
Totals				124,383		179,348		1,654,015		1,247,628		406,387

* Only nets between RA10 and RA55 were sampled to represent alosids assumed to spawn in the Rappahannock River system.

Estimated Total Catch of Shad - 303,731 lbs.

Table 5. Catch by stake gill nets in the Rappahannock River, 1968

		Roe Shad	Buck Shad	Hickory Shad
March	15	425	364	-
	16	155	169	-
	17	-	-	-
	18	278	196	-
	19	2,329	1,350	-
	20	1,526	774	-
	21	1,994	605	-
	22	657	403	-
	23	868	274	-
	24	1,421	803	-
	25	1,940	1,228	94
	26	3,106	1,500	143
	27	1,573	724	14
	28	601	533	54
	29	976	457	36
	30	1,310	806	173
	31	-	-	-
April	1	2,236	583	155
	2	2,992	1,156	497
	3	2,635	695	281
	4	2,462	598	288
	5	2,549	608	220
	6	2,941	853	688
	7	3,583	721	832
	8	4,813	1,015	1,516
	9	5,213	706	569
	10	5,839	-	-
	11	4,486	824	2,441
	12	7,549	1,256	1,321
	13	3,362	1,710	796
	14	5,915	806	1,886
	15	5,613	318	1,341
	16	3,207	292	334
	17	8,327	763	695
	18	11,275	1,094	1,458
	19	9,104	997	1,620
	20	5,357	572	882
	21	-	-	-
	22	7,790	270	1,174
	23	3,348	-	1,246
	24	2,576	175	281
	25	1,701	-	387
	26	1,379	11	234
	27	2,219	240	551
	28	-	-	-
	29	917	319	515
	30	237	82	144
Total		138,764	26,850	22,866

From the York River we obtained records from 2 upriver pound nets, 33% of the fishing effort between the York River Bridge and West Point, and 65 stake gill nets, 75% of the effort. Expansion of the catch of the pound nets indicates a catch of 557,000 pounds of river herring (217,000 pounds of alewife and 340,000 pounds of blueback) and 130,000 pounds of shad between March 12 and May 3 (Table 6). In 1967 we estimated a catch of only 159,000 pounds of river herring and 36,000 pounds of shad; however, we suspected that those estimates were lower than the actual catch. Index nets used in 1968 were presumed to be more representative of the catch and the estimates based on their catches seem to confirm our supposition about the estimates of 1967.

The record of catches of shad and hickory shad in stake gill nets in the York River extends from March 16 to April 18 (Table 7). Expansion of these records indicates that the total catch in 87 stands was 221,000 pounds of shad (204,000 pounds of roes and 16,870 pounds of bucks). In 1967 during the comparable period the catch of roe shad was 201,000 pounds. The catch of only 17,000 pounds of buck shad in 1968 in contrast to 37,000 pounds in 1967 probably reflects the very poor market for bucks in 1968. Similarly, the difference between 1200 pounds of hickory shad in 1968 and 7500 in 1967 is as likely to reflect market conditions as a change in population.

Total estimated catch of shad in the York River by pound nets and stake gill nets was 350,826 pounds.

Table 6. Catch by pound nets in the Upper York River, 1968*

Date	Ave. No. of Nets	No. Days Fished	SHAD				RIVER HERRING					
			Roe		Buck		Ave. Catch Index Nets	Estimated Total Catch (lbs.)	Alewife		Blueback	
			Ave. Catch Index Nets	Estimated Total Catch	Ave. Catch Index Nets	Estimated Total Catch (lbs.)			Per Cent	Pounds	Per Cent	Pounds
March 12-15	11	2	54.3	1,195	164.8	3,626	2,463	54,186	100	54,186	00	000
March 16-31	17	4	461.3	31,368	453.3	30,824	975	66,300	69	45,747	31	20,553
April 1-15	18	6	362.7	39,172	165.6	17,885	3,000	324,000	24	77,760	76	246,240
April 16-31	18	5	44.5	4,005	12.8	1,152	1,150	103,500	35	36,225	65	67,275
May 1-3	19	1	25.0	475	-	-	500	9,500	36	3,420	64	6,080
Totals				76,215		53,487		557,486		217,338		340,148

* Only nets between York River Bridge Y06 and West Point Y28 were sampled to represent alosids assumed to spawn in the York River system.

Estimated Total Catch of Shad - 129,702 lb.

Table 7. Catch by stake gill nets in the York River, 1968

		Roe Shad	Buck Shad	Hickory Shad
March	16	1,969	1,914	-
	17	3,432	2,068	-
	18	8,580	770	88
	19	8,305	748	-
	20	5,313	220	-
	21	3,113	330	-
	22	1,530	374	-
	23	1,353	726	33
	24	2,629	1,001	99
	25	2,074	204	-
	26	3,674	198	77
	27	4,312	132	22
	28	5,929	440	110
	29	6,314	550	77
	30	7,018	330	-
	31	6,655	242	88
April	1	6,589	759	88
	2	8,008	770	77
	3	5,753	660	22
	4	12,376	680	-
	5	8,551	850	-
	6	12,177	440	99
	7	12,325	510	-
	8	11,594	680	-
	9	3,960	198	55
	10	7,601	154	99
	11	7,381	220	99
	12	7,040	110	33
	13	7,786	204	-
	14	4,928	88	99
	15	3,828	68	-
	16	5,005	-	-
	17	4,092	-	11
	18	3,060	232	-
Total		204,254	16,870	1,276
Total shad		221,124		

PHASE 3

LOCATION OF SPAWNING SITES AND NURSERIES

Introduction

The objective of Phase 3 of the program during this contract period was to locate spawning and nursery areas of anadromous alosids in the Rappahannock and Potomac River systems, spawning areas to be tentatively identified by the presence of eggs or ripe adult fish. Areas serving as nurseries were identified by the presence of larval or juvenile fish. Additionally, growth and seasonal distribution of juveniles was followed.

Adults, eggs, larvae, and juveniles were collected from the main stream and tributaries. Adults were caught with gill nets. Drift nets were used principally in the main stream whereas anchored nets were used in the tributaries and shallow portions of the main stream. Eggs and larvae were collected with plankton nets, though few eggs were obtained. Herring eggs, being adhesive, are expected to have a short planktonic existence. Juveniles were collected with beach seine, semi-balloon trawl and Cobb midwater trawl. The midwater trawl, used for the first time this year, proved to be a very effective gear, accounting for 83% of the juveniles caught.

All alosids were counted and measured upon capture and growth rates were plotted for shad, alewife, and blueback (Figures 5 and 6).

Field work continued in the Rappahannock River system through the year (Oct. 1967 - Sept. 1968) even though significant progress toward

