

AD

**EDGEWOOD ARSENAL  
TECHNICAL REPORT**

**EATR 4609**

**AD 740735**

**FISH POPULATIONS AROUND EDGEWOOD ARSENAL'S  
CHEMICAL AGENT TEST AREA**

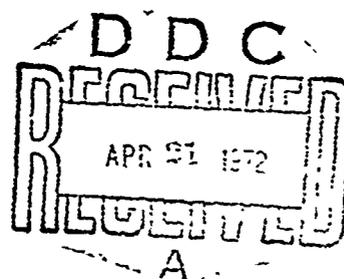
by

**Harley J. Speir, SP4**

**March 1972**



Reproduced by  
**NATIONAL TECHNICAL  
INFORMATION SERVICE**  
Springfield, Va. 22151



**DEPARTMENT OF THE ARMY  
EDGEWOOD ARSENAL  
Biomedical Laboratory  
Edgewood Arsenal, Maryland 21010**

721  
/



**UNCLASSIFIED**

Security Classification

DOCUMENT CONTROL DATA - R & D		
<i>(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)</i>		
1. ORIGINATING ACTIVITY (Corporate author) CO, Edgewood Arsenal ATTN: SMUEA-BL-RE Edgewood Arsenal, Maryland 21010		2c. REPORT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>
		2b. GROUP NA
3. REPORT TITLE <b>FISH POPULATIONS AROUND EDGEWOOD ARSENAL'S CHEMICAL AGENT TEST AREA</b>		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) This work was started in May 1970 and completed in September 1971.		
5. AUTHOR(S) (First name, middle initial, last name)  Harley J. Speir, SP4		
6. REPORT DATE March 1972	7a. TOTAL NO. OF PAGES 27	7b. NO. OF REFS 8
8a. CONTRACT OR GRANT NO.  A. PROJECT NO.  c. Task No. 1W662710AD6302  d.		8b. ORIGINATOR'S REPORT NUMBER(S)  EATR 4609
8c. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)		
10. DISTRIBUTION STATEMENT  Approved for public release; distribution unlimited		
11. SUPPLEMENTARY NOTES  Chemical safety investigations: Test Area E		12. SPONSORING MILITARY ACTIVITY  NA
13. ABSTRACT <p>Seining was conducted around Carroll Island, Maryland as part of an ecological research program initiated by the Director of Research Laboratories in Aug 1969. Carroll Island is Edgewood Arsenal's major outdoor facility for field testing of riot control agents, simulants, and signaling and screening smokes. Fish were seined periodically from waters directly downwind from most test areas and from waters that probably received most of the rainwater drainage from testing sites. During the 8-month investigation, nearly 28,000 fish, representing 24 species, were collected. Bay anchovies, white perch, and silversides accounted for 90% of the total catch. White perch and silversides were present throughout the period, but anchovies were abundant only in September and October. Diversity indices computed for Carroll Island populations compare favorably with those reported from a southern estuary. Results of this study were similar to those of another seining investigation conducted on the Susquehanna Flats by Maryland fisheries biologists. Throughout the study, young-of-year white perch from one Carroll Island area were significantly smaller than white perch from three nearby locations. However, the growth rates of Hawthorne Cove perch were similar to those of fish in the other locations. This probably means that Hawthorne Cove fish were spawned later. No effect that could be attributed to the testing of chemical agents were found.</p>		
14. KEYWORDS Fish Seining Estuary Chemical Agents Field Testing Diversity Abundance		

**DD FORM 1473**

REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

**UNCLASSIFIED**  
Security Classification

EDGEWOOD ARSENAL TECHNICAL REPORT

EATR 4609

FISH POPULATIONS AROUND EDGEWOOD ARSENAL'S  
CHEMICAL AGENT TEST AREA

by

Harley J. Speir, SP4

Veterinary Medicine Division

March 1972

Approved for public release; distribution unlimited.

Task 1W662710AD6302

DEPARTMENT OF THE ARMY  
EDGEWOOD ARSENAL  
Biomedical Laboratory  
Edgewood Arsenal, Maryland 21010

## FOREWORD

The work described in this report was authorized under Task IW662710AD6302, Chemical Safety Investigations, Test Area Ecology. This work was started in May 1970 and completed in September 1971.

Reproduction of this document in whole or in part is prohibited except with permission of the Commanding Officer, Edgewood Arsenal, ATTN: SMUEA-1 S-R, Edgewood Arsenal, Maryland 21010; however, DDC and the National Technical Information Service are authorized to reproduce the document for United States Government purposes.

## DIGEST

Seining was conducted around Carroll Island, Maryland as part of an ecological research program initiated by the Director of Research Laboratories in August 1969. Carroll Island is Edgewood Arsenal's major outdoor facility for the field testing of riot control agents, simulants, and signaling and screening smokes. Fish were seined periodically from waters directly downwind from most test areas and from waters that probably received most of the rainwater drainage from the testing sites.

During the 8-month investigation, nearly 28,000 fish, representing 24 species, were collected. Bay anchovies, white perch, and silversides accounted for 90% of the total catch. White perch and silversides were present throughout the period, but anchovies were abundant only in September and October.

Diversity indices computed for the Carroll Island populations compare favorably with those reported from a southern estuary. Results of this study were similar to those of another seining investigation conducted on the Susquehanna Flats by Maryland fisheries biologists.

Throughout this study, young-of-year white perch from one Carroll Island area were significantly smaller than white perch from three nearby locations. However, the growth rates of Hawthorne Cove perch were similar to those of fish in the other locations. This probably means that Hawthorne Cove fish were spawned later.

No effects that could be attributed to the testing of chemical agents were found.

