AR-1150

MERRIMACK RIVER MONITORING PROGRAM

A Report for the Study Period 1972

Prepared for

Public Service Company of New Hampshire

by

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MANCHESTER, NEW HAMPSHIRE

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ABSTRACT

The 1972 Merrimack River Monitoring study was designed to determine the ecological effects resulting from discharge of heated effluent from the Merrimack River Generating Station at Bow, New Hampshire. Biological parameters monitored included plankton, periphyton, aquatic plants and insects, benthic invertebrates and fish. Physical and chemical parameters measured in conjunction with biological studies were temperature, flow, transparency, nutrients, dissolved oxygen, and pH. Results of the monitoring study showed reduced concentrations of planktonic yellow-brown and green algae at Station Zero-west (Generating Station discharge area) which were still evident at Station S-17, 1.1 miles downstream. Diatoms in the periphyton community showed similar responses at Station Zero-west, and at all stations sampled south of the discharge canal, although trends toward recovery were noted. An incidence of skin fungus was found among yellow perch populations south of the discharge canal, but it is not known if this can be attributed directly to plant operations. Age distributions and length-weight relationships of yellow perch, pumpkinseed sunfish and smallmouth bass were generally comparable among stations. Results of aquatic plant, insect, and benthic samplings indicated that both abundance and diversity were largely dependent on habitat suitability, and among station differences were not the direct result of the heated discharge.

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MERRIMACK RIVER MONITORING PROGRAM - 1972

I. INTRODUCTION

The third year of the Merrimack River Monitoring Program was initiated in April, 1972. This program was developed in fulfillment of a requirement contained in a water use permit issued to Public Service Company of New Hampshire by the New Hampshire Water Supply and Pollution Control Commission. The monitoring program was designed to detect both seasonal changes in the ecology of the Merrimack River and possible adverse effects caused by thermal discharges from the Merrimack Generating Station. Emphasis was placed on that section of the Merrimack River from Garvins Falls Dam in Concord to the Hooksett Dam in Hooksett, New Hampshire, a distance of 5.75 miles (Figure 1). This area of the river is generally referred to as Hooksett Pond. The Merrimack Generating Station is located near its center at river mile 84. Sampling stations were established on transects located north and south of the mouth of the discharge canal (Station Zero). These were numbered N-1 to N-10, and S-1 to S-18, respectively. The north stations, particularly N-10, were used to depict ambient river conditions as contrasted to the thermally affected zone south of the discharge. Station Zero-West was established at the mouth of the discharge canal and all samples taken at that location

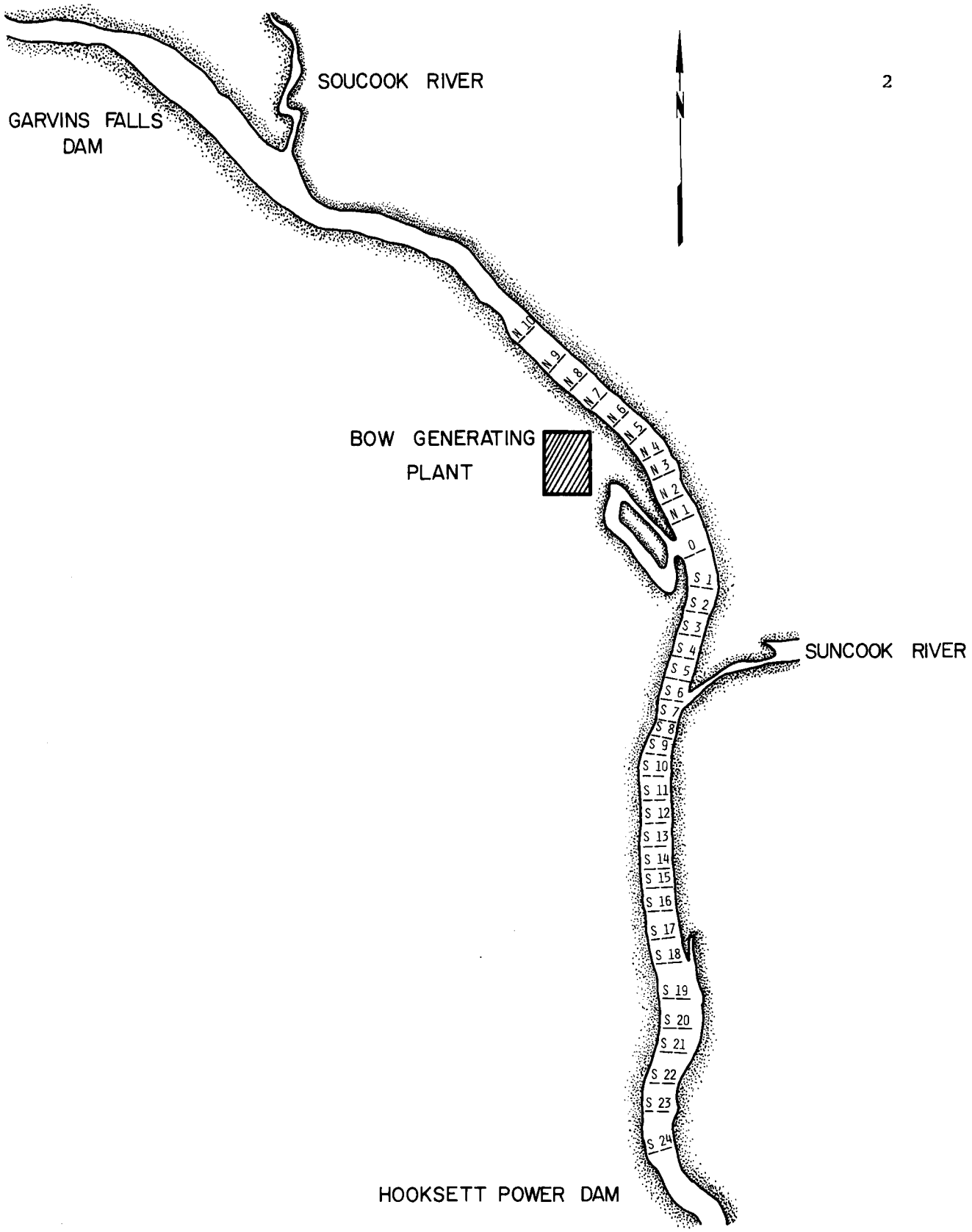

Figure 1. Location of sampling stations -- Merrimack River Monitoring Program, Hooksett Pond, New Hampshie.

were within the direct influence of the thermal discharge. The portion of the river studied is fairly uniform, with an average width of 500 to 700 feet. Much of the river is shallow, averaging less than ten feet in depth, although depths of over twenty feet are attained in some sections.

II. PHYSICAL STUDIES

A. METHODS

1. Flows

River flow measurements were obtained from gauging station data collected at Garvins Falls hydroelectric station by Public Service Company of New Hampshire personnel.

2. Depth of Visibility

Weekly Secchi Disc visibility measurements were taken at Stations N-10, Zero-West, S-4, and S-17. Results were recorded to the nearest one-half foot and represent the depth at which the disc disappeared from view.

3. Temperature

Three types of temperature studies were conducted during the 1972-73 project year: a) continuous monitoring of surface temperatures; b) weekly temperature profiles; and c) seasonal cross-sectional temperature profiles.

a) CONTINUOUS MONITORING: Surface temperature monitoring was conducted by personnel of the Public Service Company of New Hampshire at Stations N-10, Zero-West, and S-4. Instrumentation consisted of YSI thermivolt thermometers connected to Westinghouse (Hagen) signal converters and Sangamo digital pulse recorders. These units were checked weekly.

b) WEEKLY TEMPERATURE PROFILES: Weekly temperature profiles were taken with a YSI field thermistor system at one data point each at Stations N-10, Zero-West, S-4, and S-17. All temperatures, with the exception of those taken at Station Zero-West, were measured at mid-river. Periodic calibration of the field thermistor unit was accomplished with a precision grade mercury thermometer.

c) SEASONAL TEMPERATURE PROFILES: Thermal stratification occurring in the Merrimack River was measured in June, July, and September of 1972 with a Martek Model 101 temperature, depth, and conductivity meter. This instrument was checked periodically with a precision grade mercury thermometer. Temperatures were taken north and south of the generating station at five points across the river at one-foot depth intervals. During the profile studies, ambient temperature was monitored with a Rustrak Strip Recorder.

B. RESULTS AND DISCUSSION

1. Flows

Mean monthly flows ±1 standard deviation (±34% of the mean) are shown in Figure 2. Mean 24-hour flows for the year ranged from 661 cfs to 21,977 cfs. As expected, the spring months experienced the highest and most variable flows, while September exhibited the lowest and most consistent flows with 23.3% of the days having flows less than 1,000 cfs. Flows in 1972 were higher than in 1971. In 1971, low flows for the year occurred in July with 68% of the days having flows less than 1,000 cfs.

2. Depth of Visibility

Weekly depth of visibility measurements are presented in Table 1. With the exception of sampling data in April, May and June when construction activities in the discharge canal limited readings at Zero-West, measurements were comparable between stations. Low values recorded in April and May were indicative of the high flows and resultant turbidity experienced during maximum runoff. Readings ranged from a low of one foot in June to a high of ten feet[1] in October. In 1970 and 1971, shallower depth of visibility readings occurred during periods of low flows and high temperatures in July and August, probably as a result of increased phytoplankton numbers. In 1972 this was not the case, as the

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[1]Bottom reading

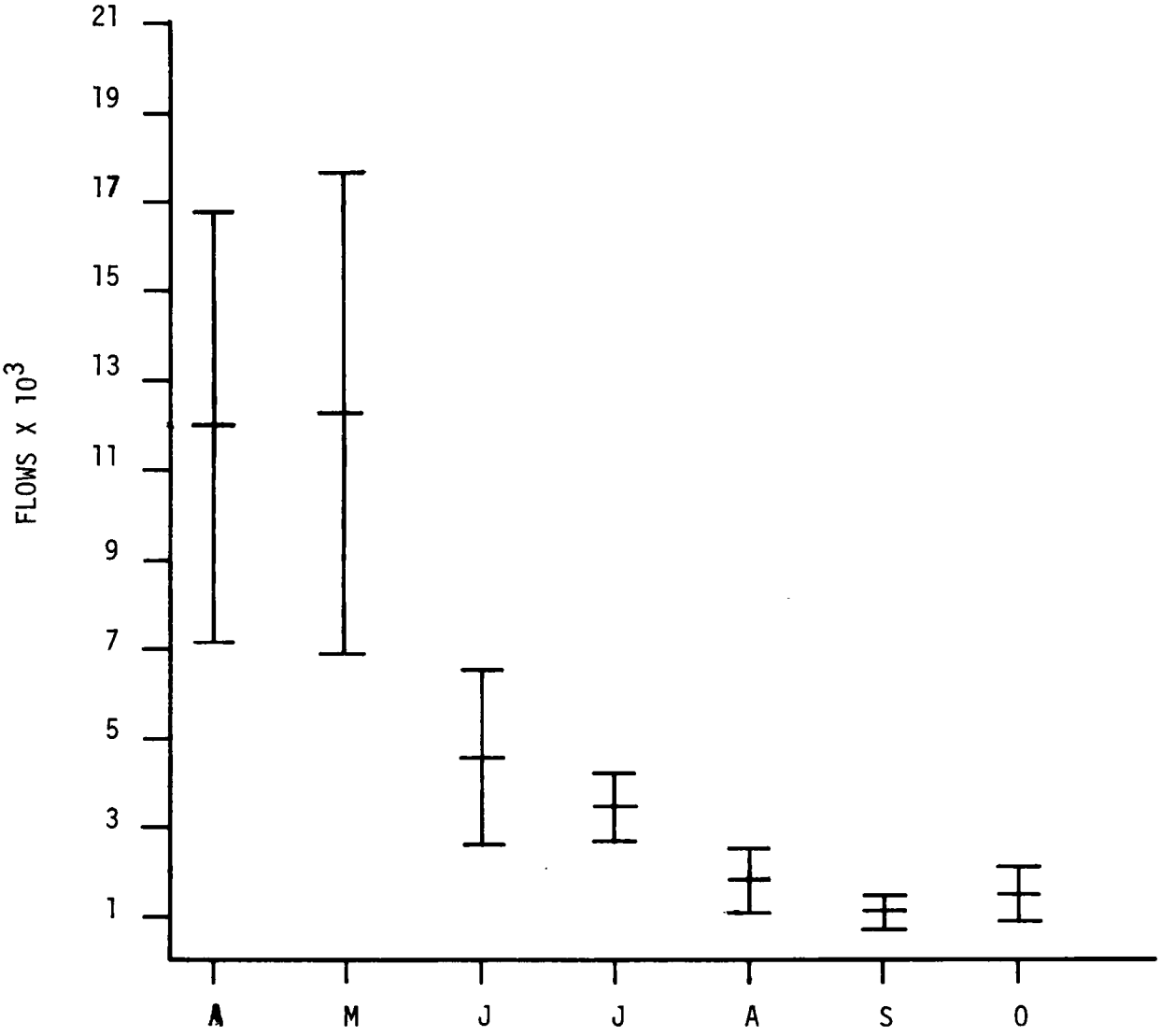


Figure 2. Mean monthly flows ±1 standard deviation -- Garvin's Falls, Merrimack River.