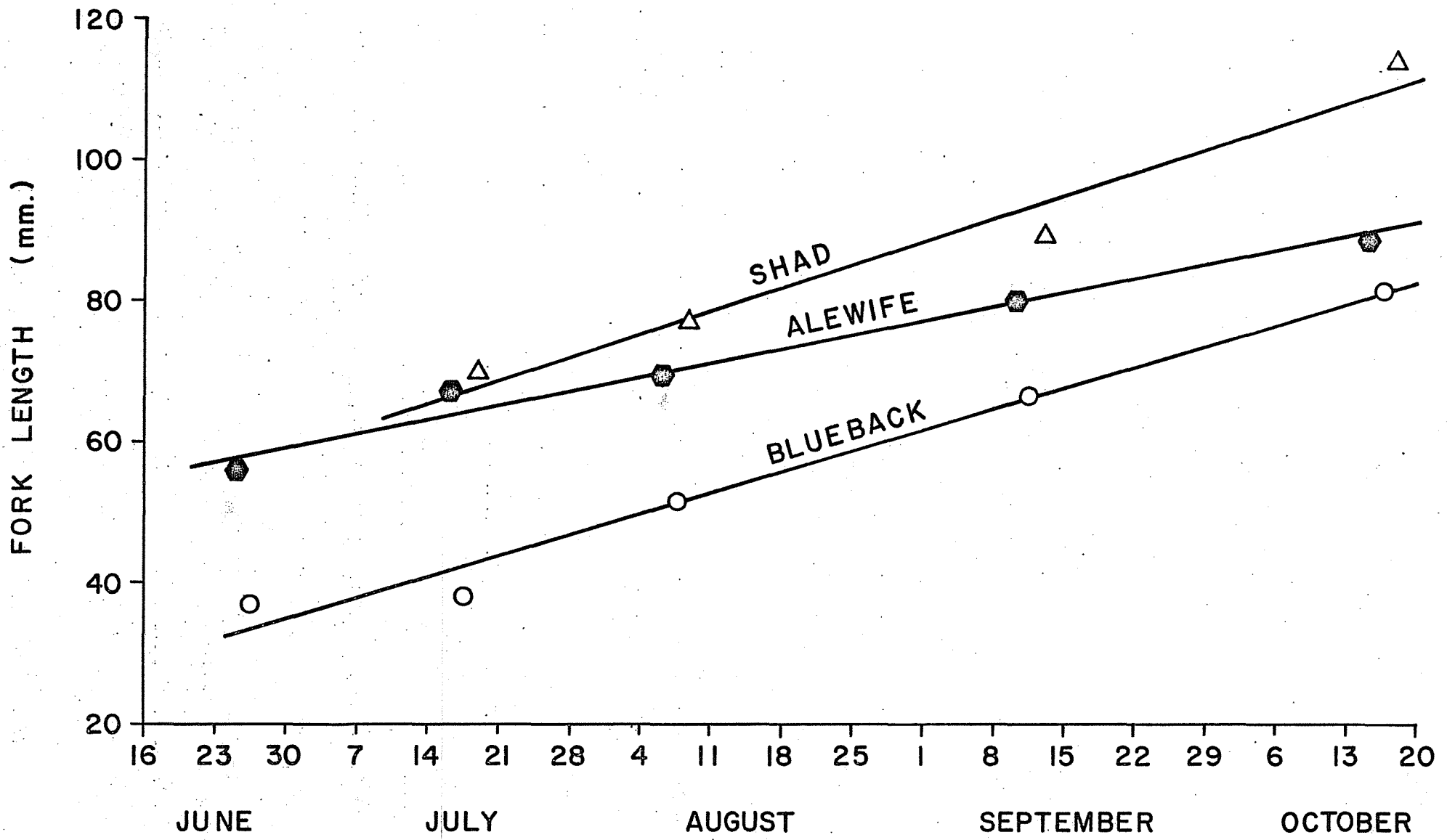


Fig. 5. Growth rates of juvenile alewife in the Rappahannock River (1968).

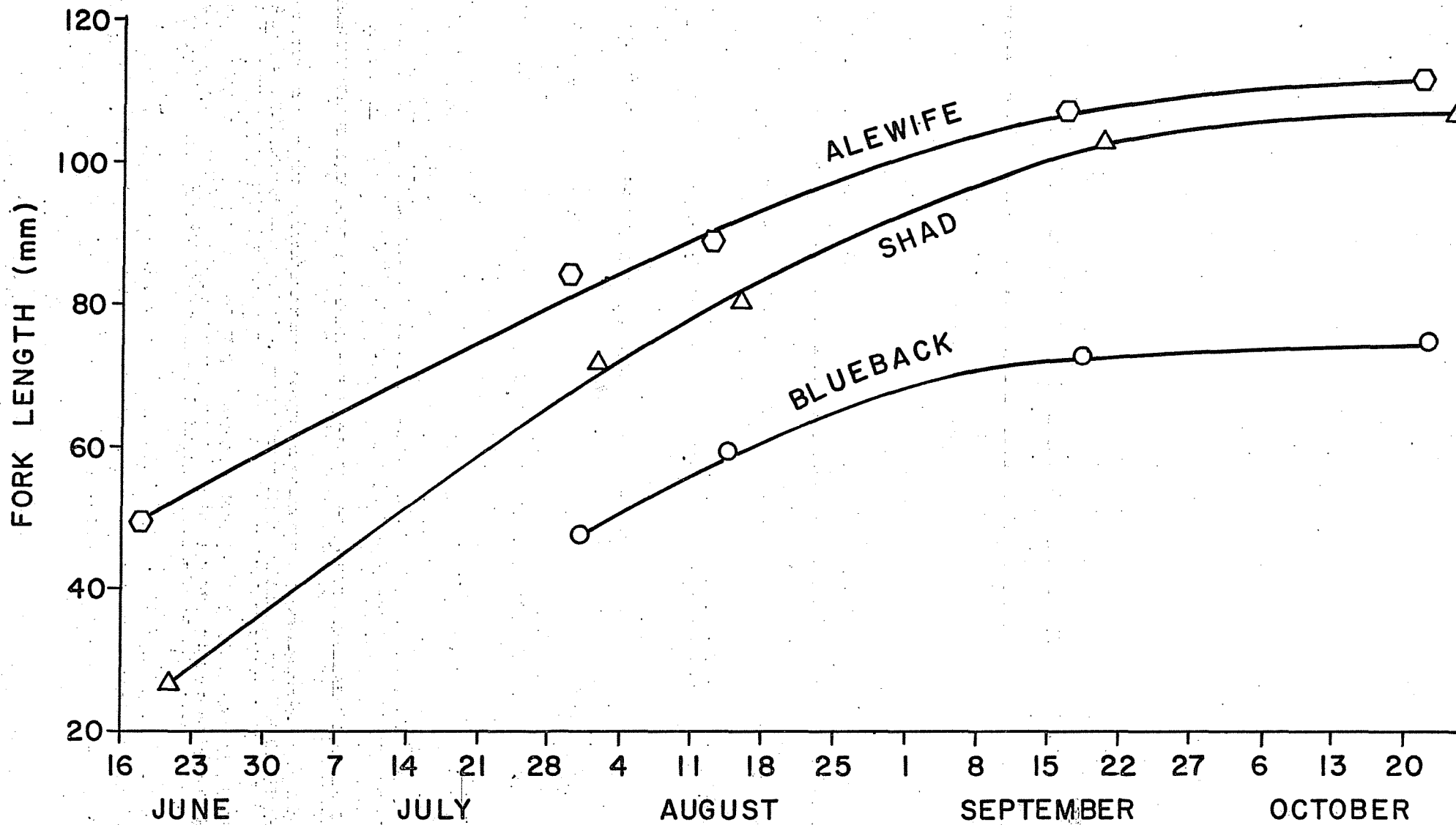


Fig. 6. Growth rates of juvenile alosids in the Potomac River (1968).

delimitation of the nursery was made in the previous year, because our newly acquired Cobb trawl proved to be much superior to the semi-balloon trawl in collecting juvenile alosids.

Work in the Potomac River system began on April 1 with the setting of gill nets. Thereafter the Potomac River and the Rappahannock River were sampled every other week through mid-June to the limit of tidal influence. After mid-June, trawl and beach seine stations were made in each river once each month. In the Rappahannock River gill nets and plankton nets were fished up to Fredericksburg at RA95; in the Potomac, PT100 in the vicinity of Georgetown was the uppermost station. Collections were also taken from the Anacostia River up to the Maryland line.

During the contract period 574 stations were occupied in the Rappahannock River system; 495 in the main stream and 79 in the tributaries. In the Potomac River system 504 stations were occupied; 388 in the main stream and 116 in the tributaries. Only those tributaries on the Virginia side of the Potomac were investigated.