## CONTENTS

	Page
I. INTRODUCTION . . . . .	7
II. STUDY AREA . . . . .	7
III. MATERIALS AND METHODS . . . . .	9
IV. RESULTS AND DISCUSSION . . . . .	9
A. Fish Abundance . . . . .	9
B. Fish Diversity . . . . .	13
C. Comparison with Another Chesapeake Bay Seining Study . . . . .	15
D. Growth Rates of Young-of-Year White Perch . . . . .	17
V. CONCLUSIONS . . . . .	19
LITERATURE CITED . . . . .	21
DISTRIBUTION LIST . . . . .	23

## LIST OF FIGURES

### Figures

1 Map of the Carroll Island Test Area Showing the Two Seining Sites . . . . .	8
2 Seasonal Abundance of the Three Most Common Fish Seined during the Study . . . . .	11
3 Water Temperature and Salinity Data from the Estuary Surrounding Carroll Island . . . . .	12
4 Fluctuations in Abundance of Fish on Different Sampling Dates . . . . .	14
5 Average Monthly Diversity Indices for Both Carroll Island Seining Sites . . . . .	16
6 Growth Curves for Young-of-Year White Perch Seined at Four Locations . . . . .	18

## LIST OF TABLES

### Table

I Relative Abundance of Fish in Seined Samples from Carroll Island, Maryland . . . . .	10
II Comparison of Seining Success at Carroll Island (100-foot seine) Versus That of Susquehanna Flats (300-foot seine) . . . . .	17

**Preceding page blank**

## FISH POPULATIONS AROUND EDGEWOOD ARSENAL'S CHEMICAL AGENT TEST AREA

### I. INTRODUCTION.

Carroll Island is located on the western shore of the Upper Chesapeake Bay in Baltimore County, Maryland. For more than 20 years this 855-acre tract has been Edgewood Arsenal's primary outdoor facility for the field testing of chemical agents.

In August 1969, the Director of Research Laboratories initiated a comprehensive ecological research program. This investigation was part of that program.

Field testing of lethal chemical agents was discontinued in July 1969 and has not been resumed; testing of incapacitating agents was discontinued in March 1971. Irritants, simulants, incendiaries, and screening and signaling smokes continue to be disseminated. Tests are conducted on the eastern half of the island only under meteorological conditions, insuring that the western half is never contaminated. A detailed background for these studies and an ecological appraisal of the test area have been published by Ward.<sup>1</sup>

In this investigation a beach seining technique was used to measure the abundance and diversity of fish in two critical locations around Carroll Island: an area directly downwind from most tests, and an area that probably receives most of the rainwater drainage from the test area. Growth rates of young white perch from several areas were also measured.

### II. STUDY AREA.

Tests of chemical agents at Carroll Island are conducted at four locations (figure 1): Agent Test Grid 1, Agent Test Grid 2, the Wind Tunnel, and the Aerial Spray Grid. Testing restrictions are such that most agent clouds move to the east or the southeast. The first seining location, Carroll Point, was selected because it is directly downwind from most test areas.

Rainwater drains from Grid 1 and from the Spray Grid through a culvert into Hawthorne Cove. Most of the drainage from the Grid 2 area also seeps into this cove, therefore, it was selected as the second seining site.

Physically, the two Carroll Island sites are quite different. Hawthorne Cove is sheltered and has a sandy beach that slopes relatively steeply to a muddy bottom. Eurasian milfoil (*Myriophyllum spicatum*) grows abundantly in the sediment during the summer and the early fall. Because of depth, bottom composition, and vegetation and debris in Hawthorne Cove, the seine could not be hauled as far from shore as it could at Carroll Point. There the beach and the bottom are firm and sandy, gently sloping, and nearly devoid of rooted aquatic vegetation. This site is exposed to more severe actions of waves and wind than in Hawthorne Cove.

Two sites across the Gunpowder River from Carroll Island were chosen as sources of young-of-year (YOY) white perch for estimates of growth rates. The Maxwell Point site (2.7 miles NNE of Grid 1) is similar to Carroll Point in exposure to wind and wave action, bottom composition and slope, and aquatic vegetation. The Picnic Area (3.5 miles NE of Grid 1) is similar to Hawthorne Cove except that the Picnic Area is less protected from wind and wave action and has greater amounts of rooted aquatic vegetation.

<sup>1</sup> Ward, F. P. EASP 100-101. A Summary of Ecological Investigations at Edgewood Arsenal, Maryland: Fiscal Year 1970. June 1971. UNCLASSIFIED Report.