TABLE 1. DEPTH OF VISIBILITY MEASUREMENTS

MONTHLY VALUES

HOOKSETT POND, MERRIMACK RIVER

APRIL - OCTOBER, 1972

Sampling Dates 1972	Stations			
	N-10	Zero-West	S-4	S-17
April 11	7.0	3.0	7.0	7.0
18	3.5	3.5	3.5	3.5
28	4.5	3.5	4.5	4.5
May 5	2.5	2.5	2.5	2.5
11	4.0	2.0	3.5	4.0
17	3.0	3.5	3.5	3.5
22	4.5	5.0	5.0	6.0
30	6.5	4.0	7.0	5.5
Jun 6	4.5	4.5	4.5	4.5
13	6.0 (B)	1.0	5.5	6.0
19	6.0 (B)	5.5	6.5	6.5
26	6.5	4.5	5.5	6.0
Jul 5	5.0	4.0	5.5	5.5
10	6.0	5.0	5.5	5.0
17	4.5	4.5	4.5	5.0
24	5.0	4.5	5.0	5.0
31	5.5	5.0	6.0	5.5
Aug 7	7.0	5.5	6.5	6.0
15	5.5	7.0	8.0	7.0
21	6.0 (B)	5.0 (B)	8.0	6.0
31	7.5	7.0	7.0	6.5
Sept 5	5.5	5.5	5.5	5.5
14	6.0	6.0	6.0	6.0
19	7.0 (B)	6.0 (B)	9.0 (B)	5.0 (B)
27	8.0 (B)	6.0 (B)	8.0	7.0 (B)
Oct 2	6.0	4.0 (B)	9.5 (B)	6.0 (B)
11	8.0 (B)	7.0 (B)	10.0 (B)	8.0 (B)
19	6.5	6.0 (B)	6.5	6.0
26	6.5	6.5 (B)	8.0	6.5 (B)

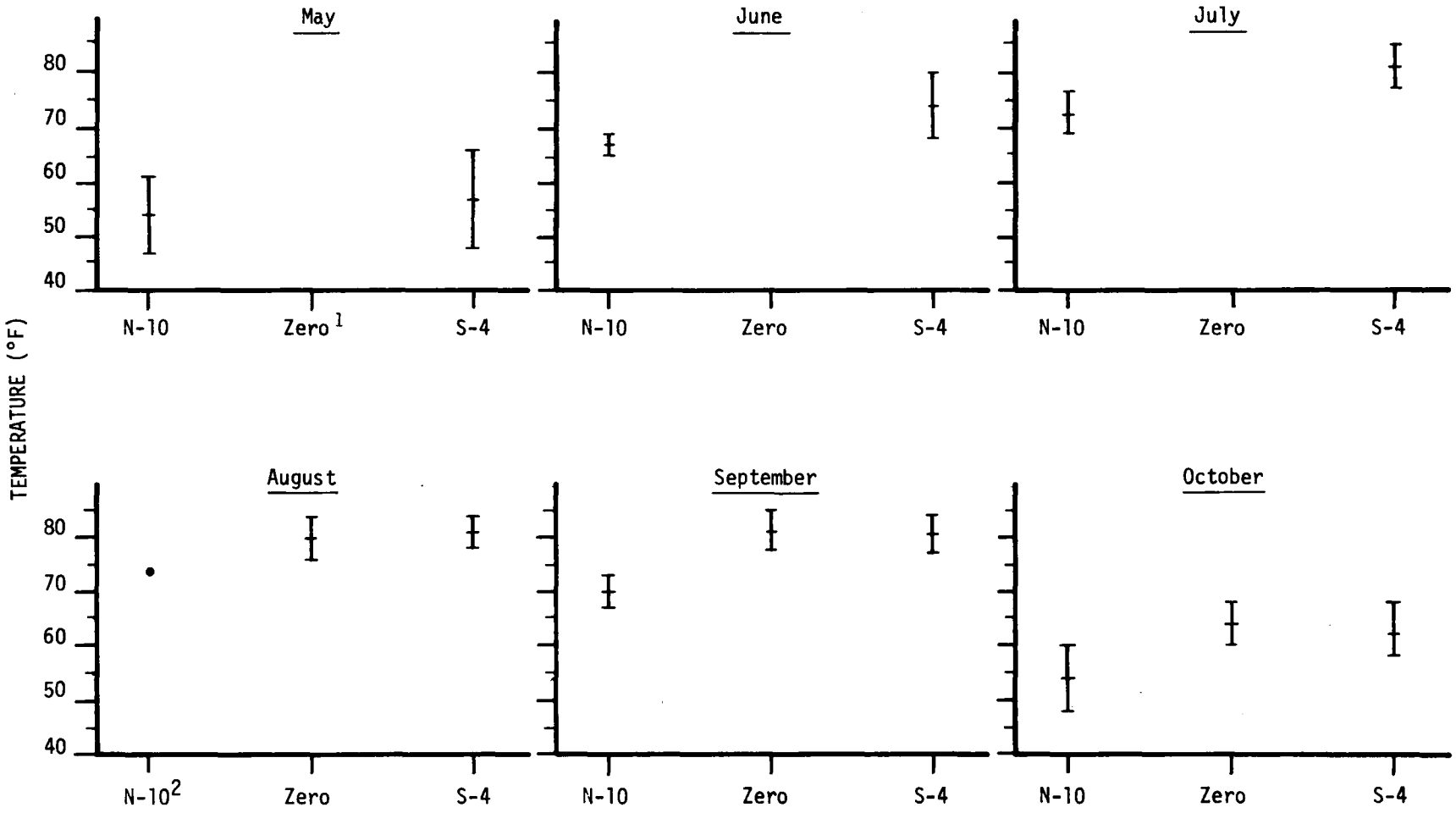
(B) = Bottom

months of low flows (August, September, and October) were characterized by greater depths of visibility. This was probably the result of higher flows and increased turbidity occurring into late spring and early summer, which masked normal declines in visibility resulting from increased productivity.

3. Temperature

a) CONTINUOUS TEMPERATURE MONITORING: Monthly means and standard deviations of daily temperature maxima are shown in Figure 3. Because of equipment malfunctions, no data were collected at Station Zero during May, June, and July, and only 19 days of data are available for Station N-10 in August. As in 1971, peak temperature conditions at Station N-10 occurred during July when monthly means of daily maxima reached 74.4° F. Monthly means of daily peak temperature Δt's between Stations N-10 and S-4 during July, August, and September ranged from 6.6° F in July to 10.9° F in September, the month of lowest flows. In general, temperatures were reduced over those of 1971, largely as a result of higher flows, coupled with the activation of the spray module cooling system in July of 1972.

b) WEEKLY TEMPERATURE PROFILES: During the study year, temperatures at Station N-10 ranged from 37.0° F in April to 77.5° F in July. A peak temperature of 86.5° F was recorded at



1 Due to equipment malfunctions no data was gathered for Station Zero from May - July.

2 •

Figure 3. Monthly means ±1 standard deviation of daily temperature maxima from May through October, 1972.

Station Zero-West during May. Monthly temperature ranges and mean surface-to-bottom Δt's by station, and mean monthly Δt's between stations are presented in Table 2. Temperature differences between stations decreased during July ($\bar{x}$ flows=3,535 cfs) from those noted during June ($\bar{x}$ flows=4,687 cfs). This was partly the result of activation of the spray module cooling system and shutting down of Unit I. With lower flows ($\bar{x}$ = 1,145 cfs) and the start-up of Unit I in September, temperature differences between stations increased to near June levels.

c) SEASONAL TEMPERATURE PROFILES:

June 24, 1972 -- Figure 4: Ambient river temperature as measured at Station N-10 was 65.5° F, and flows at this time averaged 2,778 cfs. The spray module cooling system was not yet in operation. Stations north of the discharge canal exhibited no thermal stratification. At Station Zero-West, a lens of warmer water existed near the discharge canal. This lens was approximately six feet deep with temperatures ranging from 66.4° F near the bottom to 82.6° F at the surface. Maximum stratification on a cross-sectional basis occurred from Stations S-1 through S-3, where surface temperatures ranged from 76° to 81° F. At sampling Stations S-4 through S-8 surface temperatures ranged from 70° - 78° F. A slight decrease in temperature was noted at Stations S-9 and S-10 with temperatures averaging between 69° - 76° F. Stations downstream of S-10 (S-14 through S-24) had temperatures ranging from a

TABLE 2. MONTHLY TEMPERATURE RANGES AND MEAN MONTHLY SURFACE-TO-BOTTOM Δt's AND BETWEEN STATION TEMPERATURE DIFFERENCES, MERRIMACK RIVER, 1972

STATIONS	Month						
	APR	MAY	JUN	JUL	AUG	SEPT	OCT
	Monthly Temperature Ranges (°F)						
N-10	37.0-43.0	43.0-65.0	61.0-70.0	69.0-77.5	66.0-73.0	64.0-69.0	47.0-58.8
O-W	38.0-57.0	52.0-86.5	63.0-85.5	70.0-85.0	67.0-86.0	66.0-81.0	48.7-67.9
S-4	37.1-46.0	43.0-73.5	62.5-78.5	70.0-82.0	68.0-81.5	64.0-79.5	48.9-62.1
S-17	38.0-44.0	44.0-70.0	63.0-71.5	69.0-79.0	66.0-74.0	66.0-74.5	50.9-61.0
	Mean Surface-to-Bottom Δt's						
N-10	0.0	0.4	0.5	0.4	1.4	0.2	-0.2
O-W	2.0	11.8	12.1	6.8	9.1	11.8	7.6
S-4	1.0	2.4	6.8	3.6	4.4	9.6	4.8
S-17	0.3	0.5	0.3	0.7	1.8	4.8	0.1
	Mean Δt's Between Stations						
N-10	---	---	---	---	---	---	---
O-W	7.4[1]- 8.3[2]	9.7-16.0	8.9-15.0	4.0- 7.3	3.5- 8.5	7.1-13.0	4.6- 9.3
S-4	1.7- 1.7	2.7- 4.8	2.4- 7.8	1.6- 3.9	2.0- 4.1	4.5- 9.9	2.7- 5.9
S-17	1.0- 1.0	1.2- 1.8	1.8- 1.7	1.0- 1.4	1.5- 2.3	4.3- 6.6	3.1- 3.1

[1]Δt computed from the mean temperatures of the entire profile of each station.

[2]Δt computed from the peak temperatures encountered at all stations throughout the month.