During this contract period two twenty-four hour sampling cycles were conducted at two locations on the Potomac River. The first off Quantico (PT67) on July 24-25; the second off Fort Belvoir (PT82) on October 28-29. These studies were undertaken to investigate movements of juvenile alosids during a 24-hour period for vertical or lateral diel migrations.

Rappahannock River

Spawning Areas

Field work oriented toward location of spawning areas on the Rappahannock River system commenced with collecting adult alosids in gill nets on March 4 and continued through May 23. Fishing effort amounted to 116 sets taking a total of 343 alosids over a period of 19 days. The largest percentage of the catch (88%) consisted of alewife, 8 per cent was hickory shad, 3 per cent blueback, and 1 per cent American shad.

River herring and hickory shad were captured at main stream and tributary stations from RA31 to RA95 (Table 8). Alewives were taken in greatest numbers in tributaries emptying into the main stream between RA60 and RA90. On March 5 gravid alewives were taken at RA42 and RA60, indicating that these early spawning alosids enter the Rappahannock River in late February.

Hickory shad were taken in the greatest numbers at the upper limits of sampling between RA86 and RA94 in mid-May. A few were found about a month earlier in four tributaries emptying into the Rappahannock between RA31 and RA35.

During the 19 days of gill netting in the Rappahannock River system only 12 bluebacks were taken; the majority of these were found at the upper limits of sampling between RA89 and RA95. Bluebacks were also scarce in the pound net catch; the 1968 catch was less than 15% of the 1967 catch.

Between April 23 and mid-June plankton was sampled in the Rappahannock River system. Collections were made in the main stream and all tributaries assumed to be navigable by spawning alosids regardless of whether adults were taken there in gill nets or not. A total of 92

Table 8. Spawning areas, Rappahannock River system.

River Mile	Mainstream or Tributary	Gravid or Ripe Fish					Larvae	Eggs
		Alewife	Blueback	Am. Shad	Hickory			
RA31	Richardson Creek				X			
RA32	Totuskey Cr. (upper & lower)	X			X			
RA32	Totuskey Cr. (little)	X	X					
RA35	Little Carter Creek	X						
RA35	Piscataway	X	X		X			
RA37	Hoskins Creek	X	X		X			
RA39	Cat Point Creek	X						
RA39	Mt. Landing Creek	X						
RA40	MS	X						
RA41	Waterview Creek							
RA42	MS	X		X				
RA43	Sluice Creek	X						
RA44	Occupacia Creek	X						
RA44	Farmers Hall	X						
RA48	Brockenbrough Creek	X						
RA49	Peedee Creek	X						
RA53	Drakes Marsh	X						
RA57	Troy Creek	X						
RA60	MS	X						
RA62	Jett's Creek	X						
RA63	Tobacco Creek	X			X			
RA65	MS							
RA66	Gingoteague Creek	X						
RA67	Mill Creek	X						
RA68	Goldenvale Creek	X						
RA69	Millbank Creek	X						
RA70	MS							

Table 8. Spawning areas, Rappahannock River system (cont.)

River Mile	Mainstream or Tributary	Gravid or Ripe Fish					Larvae	Eggs
		Alewife	Blueback	Am. Shad	Hickory			
RA72	Goat Island Thoro. (upper end)	X						
RA73	Mt. Swamp	X						
RA75	Jones Top Creek	X						
RA80	MS							
RA85	MS	X						
RA85	Muddy Creek	X						
RA86	MS					X		
RA89	Massaponax Creek	X						
RA89	MS	X						
RA93	Main Channel		X			X		
RA95	Mid-channel		X			X		

collections were made, 58 in the tributaries and 34 in the main stream. Examination of these samples is not complete.

Alewives spawn in all but a few of the smaller tributaries between RA32 (mean annual salinity approximately 9‰) and RA93 (mean annual salinity > 0.28‰). Present data are not considered sufficient to delineate spawning areas of blueback, American or hickory shad since only a few of each species were caught in 1968.

Nursery Areas

Upon completion of the gill netting operations, monthly trawl surveys were initiated. At 5 mile intervals stations were sampled from RA00, mid-way between Stingray Point and Windmill Point, to RA90, approximately 5 miles below the limit of tidal water at Fredericksburg, Virginia.

Surveys made from July through September 1968 and those made from October 1967 through June 1968 traced development of the juveniles from time of hatching until they left the nursery.

After hatching, young fish remained in fresh water between RA45 and RA90 with an occasional alewife found downriver as far as RA25 (salinity 12.6‰) until the fall. In 1967 seaward migration began in early October when concentrations of juvenile alosids were found farther downstream than in previous months, some appearing for the first time at RA35. As monthly cruises continued through the fall and winter fish were caught progressively lower in the river and fewer were taken. Figure 7 shows the distribution of the alosids by month in relation to water temperature.

In 1968 midwater trawls and bottom trawls were made at each station. The surface hauls consistently caught more juveniles than bottom hauls (Tables 9, 10, and 11). From the total of 6232 alosids caught, 89% were taken by the Cobb trawl fished just below the surface. A total of 306 trawl hauls were made in the Rappahannock River, capturing a total of 7,520 juvenile alosids, 3,526 (47%) alewife, 3,941 (52%) blueback, and 43 (0.4%) hickory shad. The occurrence of alewife and blueback in nearly equal numbers is noteworthy in view of the apparent scarcity of adult blueback.