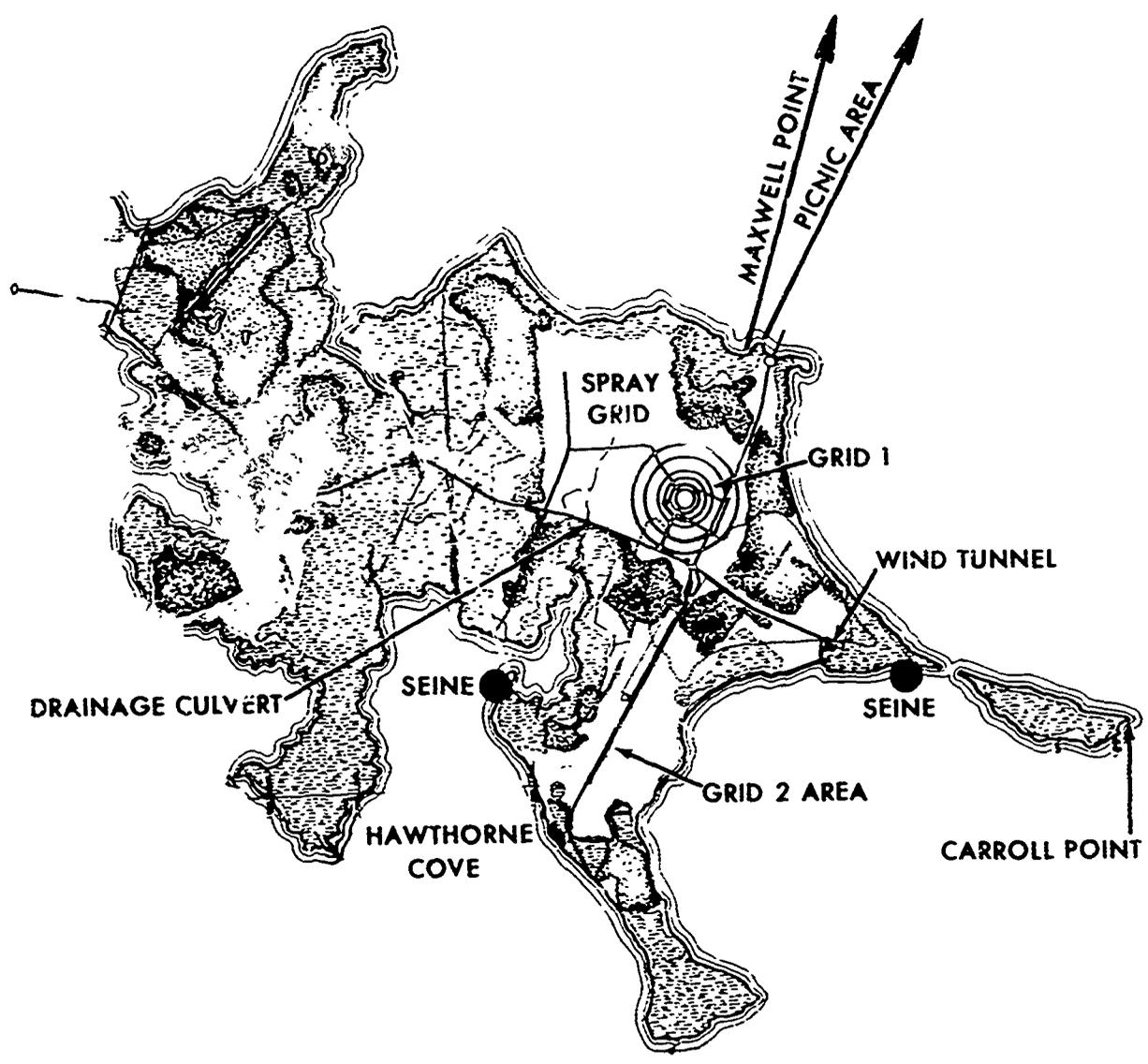


Figure 1. Map of the Carroll Island Test Area Showing the Two Seining Sites (Clear areas are mowed fields, stippled areas are woodlots, and horizontally dashed areas represent tidal marsh.)

### III. MATERIALS AND METHODS.

The seine, made of quarter-inch nylon mesh, was 100 feet long and 4 feet deep. Lead weights were attached at intervals to the bottom line, and cork floats were attached to the top. The seine was pulled into the water, by hand, perpendicular to the shore. When stretched to its full length or as far as possible, the seine was pulled in an arc (with the direction of the tide) back to the beach with the end on shore as a pivot. The distance from shore that the seine was pulled was not the same on all sampling dates. High waves or dense vegetation often resulted in short pulls; exceptionally low tides, which exposed shallow areas, resulted in sampling the areas farther from the beach. The surface area of water swept by the seine on each haul was estimated so that number of fish per square foot could be calculated.

Samples were collected intermittently at Carroll Island from May 1970 to January 1971, usually from two seine hauls at each site. All fish were counted, measured, and identified by species, except that data on killifish and silversides were lumped in these two categories.

The YOY white perch were collected intermittently and measured at the Gunpowder Neck and the Carroll Island sites.

Water temperature, wind direction and speed, tide, depth of water, visibility, vegetation, and organisms other than fish found in the seine were recorded on each sampling date at each site. Water samples were collected for laboratory salinity measurements.

Species were identified according to Eddy.<sup>2</sup>

### IV. RESULTS AND DISCUSSION.

#### A. Fish Abundance.

During the 8-month study, a total of 27,868 fish were collected at Carroll Island in 65 seine hauls on 21 sampling dates: 18,234 at Hawthorne Cove in 31 hauls, and 9,634 at Carroll Point in 34 hauls. The difference is probably a reflection of the disparate habitats. The refuge offered by the abundant vegetation in Hawthorne Cove, the higher productivity of the mud bottom, and the sheltered location might have attracted more fish to the area.

The relative abundance of species in these totals is shown in table 1. Bay anchovies, silversides (combined species), and white perch accounted for about 90% of the total fish seined at both locations. Anchovies were the most abundant fish in Hawthorne Cove, and silversides were the most abundant at Carroll Point.

The monthly abundance of anchovies, silversides, and white perch is plotted in figure 2. Significant numbers of anchovies began to appear in catches from Hawthorne Cove in late July, but the earliest they were caught at Carroll Point was mid-September. Anchovies disappeared from both areas in late October. Catches of silversides and white perch were similar at both locations.

The great influx of anchovies in late summer and autumn coincides with the peak of salinity in the area (figure 3). Minor fluctuations in water temperature (figure 3) during the

<sup>2</sup> Eddy, S. How to Know the Freshwater Fishes. p 253. William C. Brown Co., Dubuque, Iowa. 1957.

Table I. Relative Abundance of Fish in Seined Samples  
from Carroll Island, Maryland <sup>a/</sup>

Fish	Scientific Name	Hawthorne Cove	Carroll Point	Average
		% of Catch		
Bay anchovy	<u>Anchoa mitchilli</u>	40.70	22.99	31.84
Silversides <sup>b/</sup>	<u>Menedia</u> spp., <u>Membras</u> spp.	24.56	36.76	30.61
White perch	<u>Marone americana</u>	24.75	29.04	26.90
Alewife	<u>Alosa pseudoharengus</u>	0.99	5.21	3.10
Pumpkinseed	<u>Lepomis gibbosus</u>	2.74	0.80	1.77
Killifish <sup>c/</sup>	<u>Fundulus</u> spp.	2.99	0.55	1.42
Yellow perch	<u>Perca flavescens</u>	0.95	1.78	1.36
Striped bass	<u>Marone saxatilis</u>	0.40	1.32	0.86
Blueback herring	<u>Alosa aestivalis</u>	0.77	0.74	0.76
Spottail shiner	<u>Notropis hudsonius</u>	0.73	0.44	0.58
Unidentified shiners	<u>Notropis</u> spp.	0.45	0	0.22
Brown bullhead	<u>Ictalurus nebulosus</u>	0.33	0.01	0.17
Needlefish	<u>Strongylura marina</u>	0.04	0.24	0.14
Americal eel	<u>Anguilla rostrata</u>	0.07	0.07	0.07
Gizzard shad	<u>Dorosoma cepedianum</u>	0.07	0.01	0.04
Golden shiner	<u>Notemigonus crysoleucas</u>	0.08	0	0.04
Carp	<u>Cyprinus carpio</u>	0.03	0.02	0.02
Hog choker	<u>Tripterygion maculatus</u>	0.05	0	0.02
Johnny darter	<u>Etheostoma nigrum</u>	0.01	0.01	0.01
Northern pipefish	<u>Syngnathus fuscus</u>	0	0.02	0.01
Black crappie	<u>Pomoxis nigromaculatus</u>	0.01	0	0.01
Bluefish	<u>Pomatomus saltatrix</u>	0.01	0	0.01
Bluegill	<u>Lepomis macrochirus</u>	0.01	0	0.01
Carp sucker	<u>Carpiodes</u> spp.	0.01	0	0.01

<sup>a/</sup> In addition, the following species were collected using various gear in waters surrounding Edgewood Arsenal during this study: sea lamprey (Petromyzon marinus), hickory shad (Alosa mediocris), American shad (Alosa sapidissima), Atlantic menhaden (Brevoortia tyrannus), chain pickerel (Esox niger), creek chubsucker (Emysson oblongus), white catfish (Ictalurus catus), channel catfish (Ictalurus punctatus), largemouth bass (Micropterus salmoides), and spot (Leiostomus xanthurus).