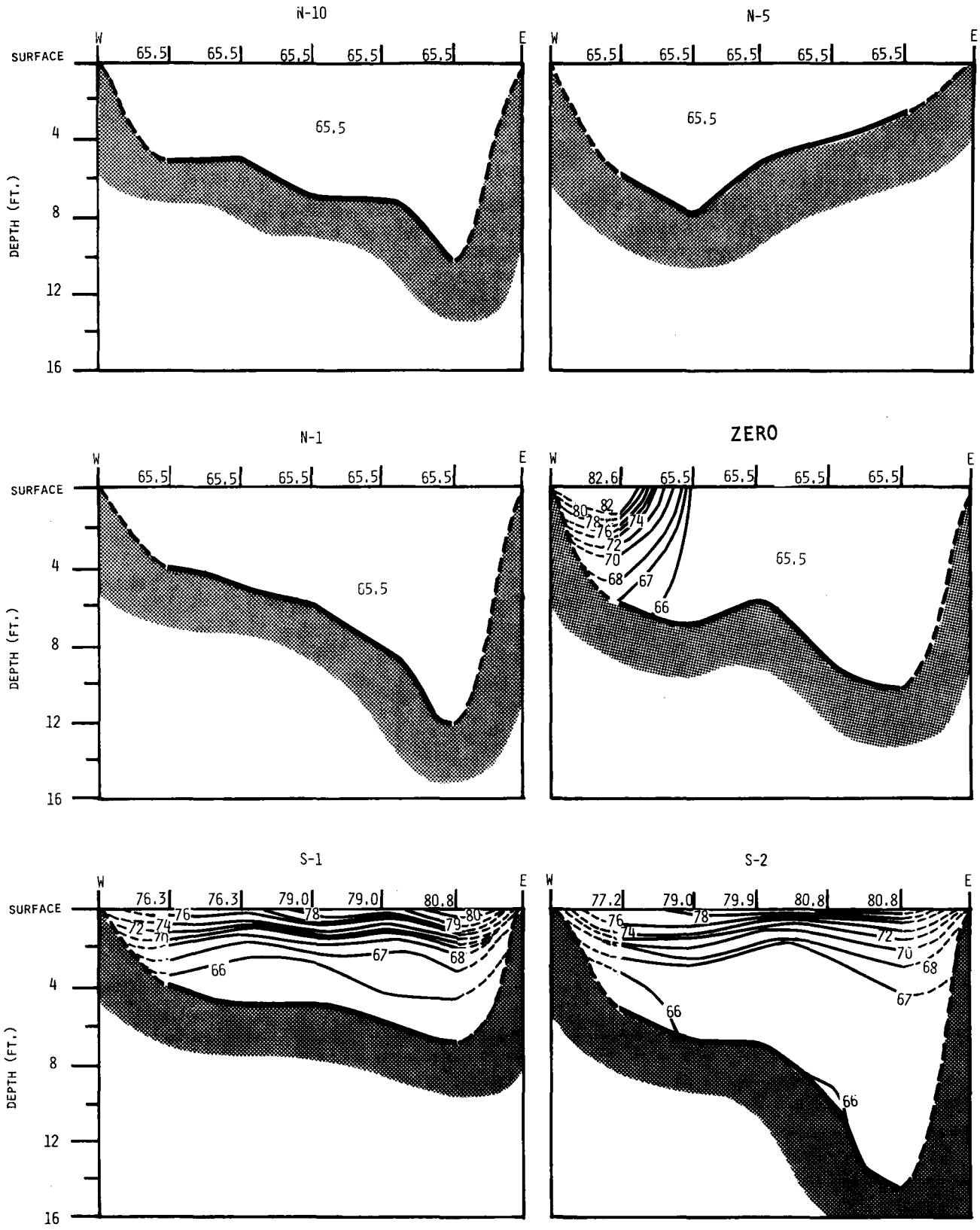
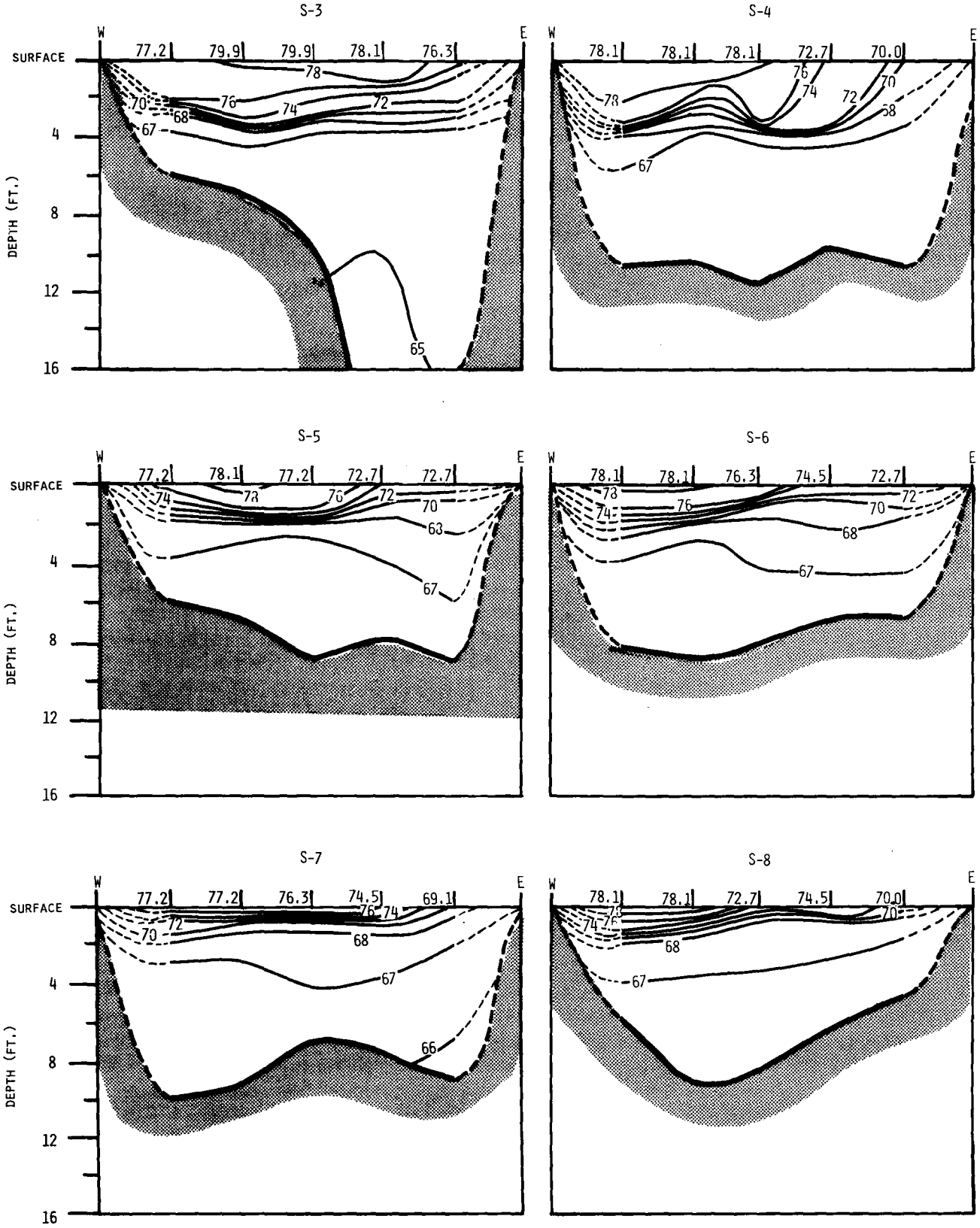


Figure 4. Isothermal cross-sections of Merrimack River sampling stations - June 24, 1972.



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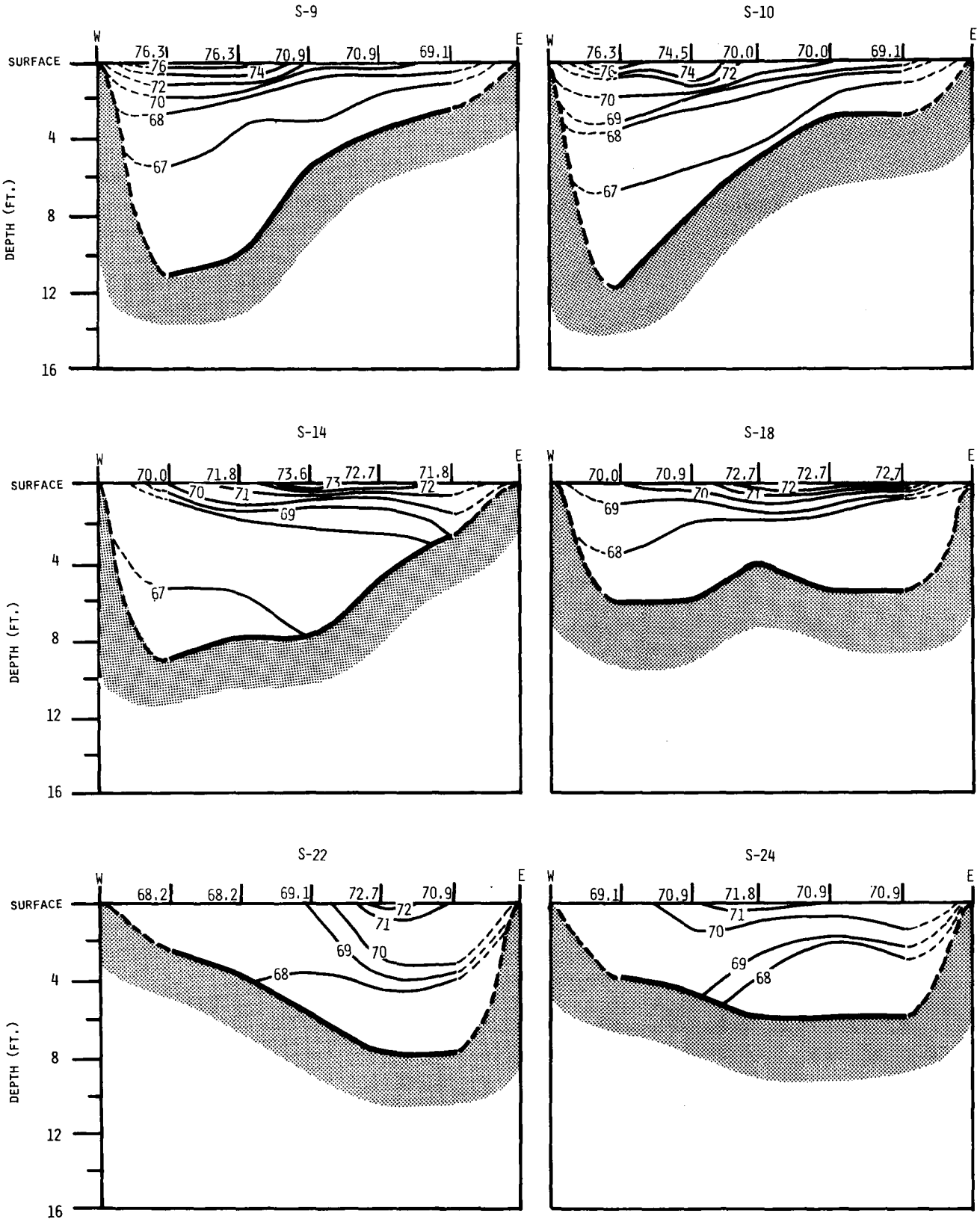


Figure 4. (continued).

a minimum of 68.2° F to a high of 73.6° F. There was no return to ambient conditions at downstream stations.

July 7, 1972 -- Figure 5: Ambient water temperatures at N-10 were 69.1° F and the current velocity was 3,125 cfs. As on the previous date, before the spray module system went on-line, stations north of the discharge canal exhibited no thermal stratification. At Station Zero-West a lens of warmer water, approximately four feet in depth with temperatures ranging from 71° F near the bottom, to 79° F at the surface, was observed. The lens had not completely diffused across the river at S-1. From Stations S-2 through S-6 the layer of water with 70° F temperatures and higher remain basically within the top four feet of the water column. At all stations downstream of Station S-7 waters were fairly well mixed throughout the entire water column at temperatures of 70° F and above. From Station S-18 downstream almost no thermal stratification existed. There was no return to ambient conditions at the downstream stations.