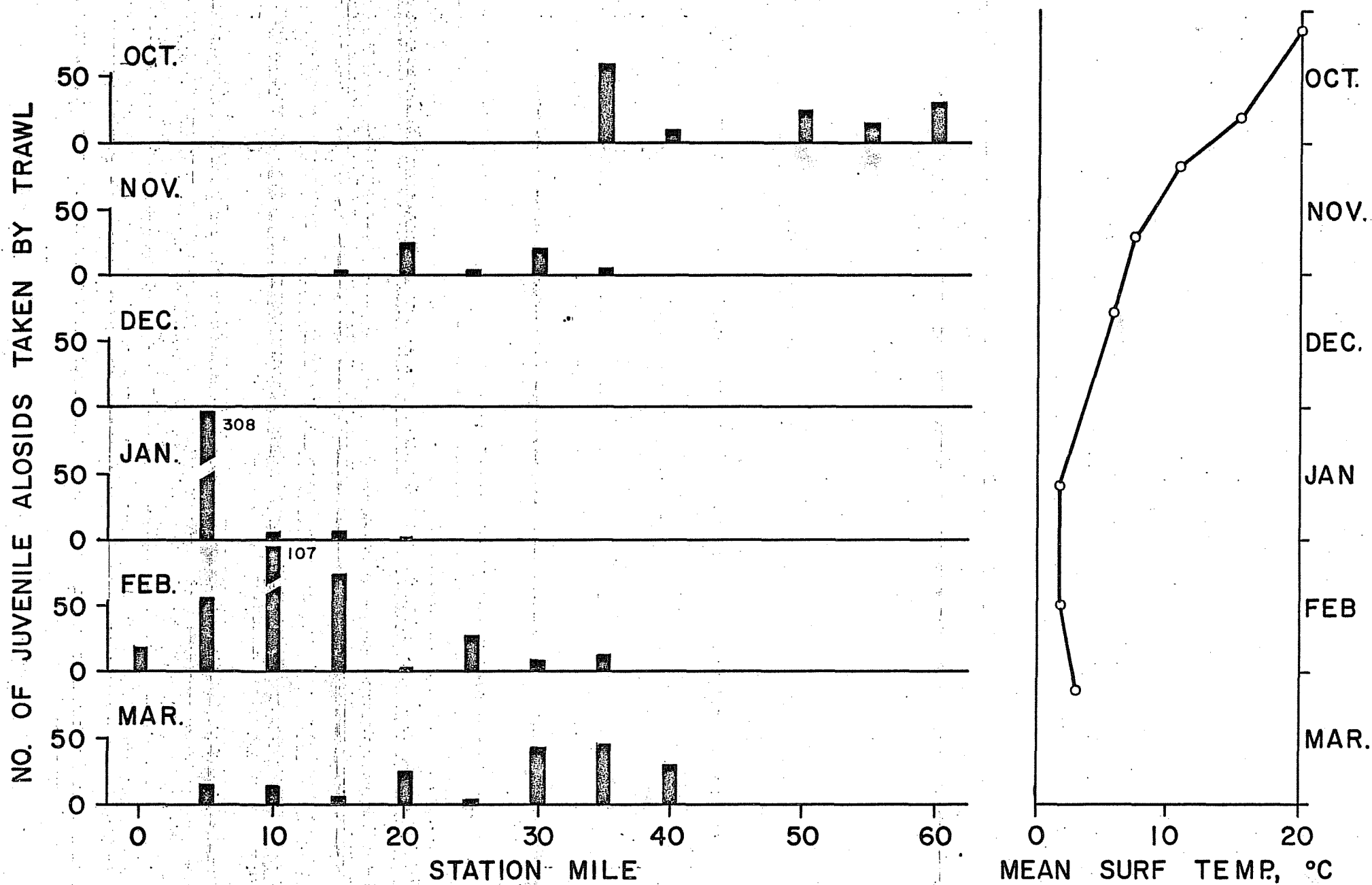


Fig. Distribution of juvenile alosids in the Rappahannock River in relation to water temperature. October, 1967 - March, 1968.

Table 9. Monthly Distribution of A. aestivalis in
the Rappahannock River in numbers of fish
per 5 min. tow at each 5 mile station

		45	50	55	60	65	70	75	80	85	90	94	Total
June		6	6	54	91	68	56	83	-	-	-	-	364
July		8	21	37	210	83	41	307	1180	122	70	-	2079
August		x	1	30	60	42	15	36	78	52	17	-	331
Sept.		x	x	x	93	13	9	74	19	86	22	-	316
Total		14	28	121	454	206	121	500	1277	260	109	-	3090
June	S	6	6	54	91	68	56	83	-	-	-	-	364
July	S	8	21	37	210	76	41	299	1093	109	70	-	1964
	B	x	x	x	x	7	x	8	87	13	x	-	115
August	S	x	1	30	48	41	12	33	78	50	17	-	310
	B	x	x	x	12	1	3	3	x	2	x	-	21
Sept.	S	x	x	x	93	13	9	74	19	86	21	-	315
	B	x	x	x	x	x	x	x	x	x	1	-	1
S	- Surface												S 2953
B	- Bottom												B 137
													x Station sampled but no blueback caught
													- Station not sampled

Table 10. Monthly Distribution of A. pseudoharengus in the Rappahannock River in numbers of fish per 5 min. tow at each 5 mile station

	25	30	35	40	45	50	55	60	65	70	75	80	85	90	Total		
June	-	-	9	31	39	37	124	117	81	33	131	-	-	-	602		
July	x	x	2	21	3	51	254	851	122	93	37	77	16	3	1530		
August	1	1	8	3	3	2	10	44	21	13	13	22	25	370	536		
Sept.	x	x	2	1	x	1	1	45	50	46	1	115	68	114	444		
Total	1	1	21	56	45	91	389	1057	274	185	182	214	109	487	3112		
June	S -	-	9	31	39	37	124	117	81	33	131	-	-	-	602		
July	S x	x	x	5	3	50	254	849	104	91	12	18	9	x	1395		
	B x	x	2	16	x	1	x	2	18	2	25	59	7	3	135		
August	S x	1	8	x	x	1	10	43	21	12	13	18	18	10	155		
	B 1	x	x	3	3	1	x	1	x	1	x	4	7	360	381		
September	S x	x	2	x	x	x	x	43	50	46	1	91	39	114	386		
	B x	x	x	1	x	1	1	2	x	x	x	24	29	x	58		
S - Surface															x Station sampled but no alewife caught	S	2538
B - Bottom															- Station not sampled	B	574

Table 11. Monthly Distribution of A. sapidissima
in the Rappahannock River in numbers of
fish per 5 min. tow at each 5 mile station

		45	50	55	60	65	70	75	80	85	90	94	Total	
June		x	x	x	x	x	x	x	-	-	-	-	0	
July		1	x	1	5	x	x	x	2	x	x	-	9	
August		x	x	2	3	x	x	x	1	1	x	-	7	
Sept.		-	-	x	1	x	1	2	x	x	x	-	4	
Total		1	x	3	9	x	1	2	3	1	x	-	20	
June	S	x	x	x	x	x	x	x	-	-	-	-	0	
July	S	1	x	1	5	x	x	x	x	x	-	-	7	
	B	x	x	x	x	x	x	2	x	x	-	-	2	
August	S	x	x	2	3	x	x	x	1	1	x	-	7	
	B	x	x	x	x	x	x	x	x	x	x	-	0	
Sept.	S	x	x	x	1	x	1	2	x	x	x	-	4	
	B	x	x	x	x	x	x	x	x	x	x	-	0	
S	- Surface													
													x Station sampled but no shad caught	S 18
B	- Bottom													
													- Station not sampled	B 2

The mean fork lengths of juvenile alosids are given for each station by month of capture in Tables 12, 13, and 14. Growth of alosids was approximately linear from June through October in the Rappahannock River. The rate of growth appeared somewhat greater at upriver stations than downriver, though this might result from the migration of fish from one area to another in the river.

Alewife increased in length 24.4 mm during the 11 week period from late June to mid-September, a rate, computed by the least squares method, of almost 2 mm per week.

Bluebacks increased 29.5 mm during the same period, a rate of nearly 3 mm per week.

For the few American shad caught the mean length increased 19 mm in the 8-week period mid-July to mid-September, a rate of 2.4 mm per week. The least squares plot including an October sample of 4 fish indicates a rate of 3.3 mm per week as shown in Fig. 5.

Table 12. Mean lengths (FL mm) of A. aestivalis in the Rappahannock River
by month and river mile

		35	40	45	50	55	60	65	70	75	80	85	90	Mean of all stations
June		-	-	35	38	37	38	37	37	35	-	-	-	36.8
July		x	x	41	50	49	51	49	44	44	31	45	46	37.8
August		x	x	x	52	57	56	51	42	44	48	56	50	51.3
September		x	x	x	x	x	66	65	67	66	68	67	65	66.3
Average length by station		0	0	38	48	46	46	47	42	43	51	54	50	
June	S	-	-	35	38	37	38	37	37	35	-	-	-	36.8
July	S	x	x	41	50	49	51	51	44	44	30	44	46	37.4
	B	x	x	x	x	x	x	31	x	42	44	52	x	44.0
August	S	x	x	x	52	57	57	52	42	43	48	56	50	51.4
	B	x	x	x	x	x	54	33	40	52	x	47	x	49.8
September	S	x	x	x	x	x	66	65	67	66	68	67	65	66.3
	B	x	x	x	x	x	x	x	x	x	x	x	73	73.0

S - Surface

x Station sampled but no blueback caught

B - Bottom

- Station not sampled

Table 13. Mean lengths (FL mm) of A. pseudoharengus in the Rappahannock
by month and river mile