<sup>b/</sup> Three species of silversides were collected and identified from Carroll Island seined samples: Atlantic silversides (Menidia menidia), tidewater silversides (Menidia beryllina), and rough silversides (Membras martinica).

<sup>c/</sup> Three species of killifish were collected and identified from Carroll Island seined samples: banded killifish (Fundulus diaphanus), striped killifish (Fundulus majalis), and mummichog (Fundulus heteroclitus).

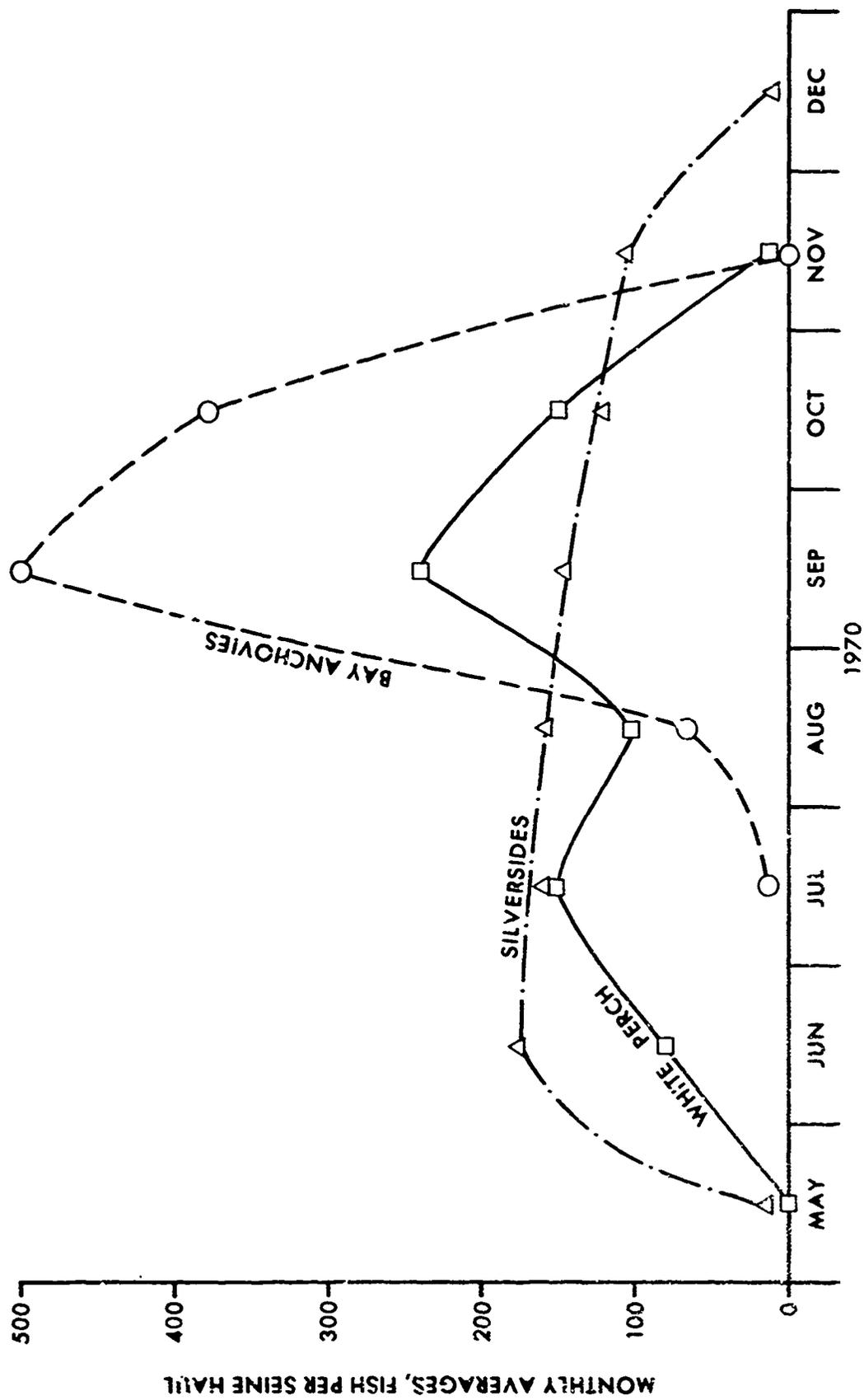


Figure 2. Seasonal Abundance of the Three Most Common Fish Seined during the Study