September 26, 1972 -- Figure 6: Ambient river temperatures during this survey ranged from 62.5° F to 63.5° F. Flows averaged 1,126 cfs. No thermal stratification was evident at Stations N-10 and N-5. Thermal layering was noted at Station N-1

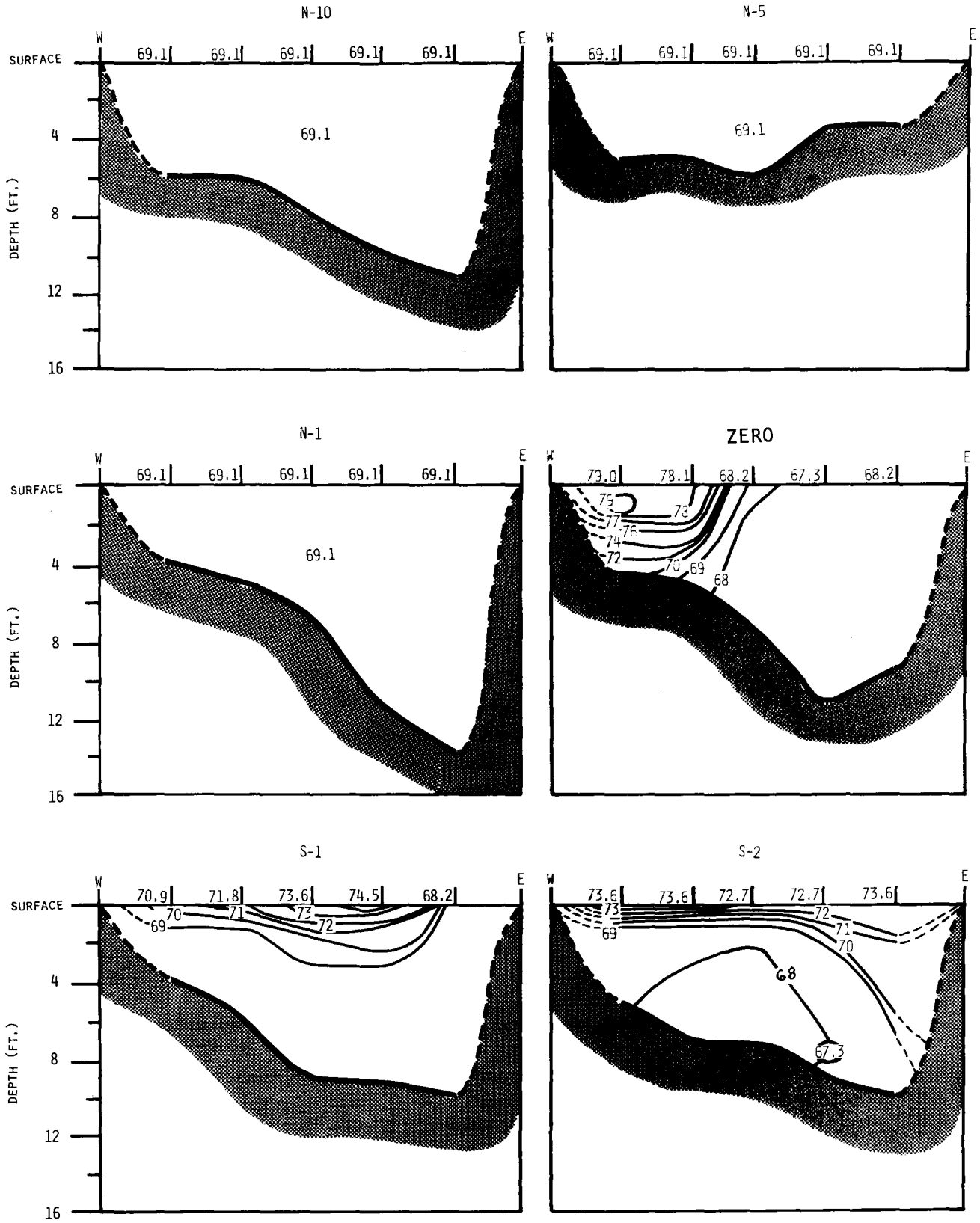


Figure 5. Isothermal cross-sections of Merrimack River sampling stations - July 7, 1972.

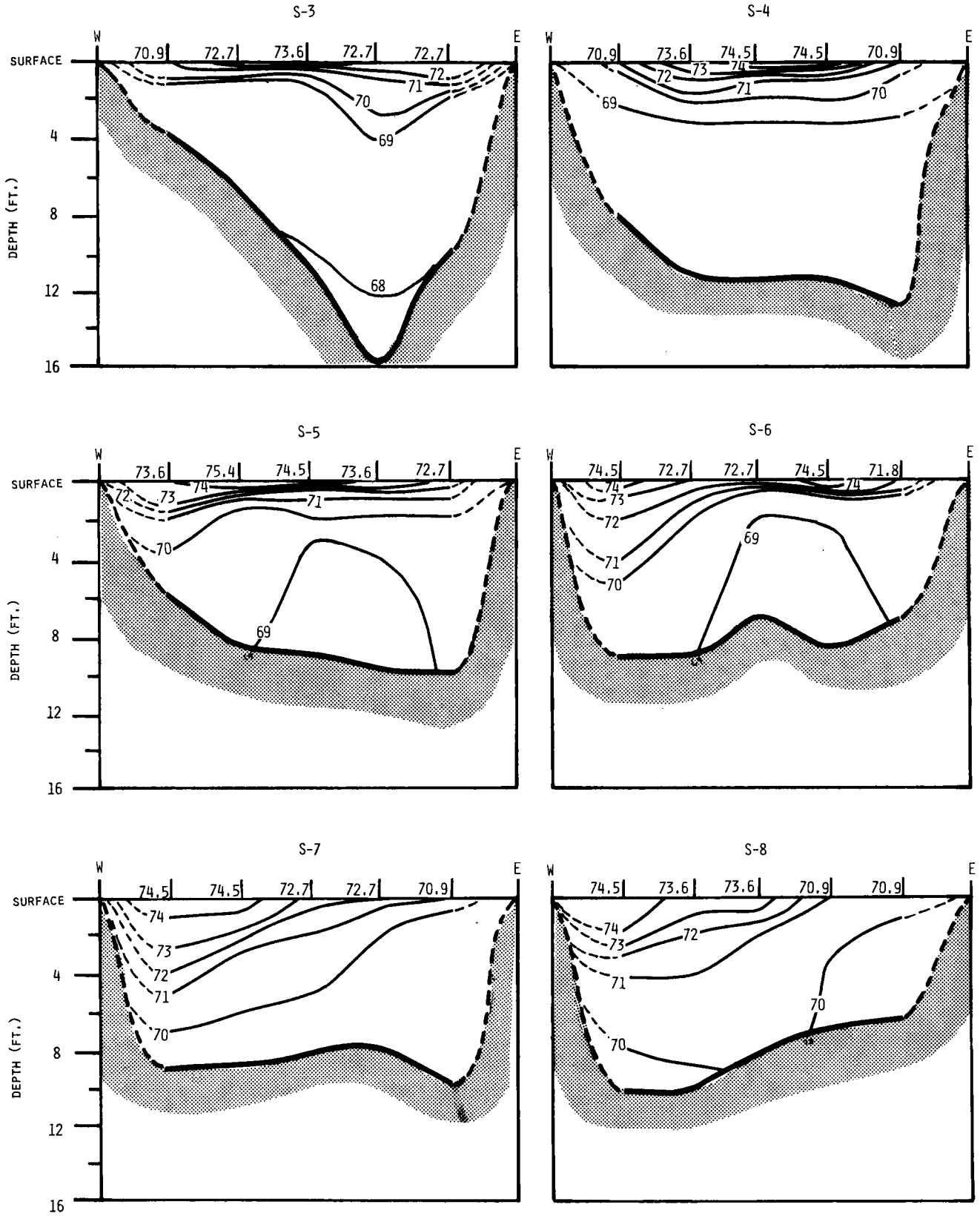
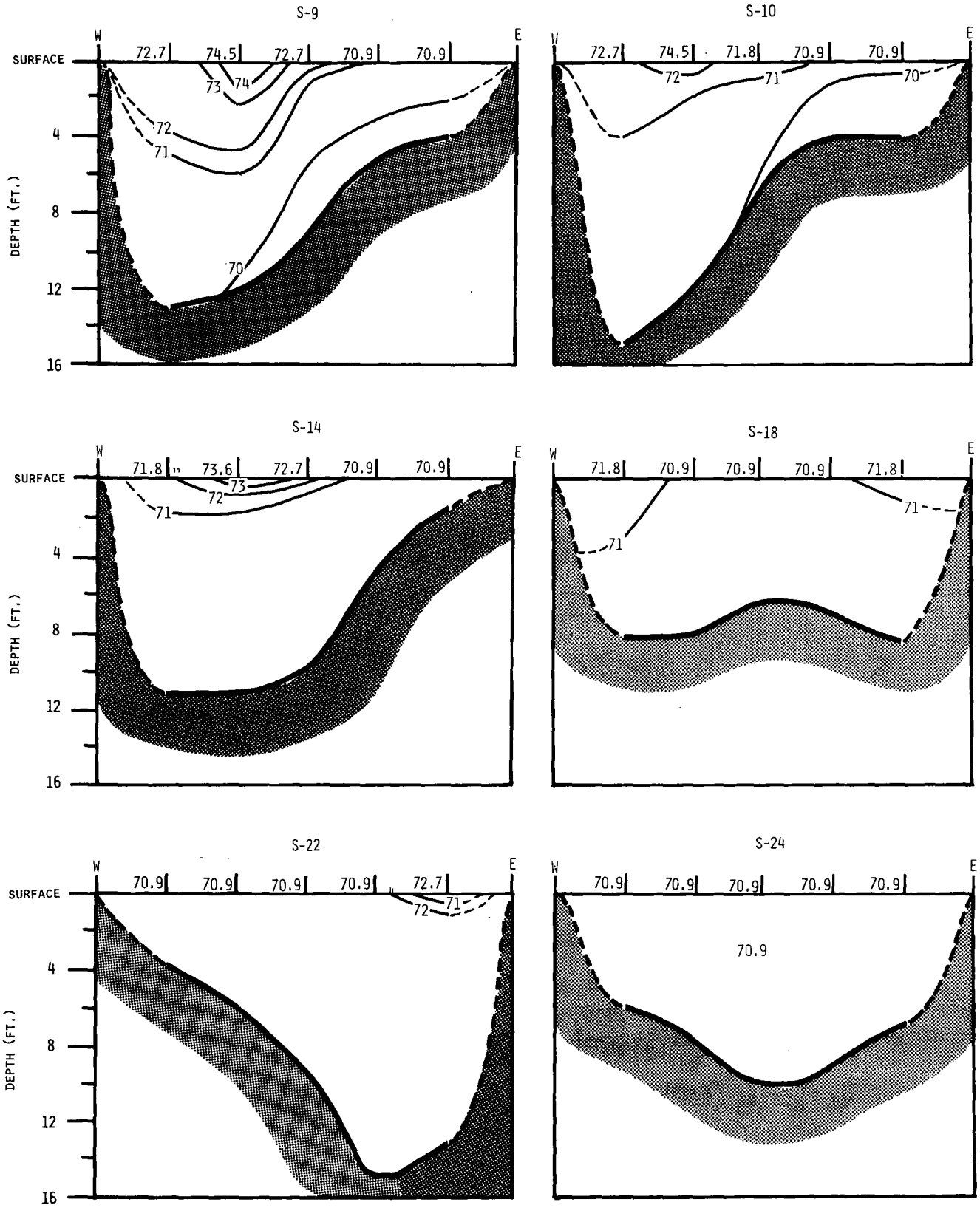


Figure 5. (continued).