		25	30	35	40	45	50	55	60	65	70	75	80	85	90	Mean of all stations
June		-	-	54	59	53	50	55	55	56	57	57	-	-	-	55.4
July		x	x	70	63	66	65	66	68	66	67	64	65	67	91	67.0
August		82	58	69	66	67	58	67	68	68	71	62	68	72	70	69.4
September		x	x	97	72	x	82	80	76	80	77	78	81	81	80	79.8
Average length by station		82	58	74	60	55	59	63	63	65	68	59	67	78	73	
June	S	-	-	54	59	53	50	55	55	56	57	57	-	-	-	55.4
July	S	x	x	x	66	66	65	66	68	66	67	65	66	68	x	67.3
	B	x	x	70	62	x	65	x	58	64	67	64	65	66	91	65.0
August	S	x	58	69	x	x	57	67	68	68	71	62	64	71	69	67.5
	B	82	x	x	66	67	60	x	67	x	75	x	88	74	70	70.2
September	S	x	x	97	x	x	x	x	76	80	77	78	80	78	80	79.1
	B	x	x	x	72	x	81	80	78	x	x	x	85	86	x	84.9
S - Surface																x Station sampled but no alewife caught
B - Bottom																- Station not sampled

Table 14. Mean length (FL mm) of A. sapidissima in the Rappahannock River by month and river mile

		35	40	45	50	55	60	65	70	75	80	85	90	Mean of all stations
June		x	x	x	x	x	x	x	x	x	-	-	-	0
July		x	x	75	x	84	78	x	x	x	81	x	x	70.0
August		x	x	x	x	78	76	x	x	x	80	73	x	76.7
September		x	x	x	x	x	85	x	101	85	x	x	x	89.0
Average length by station		0	0	75	0	80	78	0	101	85	81	73	0	
June	S	x	x	x	x	x	x	x	x	x	-	-	-	0
July	S	x	x	75	x	84	78	x	x	x	x	x	x	78.0
	B	x	x	x	x	x	x	x	x	x	81	x	x	81.0
August	S	x	x	x	x	78	76	x	x	x	80	73	x	76.7
	B	x	x	x	x	x	x	x	x	x	x	x	x	0
September	S	x	x	x	x	x	85	x	101	85	x	x	x	89.0
	B	x	x	x	x	x	x	x	x	x	x	x	x	0

S - Surface

x Station sampled but no shad caught

B - Bottom

- Station not sampled

Physico-Chemical Features

The tidal portion of the Rappahannock River extends from the fall line at Fredericksburg 96 nautical miles to the Chesapeake Bay. The mean salinity at 3 meters depth over the period June through September for each 5 mile station is given in Table 15. The limit of sea water intrusion is between RA40 and RA45 approximately at Naylor's above the Tappahannock Bridge.

Water temperatures generally followed the same trends as those recorded in 1967, with highest temperatures in August. The highest surface water temperatures recorded were 32.6° C at RA40 and 32.3 at RA65 the first week in August 1968. A high temperature of 30.4° was recorded at mile RA70 the same week in 1967. Temperatures at selected stations in the Rappahannock River are shown in Fig. 8.

Oxygen depletion was observed in the deep water from the mouth of the Rappahannock to about RA35 during August when the concentration of dissolved oxygen was 5.5 ppm or less in water deeper than 6 m. Dissolved oxygen ranged from 14% to 76% saturation in bottom water samples between RA5 and RA35. Depletion of oxygen in the upper reaches of the Rappahannock was observed in September of 1968 (Table 16). Apparently there is some organic loading at Fredericksburg. The Rappahannock River however did not show evidence of the gross over-enrichment seen in the Potomac River.

Table 15. Salinity Distribution-Rappahannock River 1968

salinities at 3m depth except as indicated

Station	May	June	July	Aug.	Sept.	Mean
R0	-		15.20	-	-	15.20
R5	-		14.32	-	-	14.32
R10	-		13.72	15.52	16.76	15.33
R15	13.08		14.40	15.24	16.00	14.68
R20	12.08		12.40	14.32	15.24	13.51
R25	12.36		11.12	12.60	13.80	12.47
R30	10.44		9.64	8.68	11.96	10.18
R35	8.00		7.20	6.60	8.88	8.03
R40	2.28	0.84*	3.08	2.48*	6.04	2.94
R45	0.44	0.09*	0.68	1.12*	3.88	1.24
R50	0.08	0.10*	-	0.28*	2.08	0.63
R55	-	0.11*	-	0.24*	1.04	0.46
R60	-	0.08*	-	-	0.44	0.26
R65	-	-	-	-	0.32	0.32
R70	-	.08*	-	-	0.28	0.18
R75	-	.07*	-	-	0.24	0.16
R80	-	-	-	-	0.24	0.24
R85	-	-	-	-	0.12	0.12
R90	-	-	-	-	0.28	0.28

* Surface samples

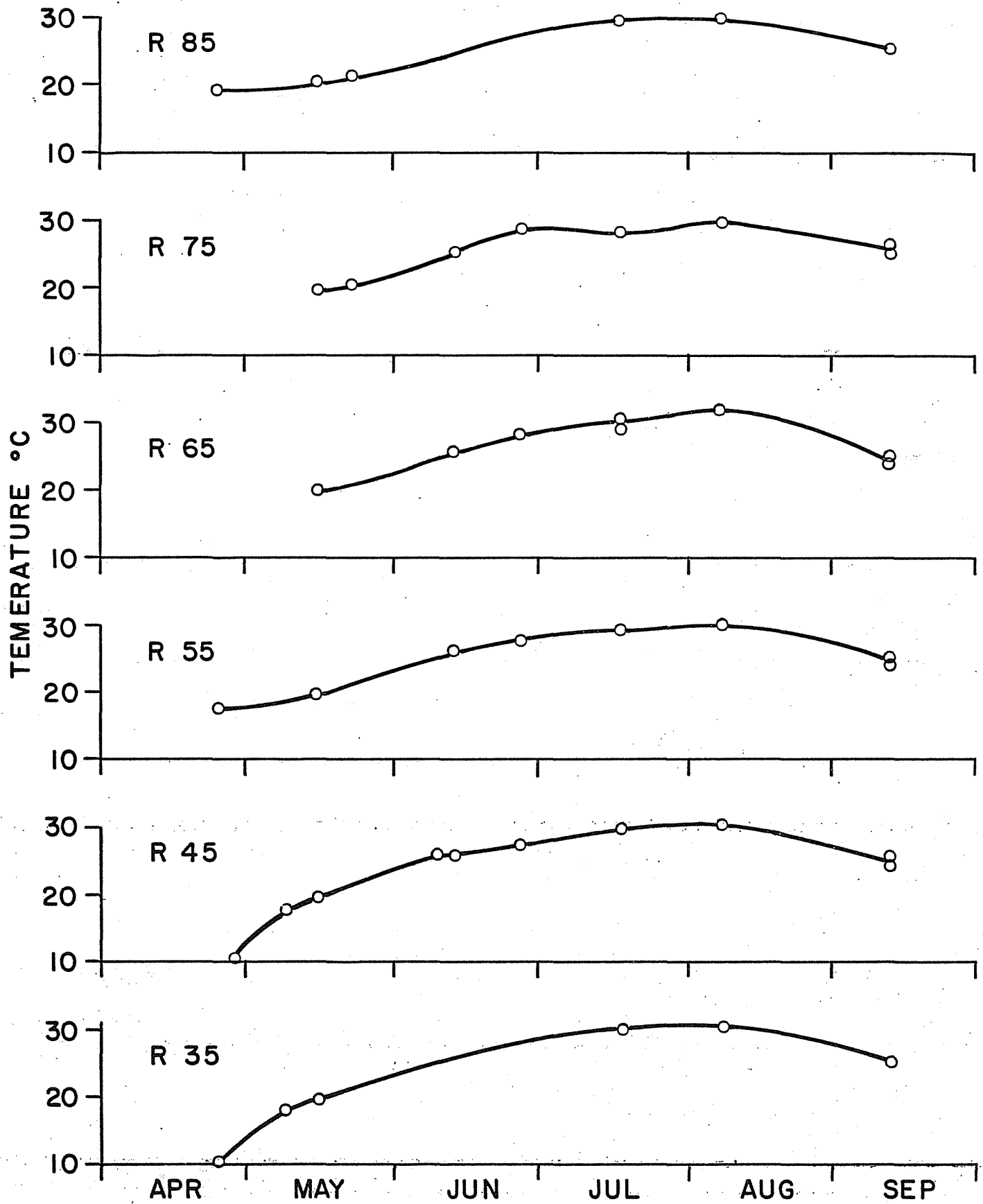


Fig. 8. 1968 surface water temperatures — Rappahannock River.