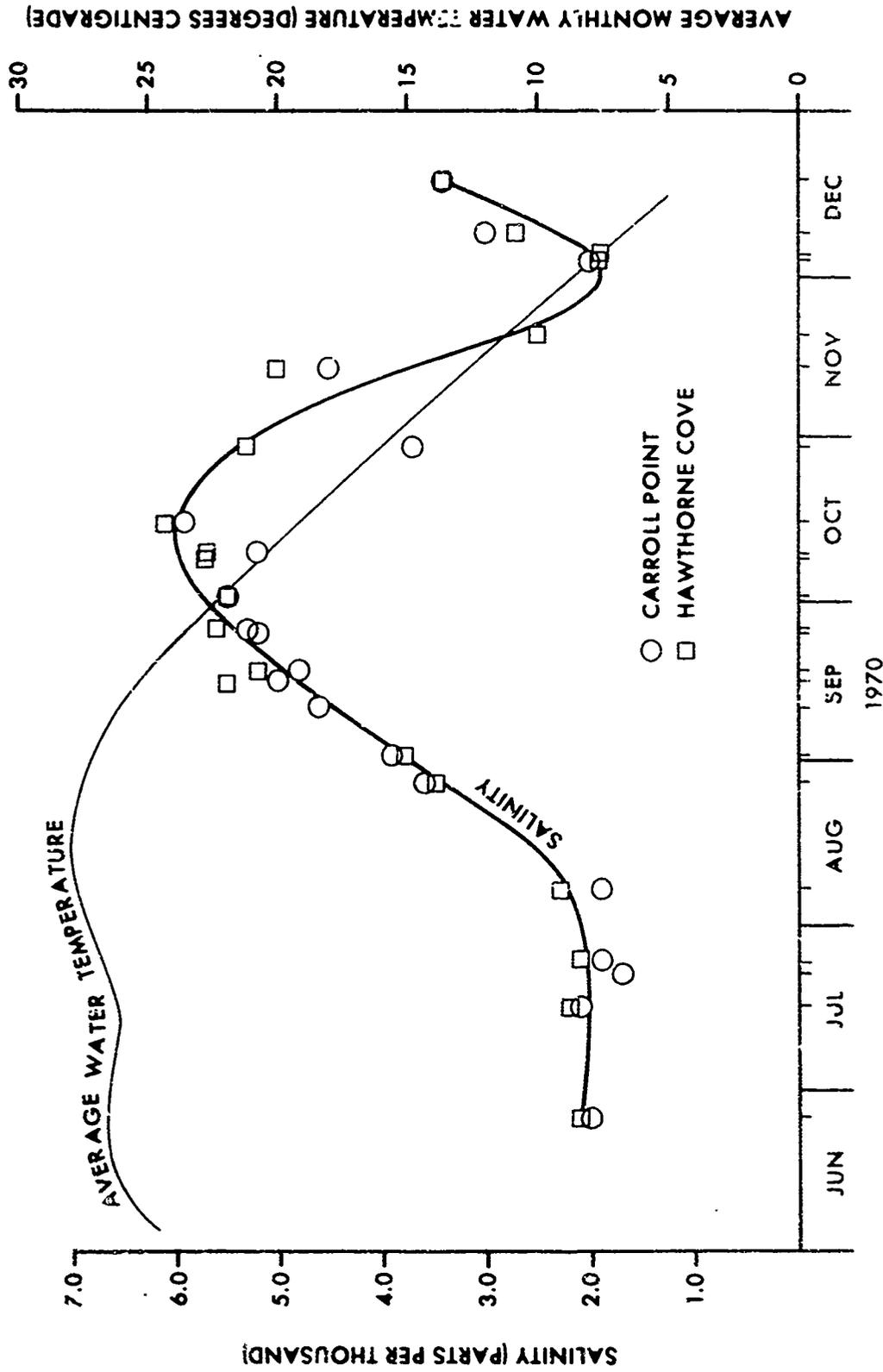


Figure 3. Water Temperature and Salinity Data from the Estuary Surrounding Carroll Island

summer months seem to have little effect on fish abundance. However, water temperature appears to be a major limiting factor later in the season. For example, on 15 October the water temperature in Hawthorne Cove was 21°C, and 3,134 fish were captured in one haul; on 29 October water temperature had dipped to 13.5°C, and only 187 fish were seined in two hauls. Water temperatures continued to decrease after this date and so did the number of fish caught.

The number of fish in individual hauls on the same day fluctuated widely. On days when both Hawthorne Cove and Carroll Point were seined, the correlation coefficient comparing fish per haul was 0.495. The correlation coefficient comparing fish per square foot was 0.260. There also appeared to be no correlation between catch and tidal conditions or other physical factors.

The total numbers of fish caught on various sampling dates were extremely variable (figure 4). The three species that accounted for 90% of the total catch (anchovies, silversides, and white perch) were schooling fish, and the chance presence or absence of schools was presumed to have caused the fluctuations. A comparison of the numbers of these fish captured at the same site on the same date often disclosed large differences between hauls. However, when numbers of these three species were excluded, the numbers of remaining fish showed the same degree of variability (figure 4).

A possible explanation for this variability is the uncertain efficacy of seining as a sampling technique. Factors including wind, wave height, strength and direction of tide, snags, vegetation, and type and slope of bottom can increase or decrease the catch on a given haul. Also, fish are never uniformly distributed; therefore, samples must be large to give accurate results.

However, inspection of the data in figure 4 suggests that fish abundance (both lines) was cyclic. Peaks of both lines generally coincide and cycle monthly (except August).

The assumption that fluctuations of natural populations are cyclic is complicated by the fact that a series of random numbers cycles. Therefore, proof of a cyclic phenomenon depends on demonstrating that the variability in the occurrence of peaks is less than that expected by chance. The data generated in this study are too few to permit a satisfactory statistical evaluation. Cycles are also substantiated if reasonably accurate predictions can be made of the course of future populations.<sup>3</sup> The validity of a cycle can be further strengthened by demonstrating synchrony in comparable data from different locations.<sup>2</sup> The correlation coefficients between total fish caught per haul at both Carroll Island sites ( $r = 0.495$ ) and between fish per square foot of water surface ( $r = 0.260$ ) do not demonstrate synchrony in this study. Until more data are available, the fluctuations should be considered as random, not cyclic.

#### B. Fish Diversity.

Diversity indices of natural communities generally relate the number of species to the total number of individuals or measure the distribution of individuals among species. These indices usually provide better assessments of environmental health than does the use of indicator organisms or total counts of organisms. For example, stresses caused by many pollutants can severely reduce a diversity index even though total numbers of individuals or total productivity remains unchanged.

---

<sup>3</sup> Kendeigh, C. S. *Animal Ecology*. p 468. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1961.