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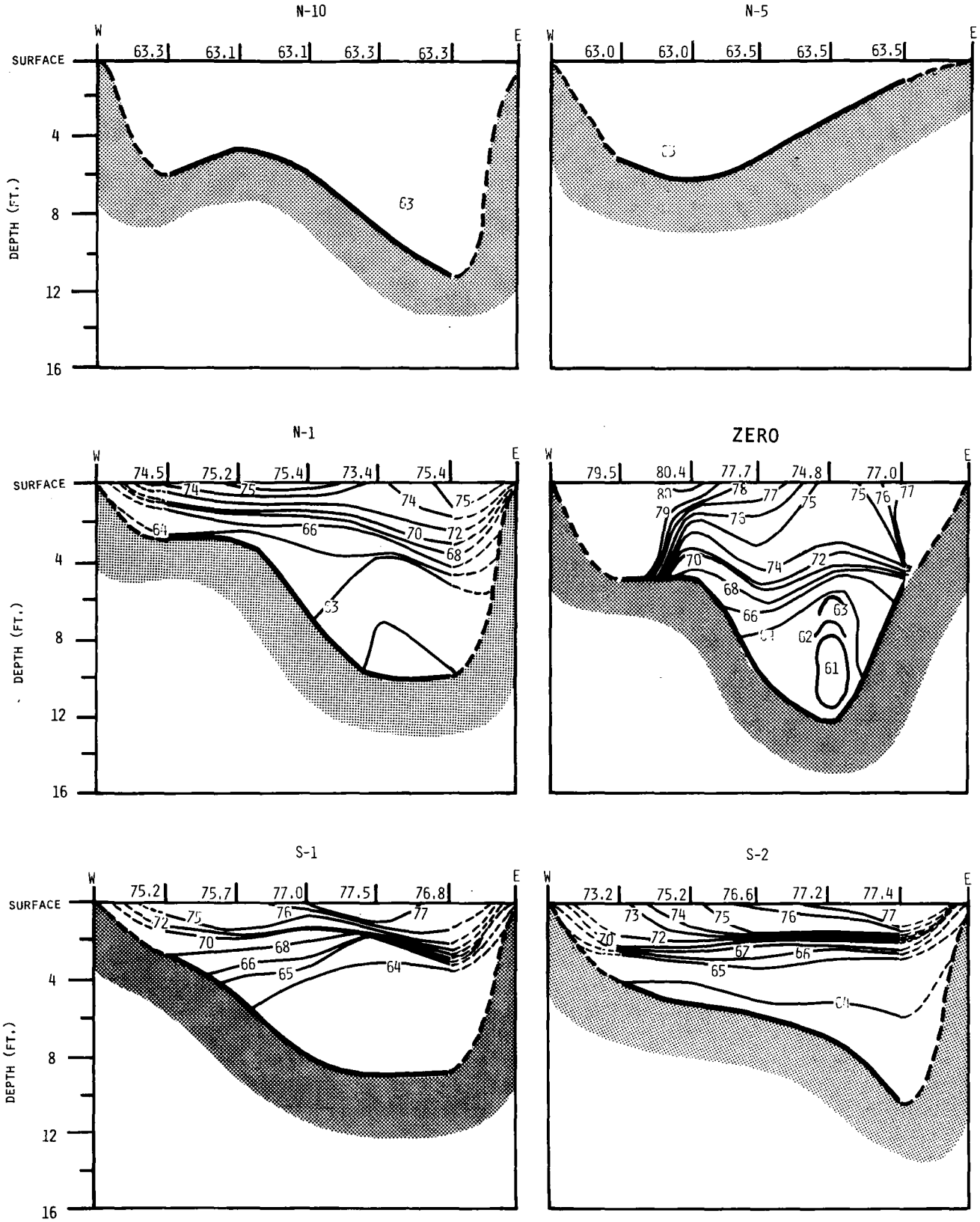
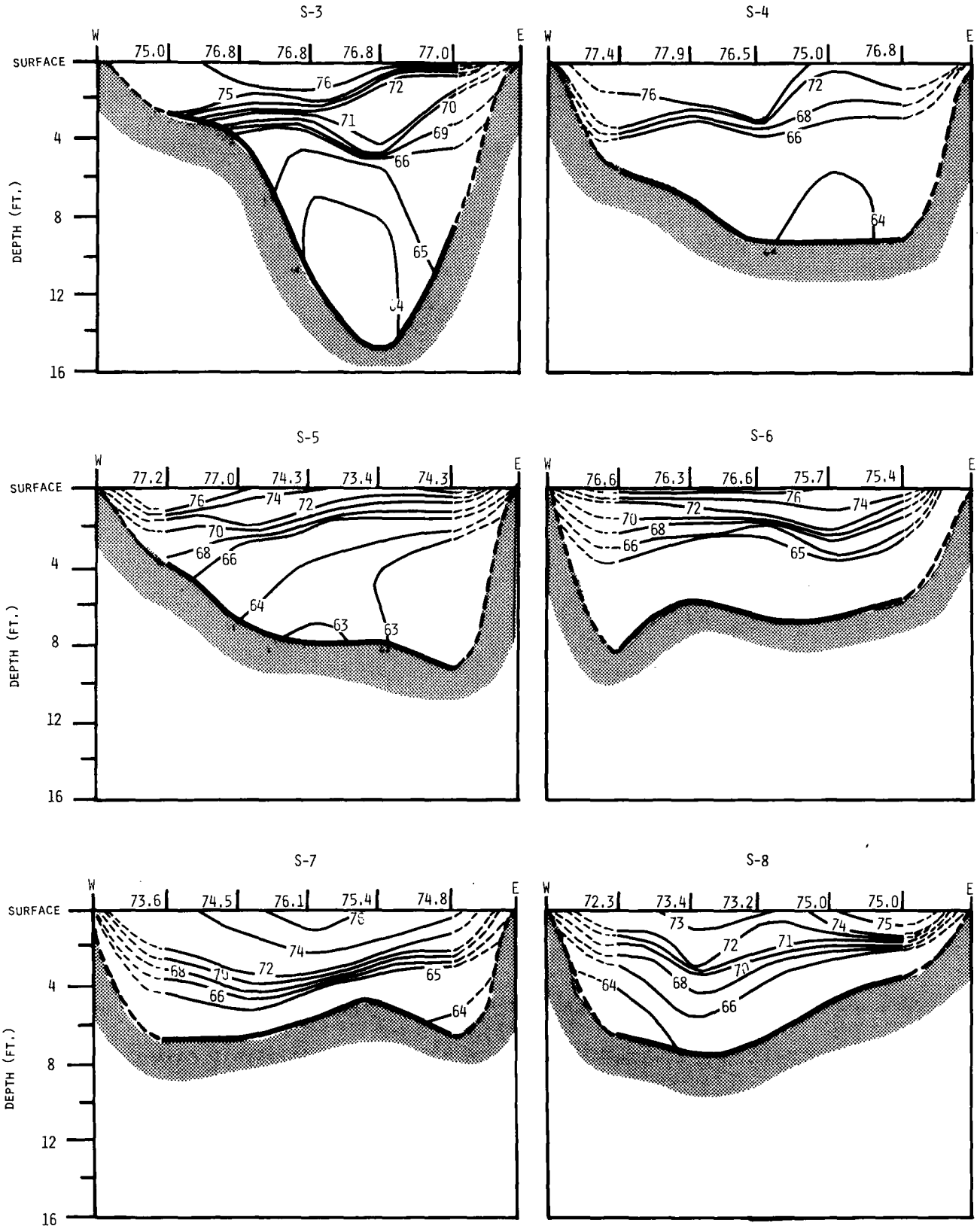


Figure 6. Isothermal cross-sections of Merrimack River sampling stations - September 26, 1972.



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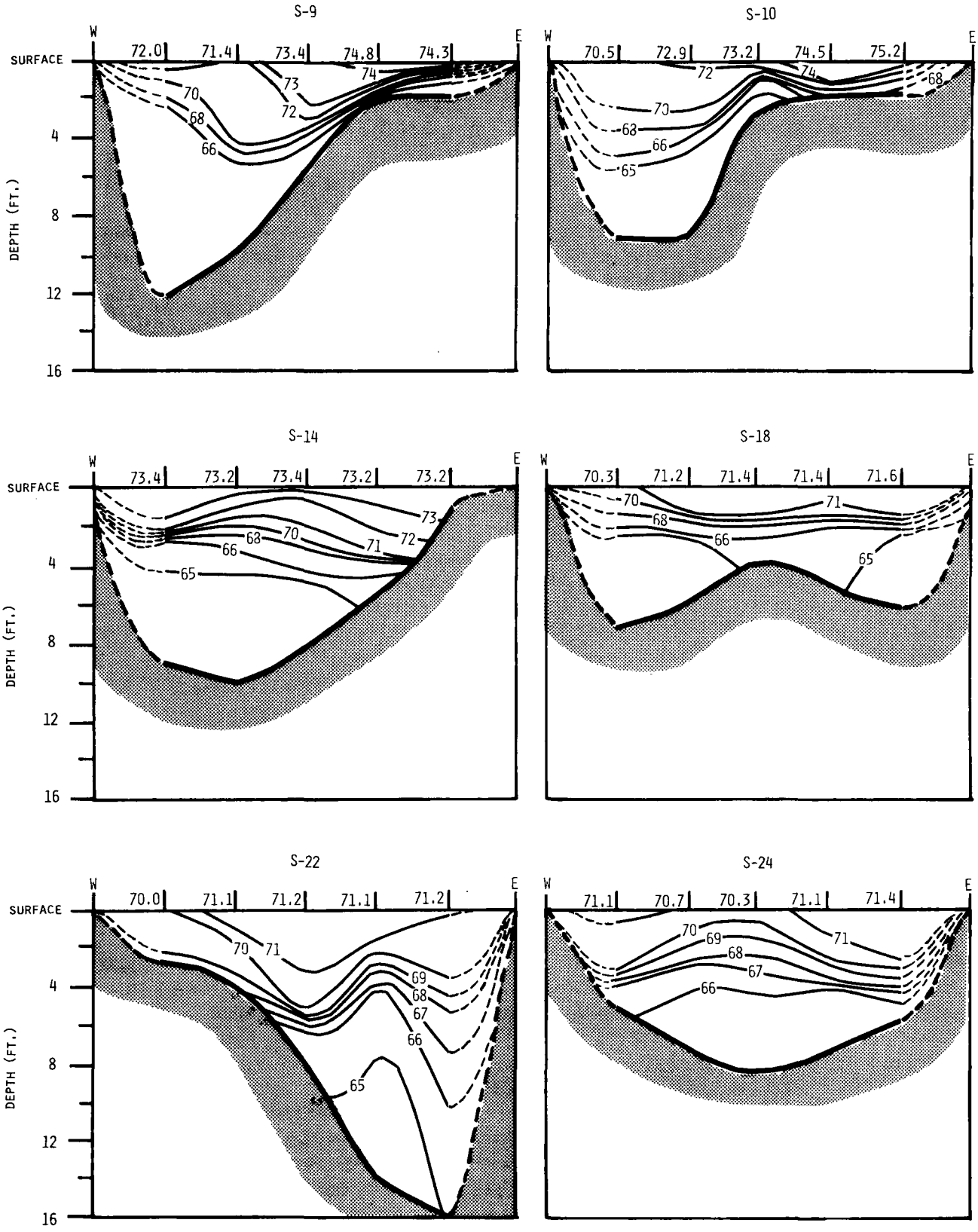


Figure 6. (continued).

as a result of the influence of the discharge canal which caused surface temperatures to range between 73.4 - 75.4° F. At Zero-West the warm-water strata extended completely across the river channel to a depth of approximately six feet. From Stations S-1 through S-2 warmer waters were also found to a depth of six feet on a cross-sectional basis. From Station S-3 downstream, stratification extended to four feet with surface temperatures ranging between 66° - 76° F. From Station S-9 and downstream, water temperatures in the upper layers began to decrease gradually. Temperatures there ranged from 66° - 74° F at S-9 and S-10, to 66° - 71° F at S-18 and S-24. There was no return to ambient conditions at downstream stations.