Table 16. Dissolved Oxygen (% sat.) - Rappahannock River

	22 July		9 Aug.		10 Sept.	
	S	B	S	B	S	B
RA05	148	14				
RA10	95	40	90	21	96	35
RA15					101	58
RA20			73	20	89	47
RA25			90	51	91	84
RA30			83	76	91	86
RA35			85	86	84	83
RA40					87	92
RA45					84	79
RA50					92	92
RA55					91	90
RA60					86	88
RA65					96	99
RA70					69	67
RA75					56	54
RA80					59	56
RA85					69	67
RA90					29	10

Potomac River

Spawning Areas

Efforts to locate spawning areas of alosids in the Potomac River began on April 1 and continued through June 20. There were 106 gill net sets made, 80 in the tributaries and 26 in the main stream. A total of 372 adult alosids were caught, of which 58% were alewife, 36% blueback, 6% American shad, and less than 1% hickory shad. The ratio of female to male was 1.9 : 1 for alewife, 1.4 : 1 for blueback, and 1.1 : 1 for American shad. The 2 hickory shad taken were males.

Alewife were taken in tributary streams from Hampton Hall Cr. at PT11 to the Anacostia River at mile 99 and were found in greatest abundance in tributaries between PT40 and PT73 (Table 17).

Bluebacks were taken in tributary streams between PT39 and mile 99 in the Anacostia River and in the main stream of the Potomac at PT77, PT80, and PT99. The greatest numbers were found in Farm Creek at PT73 and in the main stream at PT81 and PT99 in the Anacostia River. PT99 is just below Little Falls, the limit of upstream migration.

American shad were taken in drift nets in the Potomac from mile 67 to mile 99 but the majority were taken at PT80.

An attempt to verify spawning sites by the recovery of eggs or larvae was begun in the Potomac River system on April 23 using half meter and meter plankton nets. They were towed for 5 to 10 minutes at the surface in the tributaries and at the surface and near the bottom in the main stream. A total of 36 tows were made in 31 different creeks, and 39 tows were made in the Potomac itself. Analysis of plankton samples has not been completed.

Table 17. Spawning areas, Potomac River system.

River Mile	Mainstream or Tributary	Gravid or Ripe fish				
		Alewife	Blueback	Am. Shad	Hickory	Larvae Eggs
PT11	Hampton Hall Creek	X				
PT25	Nomini Creek	X				
PT33	Popes Creek	X				
PT35	Mattox Creek	X				
PT39	Rosier Creek		X			
PT40	Upper Machodoc	X				
PT40	Williams Creek	X				
PT41	Gambo Creek	X				
PT50	Chotank Creek					
PT59	Potomac Creek	X	X			
PT59	Accakeek Creek	X				
PT60	Aquia Creek	X	X			
PT66	Chopawonsic Creek	X	X			
PT69	Quantico Creek	X	X	X		
PT71	Powell Creek	X	X			
PT71	MS					
PT72	Neabsco Creek	X	X			
PT73	Farm Creek	X				
PT73	Marumsco Creek	X	X			
PT74	MS					
PT74	Occoquan Creek	X	X			
PT74	Massey Creek	X				
PT75	MS			X		
PT	MS			X		
PT77	Craney Island		X			
PT80	MS			X		

Table 17. Spawning areas, Potomac River system (cont.)

River Mile	Mainstream or Tributary	Gravid or Ripe fish				
		Alewife	Blueback	Am. Shad	Hickory	Larvae Eggs
PT81	MS (Marshall Hall)	X	X	X		
PT80	Accotink Creek	X				
PT80	Pohick Creek	X				
PT80	Gunston Bay			X		
PT74	Kane Creek	X				
PT81	Dogue Creek	X				
PT84	Little Hunting Creek	X				
PT84	MS					
PT99	MS		X	X	X	
AN	Anacostia River	X	X			

Nursery Areas

Juvenile alosids were found from PT55 (mean salinity during sampling period 4.52‰) to upper limits of sampling at PT94 (mean salinity 0.28‰) during the period from June through September (Tables 18, 19, and 20). Stations were occupied along the entire length of the Potomac from PT0, midway between Smith Point and Point Lookout, to PT94 opposite Washington National Airport. During September one station was sampled in the Anacostia River (PA96) located in mid-channel opposite the Navy docks.

All juveniles except two bluebacks collected in July at PT55 were found above PT60 which had a mean salinity of 2.99‰ during the four month sampling period. No American shad were found below PT75. Sixty-five per cent of all juvenile alosids collected in the Potomac River were found in the 20-mile section between PT65 (mean salinity 1.84‰) and PT85 (mean salinity 0.34‰). The greatest number of alosids (9,138) was captured during the July trawl series.

From June through September, 287 trawl hauls captured a total of 13,874 juvenile alosids in the Potomac River; 12,890 (93%) blueback, 945 (6.8%) alewives, and 39 (0.2%) American shad. No juvenile hickory shad were captured in the Potomac River system this year.

Usually collections were made at each station at three depths; surface and midwater, taken with the Cobb trawl and bottom collections made with 30 foot semi-balloon trawl, surface meaning the net was set to fish the water column from 0 to 10 feet, midwater meaning the net fished from 10 to 20 feet in the water column. Tables 18, 19, and 20 give the distribution of juveniles by number per 5 minute tow at each station by month during the sampling period covered in this report. From the total of 13,874 alosids of all three species found; 9,687 (70%) were taken by surface trawling, 4,029 (29%) were collected at

Table 19. Monthly Distribution of A. pseudoharengus in Potomac River
in number of fish per 5 min. tow at each 5 mile station

		55	60	65	70	75	80	85	90	94	PA96	Total
June		x	4	3	131	18	16	-	2	26	-	200
July		x	1	39	x	192	16	54	122	25	-	449
August		x	1	x	6	17	2	51	6	13	-	96
Sept.		x	1	2	x	40	14	98	1	42	2	200
Total		0	7	44	137	267	48	203	131	106	2	945
June	S	x	4	3	131	18	16	-	2	26	-	200
July	S	x	x	38	-	186	12	48	122	25	-	431
	M	x	1	x	-	6	4	6	x	x	-	17
	B	x	x	1	-	x	x	x	x	x	-	1
August	S	x	x	x	3	8	1	47	4	7	-	70
	M	-	-	x	3	6	x	4	2	6	-	21
	B	x	1	x	x	3	1	x	-	-	-	5
Sept.	S	x	x	x	x	1	2	13	x	5	-	21
	M	-	-	1	x	37	11	82	1	1	-	133
	B	x	1	1	x	2	1	3	x	36	2	46

S - Surface
M - Midwater
B - Bottom

x Station sampled but no alewife caught
- Station not sampled

S 722
M 171
B 52

midwater, and 158 (1%) were picked up from the bottom. Thus, the Cobb trawl is credited with 99% of the catch.

Comparing the catch from equal numbers of surface trawls in the two rivers indicates bluebacks more numerous in the Potomac, and alewives more abundant in the Rappahannock. Likewise catch per unit effort for bluebacks was consistently higher in the Potomac while catch per unit effort for alewives was consistently higher in the Rappahannock during the four month period. Bottom trawls in the Rappahannock averaged 15 alosids per 5-minute tow whereas in the Potomac the average catch was 4 per tow.