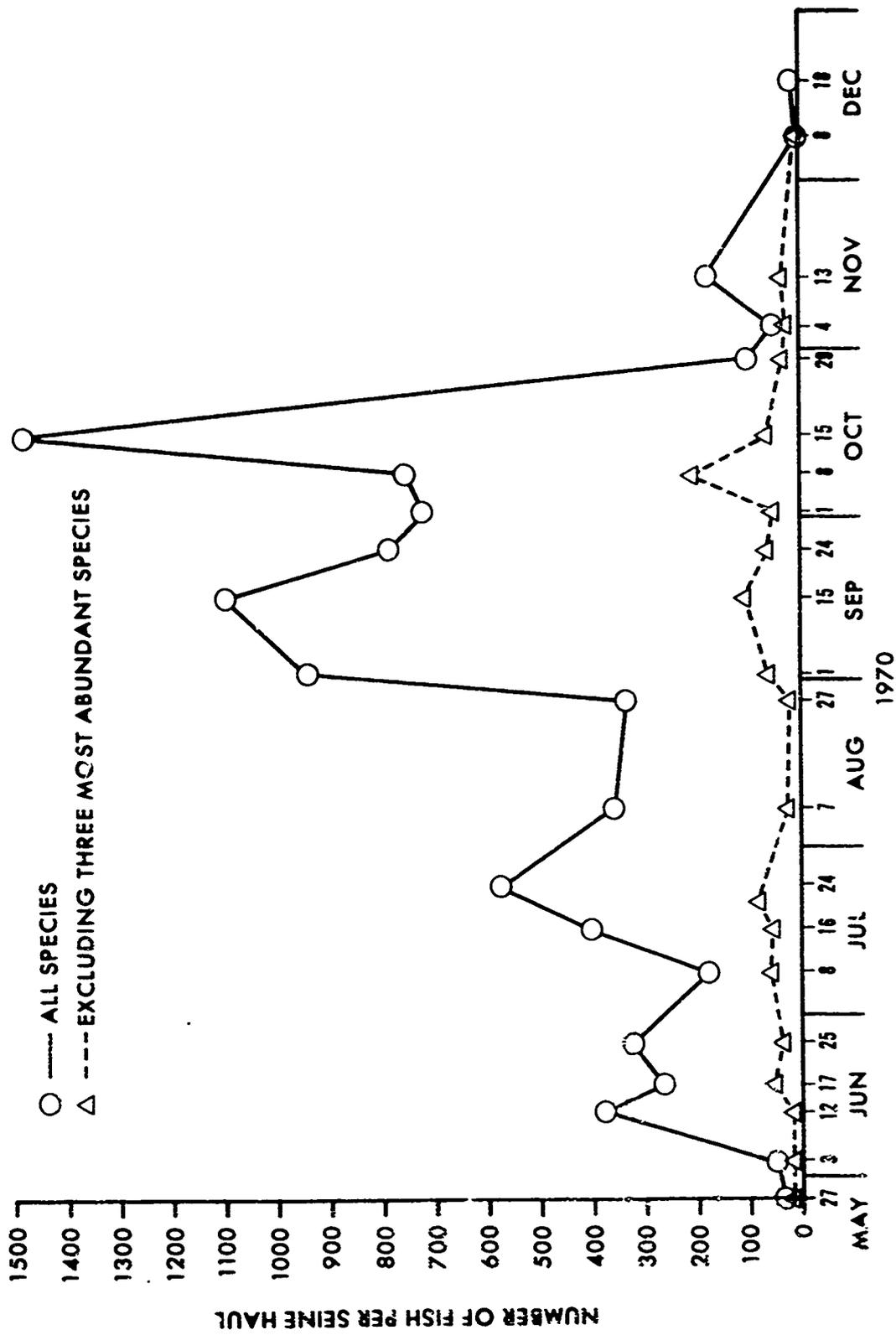


Figure 4. Fluctuations in Abundance of Fish on Different Sampling Dates  
 (Data combined for both sampling sites.)

The Shannon-Wiener index<sup>4</sup> and the species "richness" component of diversity<sup>5</sup> were calculated\* for fish collected on each sampling date at both Carroll Island sites. Monthly averages are shown in figure 5. The Shannon-Wiener index increases as the number of species in the sample increases, or as the distribution of individuals among species becomes more equal. The richness index relates number of species to total individuals, and increases as species increase or individuals decrease.

One of the few studies of estuarine fish populations to use diversity indices as potential indicators of environmental stress was reported by Dahlberg and Odum.<sup>6</sup> Using a trawl (deep water sampling method), they collected fish monthly from three areas in a Georgia estuary: small creeks, large rivers, and sounds. Shannon-Wiener indices for small creeks (most like the Carroll Island habitat sampled in this study) ranged from 1.2 to 1.8 (mean = 1.5) during their 14-month study, with lowest values in November and February. Their richness varied from 1.6 to 2.2 (mean = 1.8), with lowest values in October and November.

Comparisons of diversity indices between the two studies are difficult for many reasons, including the following: latitude, salinity, different sampling methods, as well as different fish species. Dahlberg and Odum searched a much larger area for each sample than we covered in the small sweep in shallow water near shore. However, diversity indices in both studies are similar. Only the November and December values for this study are notably divergent. This is probably because fish leave shallow water in these months seeking warmer, deeper water. The indices should be considered normal for the few fish present during that time of year.

#### C. Comparison with Another Chesapeake Bay Seining Study.

The seining data from this investigation were compared with those from a similar study on the Susquehanna Flats (near Havre de Grace, Maryland) conducted by Maryland fisheries biologists.\*\* Similar habitats were sampled in both studies, but the seine used on the Flats was longer (300 feet versus 100 feet). Their results were based on 56 hauls taken between 11 June and 23 October 1969. Table II is a comparison of total and average monthly catches from the two areas. The average catch at Susquehanna Flats was higher only in July.

Species lists compiled at both locations were similar, with the following fish seined only at Susquehanna Flats: goldfish (Carassius auratus), American Shad (Alosa sapidissima), and largemouth bass (Micropterus salmoides). Anchovies and silversides were uncommon at the Flats, composing only 2% and 1%, respectively, of the total catch. Fluctuations among numbers of fish in hauls on the same date at the same site, and fluctuations in numbers caught during the course of their study were similar to the variability in Carroll Island data.

\*Natural logs ( $\log_e$ ) were used in both formulas.

\*\*W. R. Carter. Personal communication.

<sup>4</sup> Margalef, R. La Teoria de la Informacion en Ecologia. Mem. Real Acad. Ciencias y Artes de Barcelona, 32, 373-449 (1957).

<sup>5</sup> Margalef, R. Perspectives in Ecological Theory. p 111. The University of Chicago Press, Chicago, Illinois. 1969.

<sup>6</sup> Dahlberg, M. D., and Odum, E. P. Annual Cycles of Species Occurrence, Abundance, and Diversity in Georgia Estuarine Fish Populations. Amer. Midland Naturalist 83, 382-392 (1970).