C. SUMMARY AND CONCLUSIONS

During the spring months, reduced depth of visibility readings resulted from high flows and associated turbidity. Among station visibility differences were the result of discharge canal dredging operations and were limited primarily to Station Zero-West. Periods of lowest flows (September) did not coincide with peak ambient temperatures (July). In general, water temperatures were not as high as in 1971. Maximum Δt's recorded for Station Zero-West during May and June were 16° and 15° F, respectively. Temperature stratification extended to the southern-most stations, with Δt's decreasing with movement downstream. Bottom temperatures were only slightly affected.

MERRIMACK RIVER MONITORING PROGRAM - 1972

III. WATER QUALITY MONITORING

A. METHODS

1. Nutrients

Weekly water samples were taken at Stations N-10, Zero-West, S-4, and S-17 and analyzed for nutrient content. Nitrate, nitrite, and poly-, ortho-, and total-phosphate analyses were performed in accordance with techniques presented in the 13th Edition of Standard Methods for the Examination of Water and Wastewater (1971).

2. pH

Measurements of pH were taken throughout the project season at Stations N-10, Zero-West, S-4 and S-17. The pH of water samples was determined with Orion Research Model 401 specific ion meter.

3. Dissolved Oxygen

Weekly dissolved oxygen sampling was carried out as part of the normal monitoring activities at Stations N-10, Zero-West, S-4, and S-17. Surface samples were taken and analyzed using the azide modification of the iodometric method as described in the 13th Edition of Standard Methods for the Examination of Water and Wastewater (1971). Dissolved oxygen

determinations for the 24-hour survey were accomplished with the aid of a Martek Mark II unit which was regularly calibrated utilizing the iodometric method described above. Stations N-10, Zero-West, S-4, S-17, and S-24 were sampled at mid-channel as well as west and east littoral zones at 4-hour intervals throughout the 24-hour period.

B. RESULTS AND DISCUSSION

1. Nutrients

Results of the 1972 nutrient study are presented in Table 3. As in 1970 and 1971, no important differences in nutrient concentration were noted among the stations.

Poly-, ortho-, and total-phosphates increased substantially over 1971 concentrations and were similar to those recorded for 1970. Maximum values were recorded in April during periods of high flow and low productivity. A leveling off occurred in the summer, followed by an increase during the fall months (September and October). Nitrate concentrations were reduced from those of a comparable period in 1971, with peak values occurring in May and June and reduced values from July through September. Concentrations of nitrites were similar to 1971 levels, with the highest levels occurring in April. A general increase in concentration occurred from May through October.

TABLE 3. MEAN NUTRIENT CONCENTRATIONS (mg/l)

HOOKSETT POND -- MERRIMACK RIVER, 1972

Parameter	Station			
	N-10	Zero-West	S-4	S-17
$T\text{-}PO_4$	.037	.034	.027	.032
$P\text{-}PO_4$	.009	.008	.008	.008
$O\text{-}PO_4$	.028	.026	.025	.057
NO_3	.149	.142	.144	.141
NO_2	.007	.007	.007	.006

2. pH

Mean seasonal pH values for Stations N-10, Zero-West, S-4, and S-17 were 7.05, 7.05, 6.96, and 7.01, respectively. Values for 1972 were comparable to those recorded in 1971.

3. Dissolved Oxygen

a) SURFACE DISSOLVED OXYGEN: Station Zero-west maintained near 100% saturation levels of dissolved oxygen throughout the year. As expected, this station had the lowest dissolved oxygen concentrations of the stations sampled (Table 4). As in 1971, oxygen differentials between N-10 and downstream stations tended to lessen as the season progressed, probably due to increased water temperatures and resultant oxygen demands at the ambient station. Operation of the spray module cooling system, activated on June 30, did not appear to significantly affect dissolved oxygen concentrations.

In general, oxygen concentrations for 1972 were higher than those of 1971 partially as a result of higher flows during the study season.

b) 24-HOUR DISSOLVED OXYGEN STUDY: Results of the 24-hour dissolved oxygen study are shown in Table 5. In general, Station N-10 reflected normal dissolved oxygen trends with increased concentrations in the euphotic zone as a result of photosynthetic activity during the daylight hours, and decreased concentrations at night due to respiration (Reid, 1961). At the N-10 mid-river station, higher oxygen

TABLE 4. MEAN SURFACE DISSOLVED OXYGEN CONCENTRATIONS AND MEAN TEMPERATURES -- HOOKSETT POND, MERRIMACK RIVER, 1972

Station	Range (mg/l)	Mean Oxygen (mg/l)	Mean Temperature (°F)
N-10	7.6-13.7	9.8	60.3
Zero-West	7.2-13.0	9.0	71.3
S-4	7.3-13.7	9.4	65.7
S-17	7.7-13.3	9.6	62.8

TABLE 5. MEANS AND RANGES OF TEMPERATURE AND DISSOLVED OXYGEN PROFILES

24-HOUR DISSOLVED OXYGEN STUDY -- 8 AND 9 AUGUST, 1972

	WEST		MID-RIVER		EAST	
	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)
1200 - 8 AUGUST						
Station N-10 -- R[1]	6.6 - 7.2	71.8 - 72.5	7.7 - 7.9	71.6 - 71.6	6.8 - 7.4	71.6 - 71.6
M[2]	6.9	72.1	7.8	71.6	7.1	71.6
Station Zero -- R	6.6 - 7.6	76.1 - 85.1	6.9 - 7.6	71.6 - 81.5	7.0 - 7.1	79.7 - 79.7
M	7.1	81.5	7.3	73.8	7.0	79.7
Station S-4 -- R	6.9 - 7.1	77.0 - 77.9	7.0 - 7.5	71.6 - 79.7	7.2 - 7.4	79.7 - 81.0
M	7.0	77.4	7.2	73.6	7.3	80.2
Station S-17 -- R	6.4 - 7.1	77.0 - 72.0	6.8 - 7.7	71.8 - 77.5	6.8 - 7.7	72.5 - 77.9
M	6.7	73.2	7.2	73.4	7.2	75.6
Station S-24 -- R	6.8 - 7.2	75.2 - 77.2	6.8 - 7.7	72.5 - 77.2	7.3 - 7.6	77.2 - 77.2
M	7.0	76.3	7.2	73.2	7.5	77.2

continued

1. Range
2. Mean

TABLE 5. (Continued)

	WEST		MID-RIVER		EAST	
	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)
1600 - 8 AUGUST						
Station N-10 -- R	7.3 - 7.4	73.0 - 73.0	7.9 - 8.4	72.5 - 73.0	7.7 - 7.7	73.0 - 73.0
M	7.4	73.0	8.2	72.7	7.7	73.0
Station Zero -- R	7.0 - 7.5	74.3 - 85.8	7.3 - 8.2	73.4 - 82.4	7.4 - 7.5	78.8 - 79.7
M	7.2	81.5	7.7	75.2	7.4	79.2
Station S-4 -- R	6.8 - 7.4	75.2 - 77.2	7.3 - 7.9	73.2 - 80.6	6.8 - 7.4	79.7 - 79.9
M	7.1	76.5	7.6	74.7	7.1	79.7
Station S-17 -- R	6.4 - 7.2	75.0 - 77.9	6.8 - 8.2	73.0 - 79.7	7.4 - 7.6	79.7 - 79.9
M	6.8	75.9	7.2	74.7	7.5	79.9
Station S-24 -- R	7.3 - 7.4	77.2 - 77.2	6.9 - 7.6	73.0 - 79.0	7.1 - 7.5	78.1 - 78.8
M	7.4	77.2	7.2	74.7	7.3	78.8
2000 - 8 AUGUST						
Station N-10 -- R	7.6 - 7.8	72.5 - 73.2	8.1 - 8.5	72.5 - 72.5	7.2 - 7.6	73.2 - 73.4
M	7.7	73.0	8.3	72.5	7.4	73.4
Station Zero -- R	6.7 - 7.8	77.9 - 85.6	7.0 - 8.2	73.4 - 80.6	6.1 - 6.9	82.0 - 82.2
M	7.1	81.7	7.7	75.2	6.5	82.0
Station S-4 -- R	6.6 - 7.1	74.3 - 80.1	7.3 - 7.7	73.4 - 80.6	6.8 - 7.3	74.3 - 77.0
M	6.8	77.7	7.5	71.4	7.1	75.6
Station S-17 -- R	6.4 - 7.2	75.0 - 77.9	6.8 - 8.2	73.0 - 79.7	7.4 - 7.6	79.7 - 79.9
M	6.8	75.9	7.2	74.7	7.5	79.9
Station S-24 -- R	7.3 - 7.4	77.2 - 77.2	6.9 - 7.6	73.0 - 79.0	7.1 - 7.5	78.1 - 78.8
M	7.4	77.2	7.2	74.7	7.3	78.8

continued

TABLE 5. (continued)

	WEST		MID-RIVER		EAST	
	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)
2400 – 8 AUGUST						
Station N-10 -- R	7.2 - 7.6	71.6 - 71.6	7.5 - 8.0	71.6 - 72.5	7.1 - 7.4	71.6 - 72.1
M	7.4	71.6	7.8	72.1	7.3	72.0
Station Zero -- R	6.7 - 7.2	80.6 - 85.1	7.2 - 7.9	72.5 - 81.5	6.3 - 7.0	81.7 - 82.0
M	6.9	83.8	7.6	74.8	6.6	81.9
Station S-4 -- R	6.8 - 7.2	79.3 - 79.7	7.3 - 7.7	73.0 - 80.6	6.4 - 7.3	75.6 - 76.1
M	7.0	79.7	7.4	74.5	6.8	75.9
Station S-17 -- R	6.7 - 7.0	74.3 - 74.8	7.4 - 8.1	73.9 - 75.2	6.8 - 7.5	74.3 - 74.3
M	6.8	74.7	7.9	74.5	7.1	74.3
Station S-24 -- R	6.3 - 6.8	73.4 - 73.4	6.6 - 7.8	74.3 - 74.7	6.4 - 6.4	74.1 - 74.1
M	6.5	73.4	7.4	74.5	6.4	74.1
0400 - 9 AUGUST						
Station N-10 -- R	6.9 - 7.2	70.7 - 70.7	7.2 - 7.8	70.7 - 70.7	6.7 - 6.9	70.7 - 70.7
M	7.1	70.7	7.6	70.7	6.8	70.7
Station Zero -- R	5.9 - 6.6	74.3 - 80.6	6.9 - 7.3	71.6 - 82.4	6.0 - 6.9	80.6 - 81.5
M	6.3	77.7	7.1	71.5	6.6	81.3
Station S-4 -- R	5.4 - 7.3	77.9 - 77.9	6.3 - 7.2	72.5 - 79.0	4.3 - 6.8	73.4 - 74.3
M	6.6	77.9	6.9	74.5	6.1	73.6
Station S-17 -- R	5.3 - 7.2	73.4 - 74.3	6.9 - 7.7	73.4 - 74.3	6.1 - 6.5	73.4 - 73.4
M	6.5	73.9	7.2	73.8	6.4	73.4
Station S-24 -- R	6.7 - 6.8	73.4 - 73.4	6.6 - 7.0	74.3 - 74.3	6.5 - 7.0	73.4 - 73.4
M	6.7	73.4	6.8	74.3	6.6	73.4

continued

TABLE 5. (continued)