The mean length of juvenile alosids generally increased in successive weeks of sampling at each station with larger fish usually found at the upriver stations (Tables 21-23). This situation is very similar to that in the Rappahannock except that alosids from the Potomac were consistently larger than those from the Rappahannock.

The growth increment of alewives in the Potomac River (57.3 mm in 13 weeks) is more than twice the increase of the Rappahannock alewives while the increment for bluebacks is very similar. Bluebacks increased in mean length by 25 mm in the 7 week period from the last week in June through the middle of September. American shad grew 75.4 mm in the 13 weeks from mid-June through mid-September.

Apparently the conditions which initiate seaward migration had not occurred in the Potomac by the end of September.

Table 21. Mean lengths (FL mm) of A. aestivalis in the Potomac River
by month and river mile

		45	50	55	60	65	70	75	80	85	90	94	PA96	Mean of all stations
June		-	-	x	x	x	x	x	x	-	x	x	-	0
July		x	x	51	50	46	-	52	48	57	57	54	-	47.7
August		x	x	x	48	51	58	62	58	63	67	x	-	59.7
September		x	x	x	48	50	60	69	65	74	x	78	86	72.7
Average length by station		0	0	51	50	47	59	55	57	72	58	77	86	
June	S	-	-	x	x	x	x	x	x	-	x	x	-	0
July	S	x	-	52	50	46	-	52	48	59	58	54	-	47.8
	M	x	-	x	50	47	-	53	49	52	51	x	-	47.4
	B	x	x	50	48	51	-	54	47	x	x	x	-	50.7
August	S	x	x	x	49	48	56	64	58	63	67	x	-	60.6
	M	-	-	-	-	51	59	62	61	63	x	x	-	58.3
	B	x	x	x	47	x	x	61	58	x	-	-	-	59.8
September	S	x	x	x	x	x	60	64	65	74	x	78	-	73.0
	M	-	-	-	-	49	65	69	69	78	x	77	-	70.4
	B	x	x	x	48	56	x	74	x	78	x	x	86	62.0

S - Surface
M - Midwater
B - Bottom

x Station sampled but no blueback caught

- Station not sampled

Table 22. Mean lengths (FL mm) of A. pseudoharengus in the Potomac River
by month and river mile

		45	50	55	60	65	70	75	80	85	90	94	PA96	Mean of all stations
June		-	x	x	54	52	47	64	64	-	25	46	-	49.8
July		x	x	x	90	77	-	82	84	85	86	99	-	84.1
August		x	x	x	93	x	89	86	92	88	92	93	-	89.0
September		x	x	x	115	99	x	103	107	106	111	115	108	107.1
Average length by station		0	0	0	73	82	49	84	84	96	86	92	108	
June	S	-	x	x	54	52	47	64	64	-	25	46	-	49.8
July	S	x	-	x	x	77	-	82	84	85	86	99	-	84.1
	M	x	-	x	90	x	-	83	84	84	x	x	-	84.0
	B	x	x	x	x	88	-	x	x	x	x	x	-	88.0
August	S	x	x	x	x	x	87	85	93	88	92	94	-	88.5
	M	-	-	-	-	x	90	86	x	92	93	93	-	90.4
	B	x	x	x	93	x	x	90	90	x	-	-	-	90.6
September	S	x	x	x	x	x	x	110	109	104	x	114	-	107.3
	M	-	-	-	-	87	x	103	107	105	111	103	-	104.5
	B	x	x	x	115	110	x	107	114	121	x	115	108	114.7

S - Surface
M - Midwater
B - Bottom

x Station sampled but no alewife caught

- Station not sampled

Table 23. Mean lengths (FL mm) of *A. sapidissima* in the Potomac River by month and river mile

		45	50	55	60	65	70	75	80	85	90	94	PA96	Mean of all stations
June		-	x	x	x	x	x	x	27	-	x	x	-	27.0
July		x	x	x	x	x	-	67	x	74	77	x	-	72.1
August		x	x	x	x	x	x	x	74	79	88	81	-	80.3
September		x	x	x	x	x	x	108	101	100	x	x	x	102.4
Average length by station		0	0	0	0	0	0	92	71	83	86	81	0	
June	S	-	x	x	x	x	x	x	27	-	x	x	-	27.0
July	S	x	-	x	x	x	-	x	x	73	77	x	-	74.0
	M	x	-	x	x	x	-	67	x	75	x	x	-	69.7
	B	x	x	x	x	x	-	x	x	x	x	x	-	0
August	S	x	x	x	x	x	x	x	73	79	88	81	-	80.4
	M	-	-	-	-	x	x	x	80	x	x	x	-	80.0
	B	x	x	x	x	x	x	x	x	x	x	-	-	0
September	S	x	x	x	x	x	x	116	95	100	x	x	-	100.0
	M	-	-	-	-	x	x	104	x	x	x	x	-	103.5
	B	x	x	x	x	x	x	x	120	100	x	x	x	110.0

S - Surface
M - Midwater
B - Bottom

x Station sampled but no shad caught

- Station not sampled

Physico-Chemical Features

The tidal portion of the Potomac River extends from the fall line at Washington D.C. for a distance of 101 nautical miles to the Chesapeake Bay. The salinity distribution in the river during the months of June through September is given in Table 24 as the mean salinity at 3 meters depth and at five mile intervals. The limit of sea water intrusion is about mile 60 near Quantico, though salinity values of greater than 1 ppt were found as high as mile 70 in September.

Water temperatures in the upper half of the Potomac reached 15°C in late April, 20° early in June, 25° by the end of June, and 30° at several stations by the end of July. The maximum recorded temperature was 31.2°C at mile 65 on July 24 and again at mile 70 on August 15. A plot of the temperatures at ten mile intervals is shown in Fig. 9. Water temperatures tended to be somewhat warmer in the upper Potomac than in the lower half of the river during the summer months.

Over enrichment is evidenced in the Potomac from Washington, D.C. downriver for about 50 miles by a tremendous bloom of algae. The pollution load is also evident from the depressed dissolved oxygen values found in almost all bottom water samples (Table 25).

The lower river is characterized by a relatively shallow shelf at the mouth, as is typical of tidal rivers, and deeper holes up river from the mouth. Oxygen-poor water occupies the deep water during the summer months. Water at depths greater than 9 meters below PT40 was devoid of dissolved oxygen in July and August.

Oxygen was depleted near the bottom from PT94 downstream to PT85 from June through September and very few alosids were caught at mile 90 in August and September when the dissolved oxygen concentrations were 1.9 and 1.1 ppm respectively.

Table 24. Salinity Distribution-Potomac River 1968
salinities at 3m depth except as indicated

Station	April	May	June	July	Aug.	Sept.	Mean
P00	11.84						11.84
P05	11.62			12.20			11.91
P10	11.72			11.76		15.20	12.89
P15	11.84			11.48		15.56	12.96
P20	8.12			10.52		13.24	10.63
P25	7.36			9.64		12.72	9.91
P30	7.36			9.08		13.04	10.49
P35	6.32			8.08		11.88	8.76
P40	5.42			7.92		-	6.67
P45	-		2.68	8.28	8.92	9.20	7.26
P50	-		2.48	8.36	8.80	8.60	7.06
P55	-		0.28	4.64	6.44	6.72	4.52
P60	1.12			2.28	3.36	5.20	2.99
P65	0.28			-	1.92	3.32	1.84
P70				0.08	0.44	2.00	0.84
P75				0.28		0.32	0.30
P80				0.36		0.20	0.28
P85				0.32		0.36	0.34
P90				0.32		0.36	0.34
P94				0.28		0.28	0.28