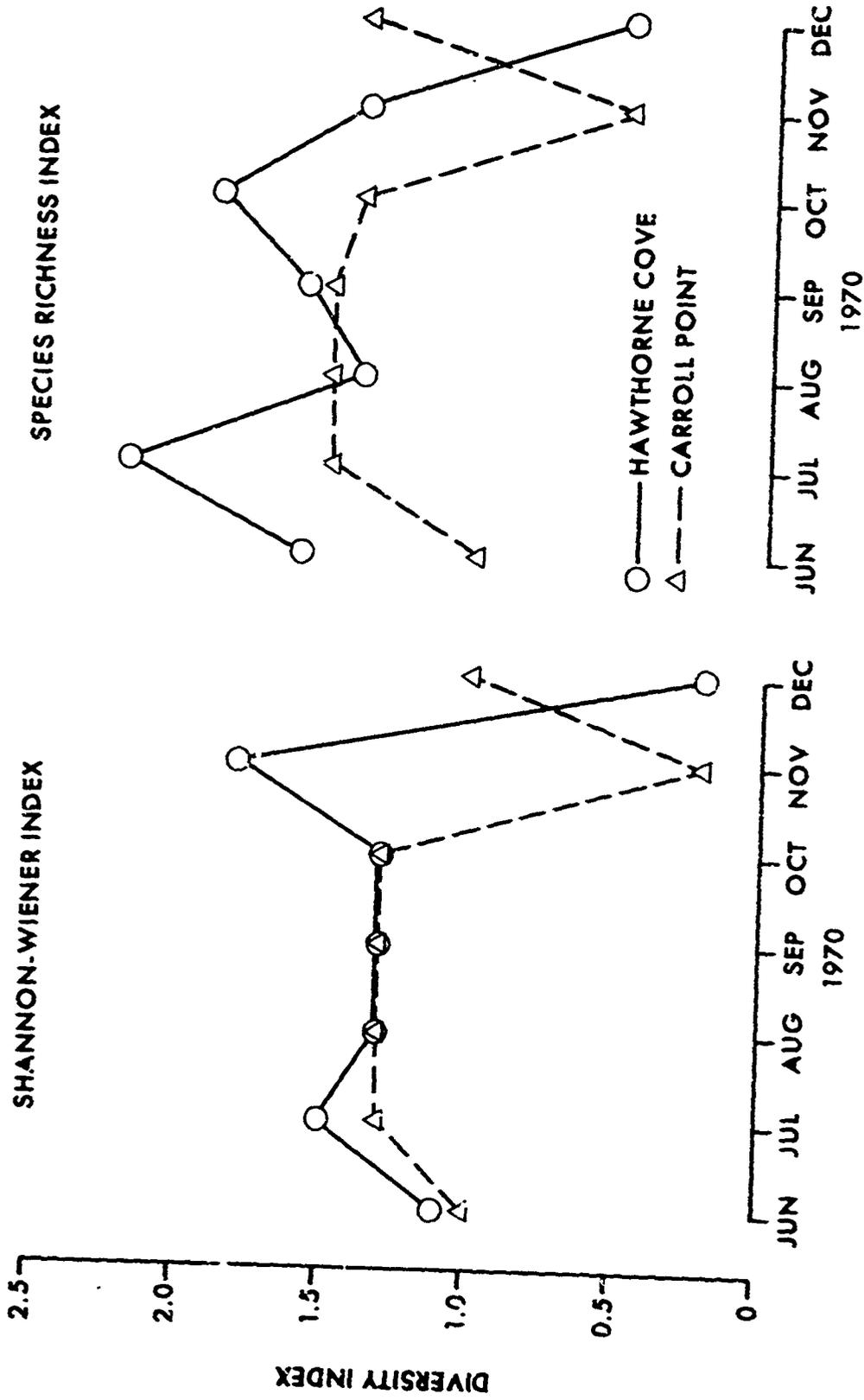


Figure 5. Average Monthly Diversity Indices for Both Carroll Island Seining Sites

Table II. Comparison of Seining Success at Carroll Island (100-foot seine)  
Versus That of Susquehanna Flats (300-foot seine).

Month	Carroll Island (1970)			Susquehanna Flats (1969)		
	Total Fish	No. of Hauls	Average Per Haul	Total Fish	No. of Hauls	Average Per Haul
June	2887	10	289	828	6	138
July	4534	12	378	7324	14	524
August	2420	7	346	4634	19	244
September	8613	9	957	1195	9	133
October	8451	12	704	1151	8	144

D. Growth Rates of Young-of-Year White Perch.

Samples of YOY white perch were collected and measured in seine hauls from Hawthorne Cove (June to November, 302 fish), and from Carroll Point (June to October, 232 fish). For comparative purposes, perch YOY were also collected from Maxwell Point (August to October, 229 fish), and from the Picnic Area (September to November, 71 fish). Fish growth in these four areas is shown in figure 6.

White perch YOY from Hawthorne Cove were consistently shorter than those from the other areas. Also, Carroll Island fish, as a group, were always shorter than YOY from the other two sites. By calculating t values for YOY lengths on comparable dates, Hawthorne Cove fish were significantly shorter ( $p < 0.001$ ) in September and October than YOY perch from the other sites.

Comparing data from the same time of the month for August, September, and October, YOY from the Picnic Area were significantly longer ( $p < 0.01$ ) than Carroll Island fish. Picnic Area fish were also significantly longer ( $p < 0.01$ ) than Maxwell Point fish in September and October. Differences between Carroll Point and Maxwell Point fish were not significant.

Although Hawthorne Cove YOY white perch were consistently smaller than fish at the other locations, their rate of growth was parallel to the growth rates of the other fish. This probably means that the Hawthorne Cove population was spawned slightly later in the season. This explanation, if correct, means that the movement of YOY white perch is restricted, and that no significant exchange of young fish occurred among the sampling areas.

However, Mansueti<sup>7</sup> reported that the adult white perch population of the Patuxent River, Maryland estuary was homogeneous, and that high salinity (mean = 13.7 ppt) at the mouth of the river acted as a barrier to emigration. Salinity in those portions of the river inhabited by perch ranged from zero in the headwaters to about 12.9 near the mouth.

<sup>7</sup> Mansueti, R. J. Movements, Reproduction, and Mortality of the White Perch, *Roccus americanus*, in the Patuxent Estuary, Maryland. *Chesapeake Sci.* 2, 142-205 (1961).