	WEST		MID-RIVER		EAST	
	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)	DO (ppm)	TEMP. (°F)
0830 - 9 AUGUST						
Station N-10 -- R	6.6 - 7.1	71.4 - 71.4	7.2 - 7.5	71.4 - 71.4	7.2 - 7.4	71.4 - 71.4
M	6.8	71.4	7.3	71.4	7.4	71.4
Station Zero -- R	6.8 - 7.9	72.5 - 78.8	7.1 - 8.0	71.6 - 80.6	7.5 - 7.8	75.2 - 77.4
M	7.3	75.9	7.5	74.8	7.7	76.5
Station S-4 -- R	7.7 - 7.8	76.1 - 77.0	6.8 - 7.6	71.6 - 75.2	7.1 - 7.2	71.6 - 71.6
M	7.7	76.3	7.2	72.3	7.2	71.6
Station S-17 -- R	6.9 - 7.1	73.4 - 74.8	7.2 - 7.4	73.4 - 73.4	7.4 - 7.6	73.4 - 73.4
M	7.0	74.1	7.3	73.4	7.6	73.4
Station S-24 -- R	6.6 - 7.2	73.4 - 73.4	7.6 - 8.0	73.4 - 73.4	7.4 - 7.8	73.4 - 73.4
M	6.9	73.4	7.8	73.4	7.6	73.4
1200 - 9 AUGUST						
Station N-10 -- R	6.6 - 6.7	71.6 - 71.6	7.3 - 7.6	71.6 - 71.6	6.8 - 7.2	71.6 - 71.6
M	6.6	71.6	7.4	71.6	7.0	71.6
Station Zero -- R	6.2 - 7.6	74.3 - 85.8	7.2 - 7.5	71.6 - 81.5	6.9 - 7.2	71.6 - 71.6
M	6.9	81.7	7.3	73.9	7.0	71.6
Station S-4 -- R	7.4 - 7.6	78.8 - 78.8	7.1 - 7.8	71.6 - 77.9	7.2 - 7.6	72.5 - 72.5
M	7.5	78.8	7.4	73.8	7.4	72.5
Station S-17 -- R	6.9 - 7.8	73.0 - 73.8	7.5 - 7.8	72.1 - 73.0	7.4 - 7.8	74.3 - 74.3
M	7.2	73.6	7.6	72.7	7.6	74.3
Station S-24 -- R	6.9 - 6.9	73.8 - 73.8	6.9 - 7.7	73.2 - 73.4	6.5 - 7.4	73.4 - 73.6
M	6.9	73.8	7.4	73.2	6.9	73.6

concentrations were generally encountered between 1200 - 2000 hours as compared to similar locations downstream from the discharge canal. Dissolved oxygen differences between N-10 and southern stations tended to diminish during the early morning hours (2400 - 0830). Between-station differences were less discernible at east and west littoral zone sampling sites. As expected, the littoral stations generally had lower oxygen concentrations than mid-river sites. The lowest dissolved oxygen concentration encountered was 4.3 ppm recorded at Station S-4 East at 0400 on 9 August, 1972. This reading was the only value below 5.0 ppm noted during the 24-hour period.

C. SUMMARY AND CONCLUSIONS

As in 1970 and 1971, concentrations of nutrients did not vary significantly among stations and followed expected seasonal trends. Dissolved oxygen concentrations were similar to those encountered in 1971 and, as previously noted, were generally lower at stations south of the discharge canal. Results of a 24-hour dissolved oxygen survey indicated no critical dissolved oxygen problems at any of the stations sampled.

MERRIMACK RIVER MONITORING PROGRAM - 1972

IV. BIOLOGICAL STUDIES

A. METHODS

1. Chlorophyll *a*

Weekly surface water samples were obtained from Stations N-10, Zero-West, S-4, and S-17. Chlorophyll *a* determinations were made using the trichromatic method outlined in the 13th Edition of Standard Methods for the Examination of Water and Wastewater (1971).

2. Plankton

Metered plankton nets (#20 mesh) were used to collect plankton samples at Stations N-10, Zero-West, S-4, and S-17. At Stations N-10 and S-4, both surface and sub-surface (approximately six-foot depths) samplings were made, while at Stations Zero-West and S-17, only surface tows were taken. Collections were made weekly. Living plankton were identified and enumerated in the laboratory.

3. Periphyton

Periphyton accumulators were installed at Stations N-10, Zero-West, S-4, and S-17 approximately two feet below the surface of the water. At Stations N-10 and S-4 an additional accumulator was employed at a depth

of six feet, below the level of significant thermal influence. Glass accumulator slides were sampled weekly (short-term) and monthly (long-term) to determine the effects of the heated discharge on the periphyton community. Biota were identified to major groups (green, blue-green, diatoms) and percent composition of each determined.

4. Aquatic Plants

Aquatic plants were sampled in spring and late summer at the discharge canal and Stations N-10 through S-24. Data on relative abundance of each species were noted.

5. Aquatic Insects

Qualitative samples were taken in July and October from the east and west banks of Stations N-10, Zero, S-4, and S-17. Collections were made by two field personnel working for 10 minutes at each station. Substrate types at each sample location were noted. Organisms were preserved in 10% buffered formalin for later identification.

6. Benthic Invertebrates

Stations N-10, Zero-West, S-4, and S-17 were sampled with a Ponar grab in June, August, and October. Two replicates were taken at mid-river and two from both the east and west banks at each station. Samples were sieved in the field and the organisms were returned to the laboratory for identification.

7. Fish Surveys

a) ELECTROFISHING: Fish were collected by shocking 1000-foot sections of both the east and west banks of the river at the following stations: N-9 and N-10; N-6 and N-7; Zero and S-1; S-4 and S-5; S-17 and S-18. Fish collected during the June, August, and October samplings were identified and counted.

b) FYKE NETTING: Four fyke netting stations (N-10 East, N-10 West, S-4 East, and S-2 West) were sampled monthly from August through October. Nets were set twice within one-week for periods of two days each month. Smallmouth bass, yellow perch, and pumpkinseed sunfish were weighed, measured, and sexed. Scale samples from 10 fish per "inch-class" of each species were taken for aging. Age determinations were used to verify findings of length/frequency analyses which were employed to gain a better insight into the Merrimack River fish populations in the area of the Bow Generating Plant.

c) SEINING: High flows during the spring and early summer months prohibited scheduled seining activities. In August attempts at gathering littoral fish samples produced so few numbers at all stations that additional efforts were abandoned.

B. RESULTS AND DISCUSSION

1. Chlorophyll *a*

Monthly means of chlorophyll *a* concentrations are shown in Table 6.

TABLE 6. MEAN MONTHLY CONCENTRATIONS (ppm) OF CHLOROPHYLL *a* AT STATIONS N-10, ZERO-WEST, S-4, AND S-17

MERRIMACK RIVER MONITORING PROGRAM - 1972

MONTH	Stations			
	N-10	Zero-West	S-4	S-17
April	1.52	1.52	1.42	1.45
May	1.87	1.54	1.89	1.76
June	2.96	2.36	2.63	3.18
July	4.01	3.48	3.78	4.65
August	7.65	5.72	7.68	9.04
September	10.60	9.86	12.11	13.35
October	3.02	3.03	3.14	3.20

Concentrations underwent a progressive seasonal increase as the water warmed and flows diminished. During September, the month of lowest flows, chlorophyll *a* reached peak values and then declined in October as water temperatures began to decrease. From May to September, chlorophyll *a* concentrations at Station Zero-West were slightly reduced from those at N-10. At Station S-17 from June to October, concentrations were greater than at other stations, possibly as a result of the influence of the Suncook River. Both the reduction in chlorophyll *a* at Station Zero-West and the higher concentrations at Station S-17 were also noted in the 1971 study period. Results of a parametric one-way analysis of variance showed these station differences to be non-significant at the 0.05 level of significance.

2. Plankton

Numbers of plankton per 100 liters of sample are shown by station and sampling date in Figures 7 - 13. Major groups considered were diatoms (Chrysophyta), green algae (Chlorophyta), zooplankton, and blue-green algae (Cyanophyta). Other groups encountered in fewer numbers are presented and will be discussed briefly.

a) DIATOMS: Numbers of diatoms collected are shown in Figure 7. Representative genera encountered during the study were *Asterionella* sp., *Fragillaria* sp., *Tabellaria* sp. and *Navicula* sp., all pennate forms. While not readily evident from the figures, individual genera did appear to be adversely affected by

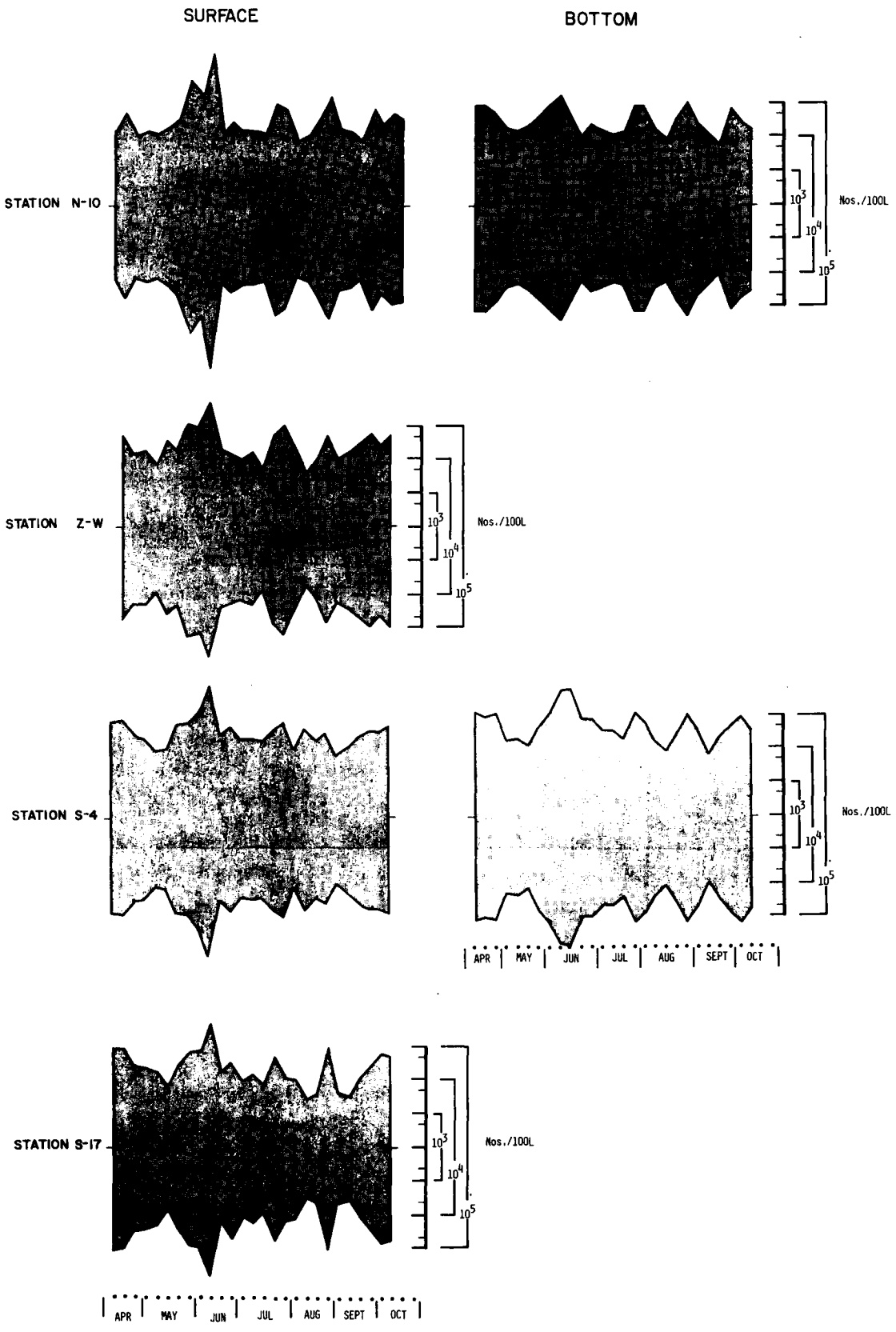


Figure 7. Weekly abundance of diatoms in plankton hauls taken in the Merrimack River, April - October, 1972.