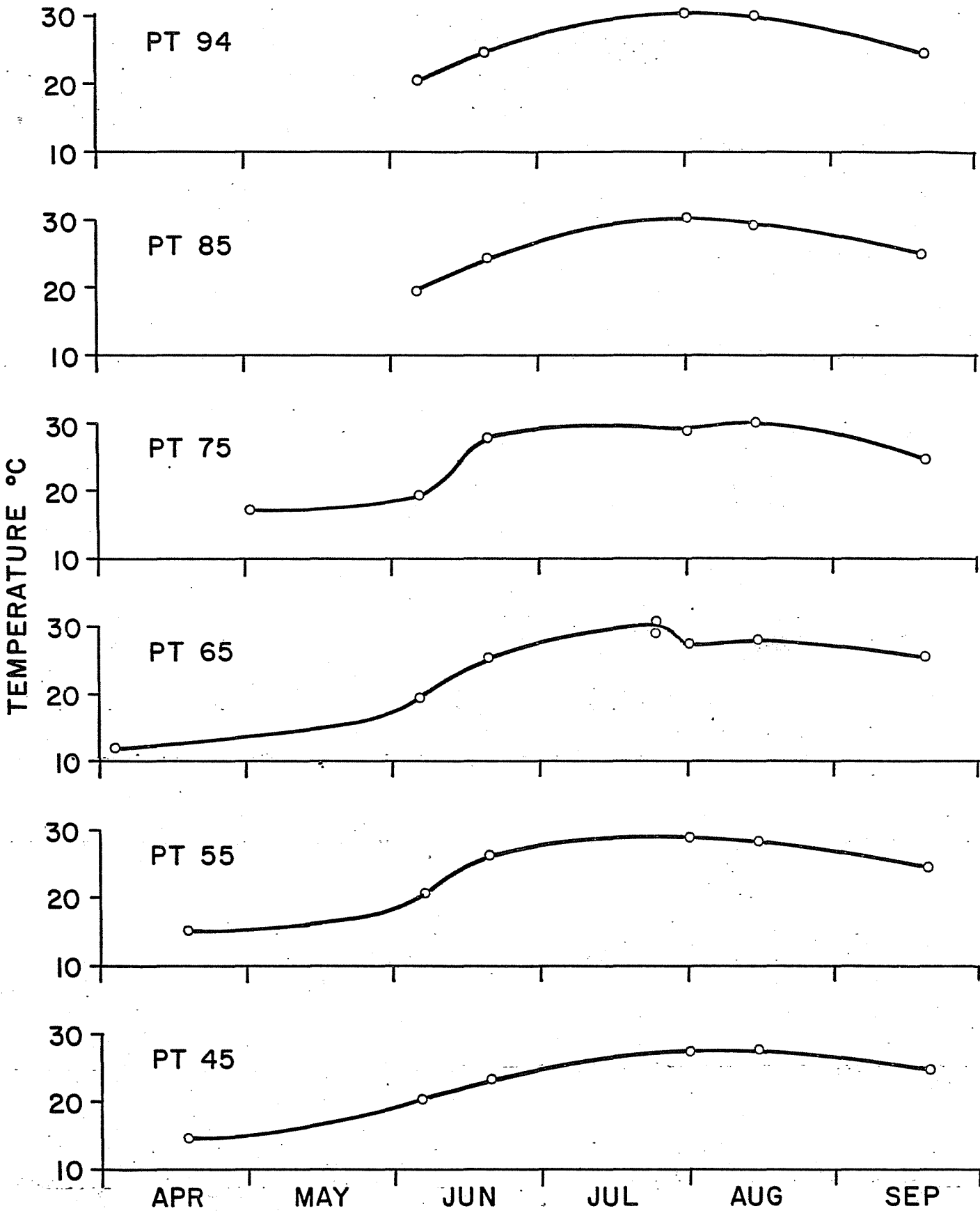


Fig. 9. 1968 surface water temperatures - Potomac River.

Table 25. Dissolved oxygen (% sat.) - Potomac River

	17-18 April		4-5 June		18-19 June		22-23 July 1-2 Aug.		15-16 Aug.		17-19 Sept.	
	S	B	S	B	S	B	S	B	S	B	S	B
PT 05	115	102										
10	99	101					107	0			124	1
15	109	74					120	0			121	1
20	97	69					130	0			148	54
25	95	65					114	1			134	38
30	122	82					140	0			122	1
35	77						140	0			---	
40	82	60					139	3			---	
	72	64	65	40	69	23	106	75			81	52
50	72	68	61	46	67	27	79	63	81	37	37	55
55			65	60	70	63	88	76	85	69	83	66
60			71	66	70	71	106	98	95	91	75	75
65			78	72	74	68	---		82	86	118	77
70			84	76	62	58	70	69	122	48	100	70
75			81	76	71	60	94	92	148	31	74	54
80			81	76	24	23	91	92	84	56	87	63
85			73	74	22	18	154	77	162	40	34	29
90			89	87	40	31	80	43	103	24	15	13
94			94	86	72	58	57	40	66	34	66	60

APPENDIX II
GEAR AND METHODS

Gill Nets

Main stream stations - Drift gill nets were fished in the main stream of both the Rappahannock and Potomac Rivers for $1/2$ to 1 hour at or near five mile stations and off the mouths of numerous tributaries. The nets consisted of 100 yards of 3" and 5" stretch mesh nylon for herring and shad respectively. In most cases nets were 8 feet deep, however the deep water stations in the Potomac were fished with shad nets 16 feet deep.

Tributary streams - These streams were fished as near the headwaters as could be reached by outboard skiffs. The gear consisted of 25 yard 3" stretch mesh monofilament anchor gill net.

Beach Seines

Beach seining was done with bag seines 50' x 6' x $3/16$ ". Seine hauls were made at suitable sites at approximately five mile intervals and in some tributaries. Most were made by wading but where the bottom dropped off quickly the hauls were made by fixing one end of the seine on the bank and towing the other end in an arc to the beach some distance away. The seine was then hauled by hand.

Trawls

Two types of trawl gear were used during this contract period, a semi-balloon bottom trawl and a Cobb trawl for midwater and surface sampling. The two bottom trawls used were a 30' semi-balloon trawl made of $1/2$ in. stretch mesh netting with $1/2$ in. mesh cod end liner used

for fishing the channel in the main stream, and a 16' semi-balloon trawl with $1\frac{1}{2}$ in. stretch mesh netting equipped with a small mesh cod end liner for the shoal water and tributaries.

The R/V Langely was equipped with a larger trawl winch and an overhead trawl block travelling on a 12" I-beam suspended 14' above the deck. This gear handling arrangement enabled us to use a 10' x 10' Cobb trawl equipped with 13' horizontal spreader bars. The trawl block could be brought inboard, bringing the body of the trawl aboard. The net consists of a body of $\frac{3}{4}$ in. stretch mesh No. 110 knotless nylon netting and the cod end of $\frac{1}{2}$ in. stretch mesh No. 126 knotless nylon netting. The Cobb trawl proved to be a very effective gear for taking juvenile alosids.

Routinely trawls were towed for 5 minutes at each station.

Plankton Net

Plankton collections were taken in the mainstream and larger tributaries with a cone-shaped net, one meter in diameter at the mouth and 6 feet long, made from nylon marquisette having about 36 meshes per inch. A one-half meter net made of the same material was used in the smaller tributaries.-- Nets were fished for 10 minutes at each station. Both bottom and surface were sampled at all mainstream stations.

Salinity

Water samples were taken routinely at each station for salinity determinations throughout the spring and summer months. These were analyzed by a laboratory model RS-7A salinometer. Field salinity profile determinations were made at trawl stations with an RS-5 portable salinometer.

Temperature

Temperature profiles were determined with an RS-5 portable salinometer at trawl stations and surface temperatures were routinely taken at all other stations with a stem thermometer.

Dissolved Oxygen

Some 367 water samples were analyzed for dissolved oxygen by the modified Winkler technique.