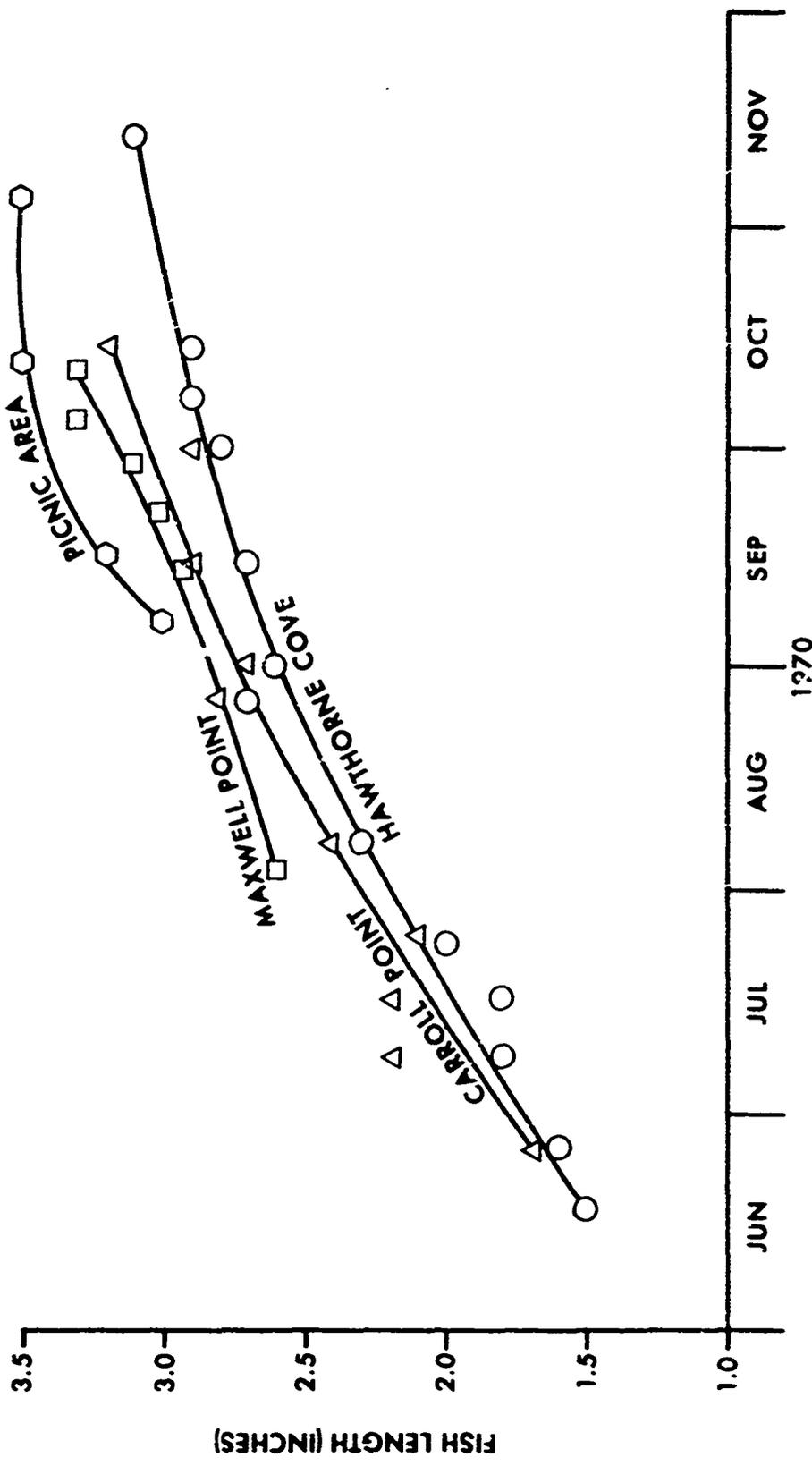


Figure 6. Growth Curves for Young-of-Year White Perch Seined at Four Locations

Salinity was probably not a barrier to Carroll Island and Gunpowder Neck fish because: (1) the highest salinity recorded during this investigation was 6.1 (in Hawthorne Cove in October); (2) there was no appreciable salinity gradient between any of the four sites (in contrast to the Patuxent River gradient of zero at the headwaters to 13.7 ppt at the mouth); (3) Carroll Island is located north of the Patuxent River on the upper Chesapeake in close proximity to the Susquehanna River, which provides 95% of the fresh water north of the Patapsco River.<sup>8</sup>

Mansueti also discovered that adult white perch tagged in the spring traveled a mean distance of 15.6 miles, and those tagged in the summer and fall, 7.9 miles. These distances are greater than those between Carroll Island and Gunpowder Neck sampling stations. However, it is likely that YOY white perch are more limited in movement and more restricted to shallow water than are adults. A mark and recapture study would resolve many of these uncertainties.

#### V. CONCLUSIONS.

The abundance, diversity, seasonal cycles, and growth rates of fish surrounding Carroll Island are characteristic of a normal estuarine community. No differences between that area and control areas that could be attributed to contamination with chemical agents or simulants were found.

---

<sup>8</sup> Beaven, G. F. Effect of Susquehanna River Stream Flow on Chesapeake Bay Salinities and History of Past Oyster Mortalities on Upper Bay Bars. Md. Dept. Rsch. Educ. Publ. 68, 1-11 (1947).

### LITERATURE CITED

1. Ward, F. P. EASP 100-101. A Summary of Ecological Investigation at Edgewood Arsenal, Maryland: Fiscal Year 1970. June 1971. UNCLASSIFIED Report.
2. Eddy, S. How to Know the Freshwater Fishes. p 253. William C. Brown Co., Dubuque, Iowa. 1957.
3. Kendeigh, C. S. Animal Ecology. p 468. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 1961.
4. Margalef, R. La Teoria de la Informacion en Ecologia. Mem. Real Acad. Ciencias y Artes de Barcelona, 32, 373-449 (1957).
5. Margalef, R. Perspectives in Ecological Theory. p 111. The University of Chicago Press, Chicago, Illinois. 1969.
6. Dahlberg, M. D., and Odum, E. P. Annual Cycles of Species Occurrence, Abundance, and Diversity in Georgia Estuarine Fish Populations. Amer. Midland Naturalist. 83, 382-392 (1970).
7. Mansueti, R. J. Movements, Reproductions, and Mortality of the White Perch, Roccus americanus, in the Patuxent Estuary, Maryland. Chesapeake Sci. 2, 142-205 (1961).
8. Beaven, G. F. Effect of Susquehanna River Stream Flow on Chesapeake Bay Salinities and History of Past Oyster Mortalities on Upper Bay Bars. Md. Dept Rsch. Educ. Publ. 68, 1-11 (1947).

Preceding page blank