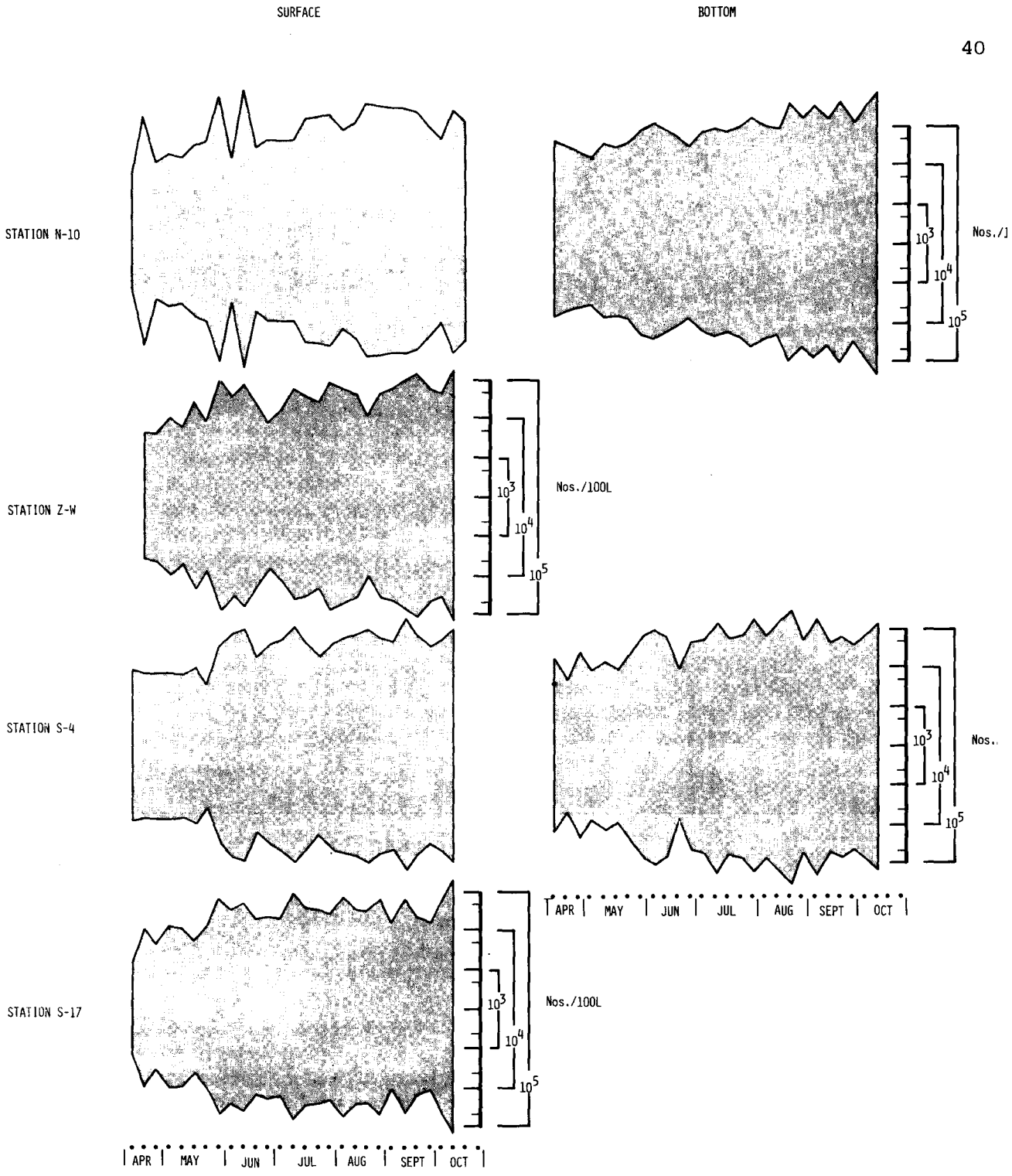


Figure 8. Weekly abundance of Chlorophyta (green algae) in plankton hauls taken in the Merrimack River, April - October, 1972.

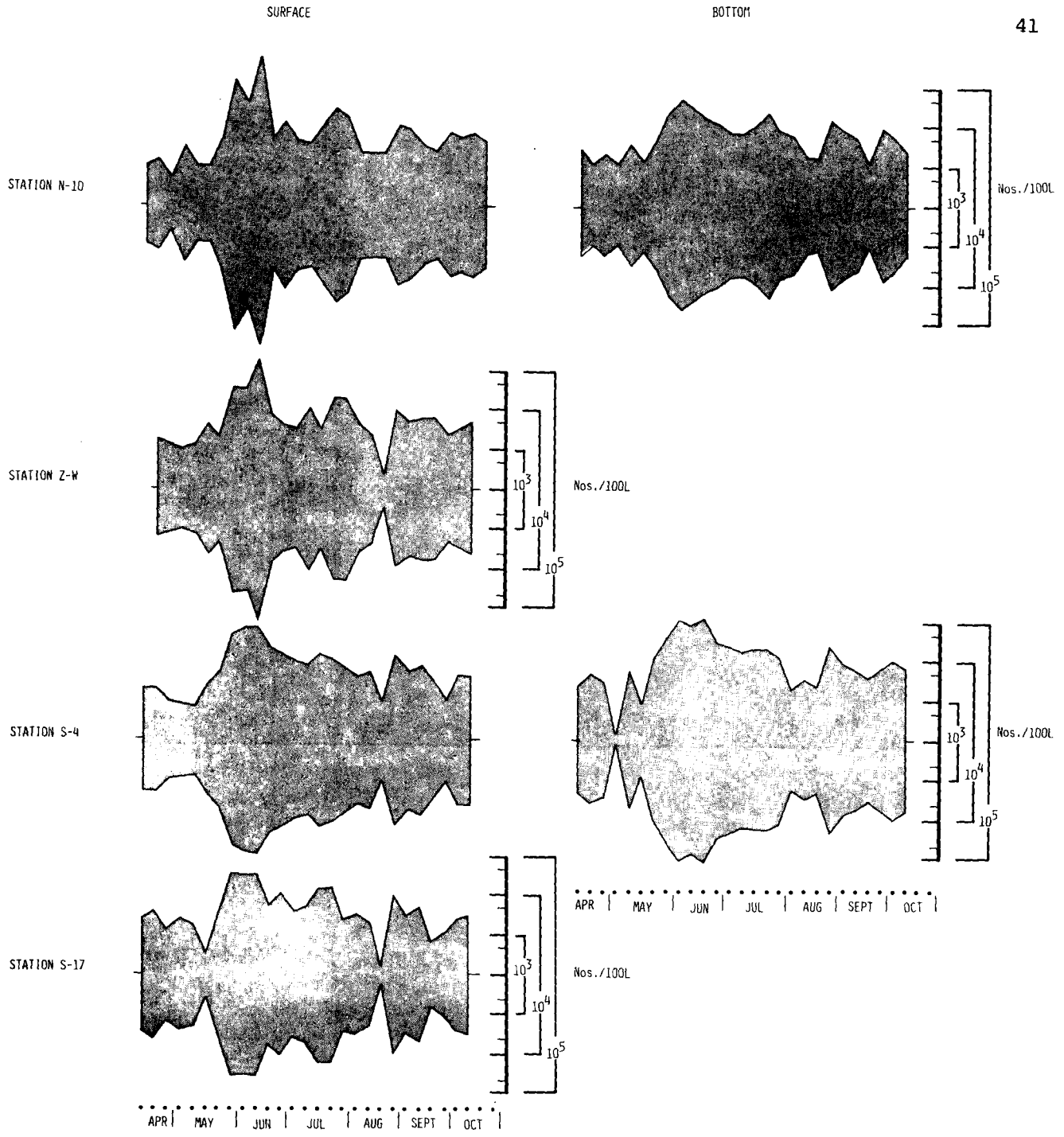


Figure 9. Weekly abundance of zooplankton in plankton hauls taken in the Merrimack River, April - October, 1972.

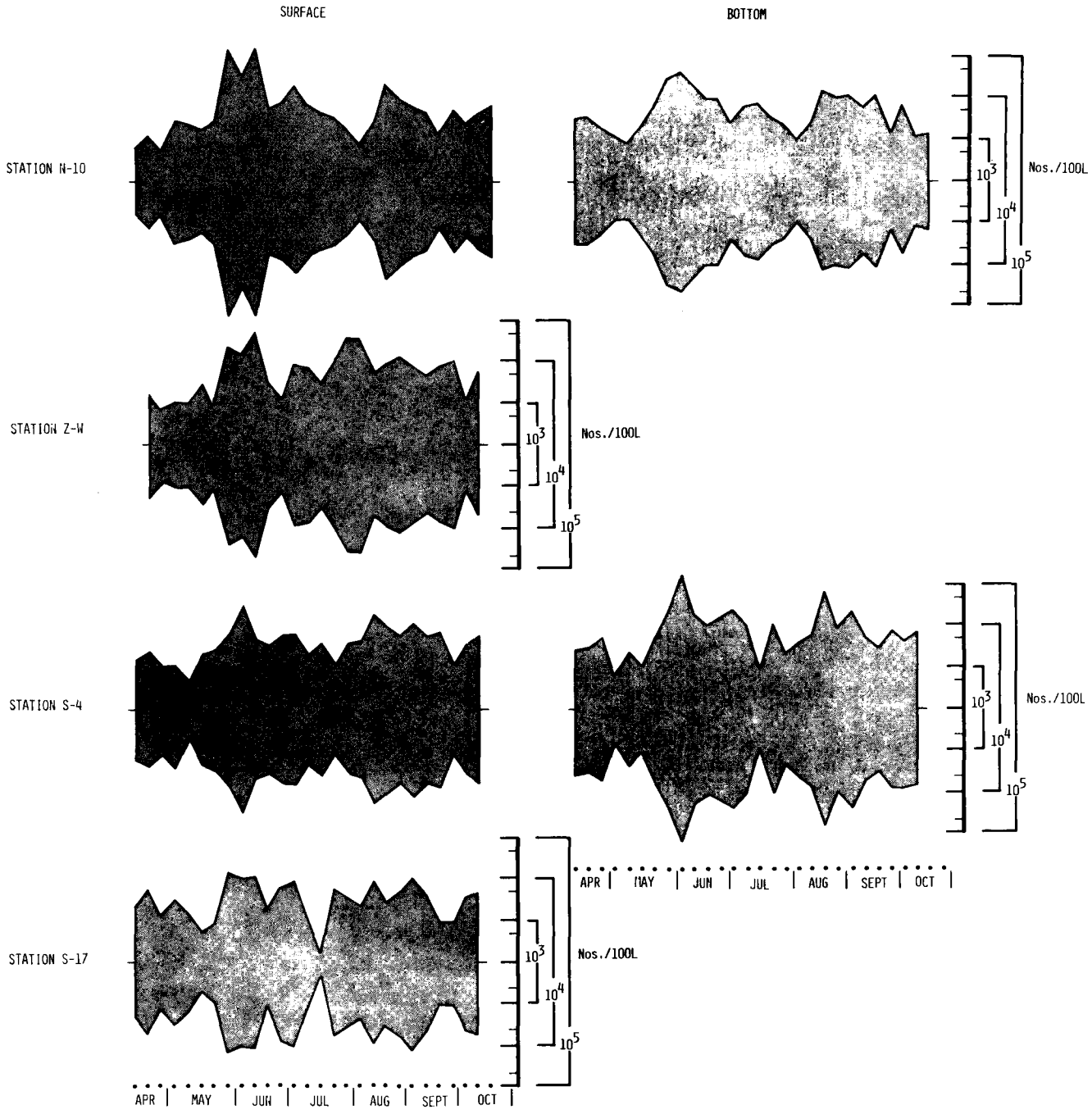


Figure 10. Weekly abundance of Cyanophyta (Blue-green algae) in plankton hauls taken in the Merrimack River, April - October, 1972.

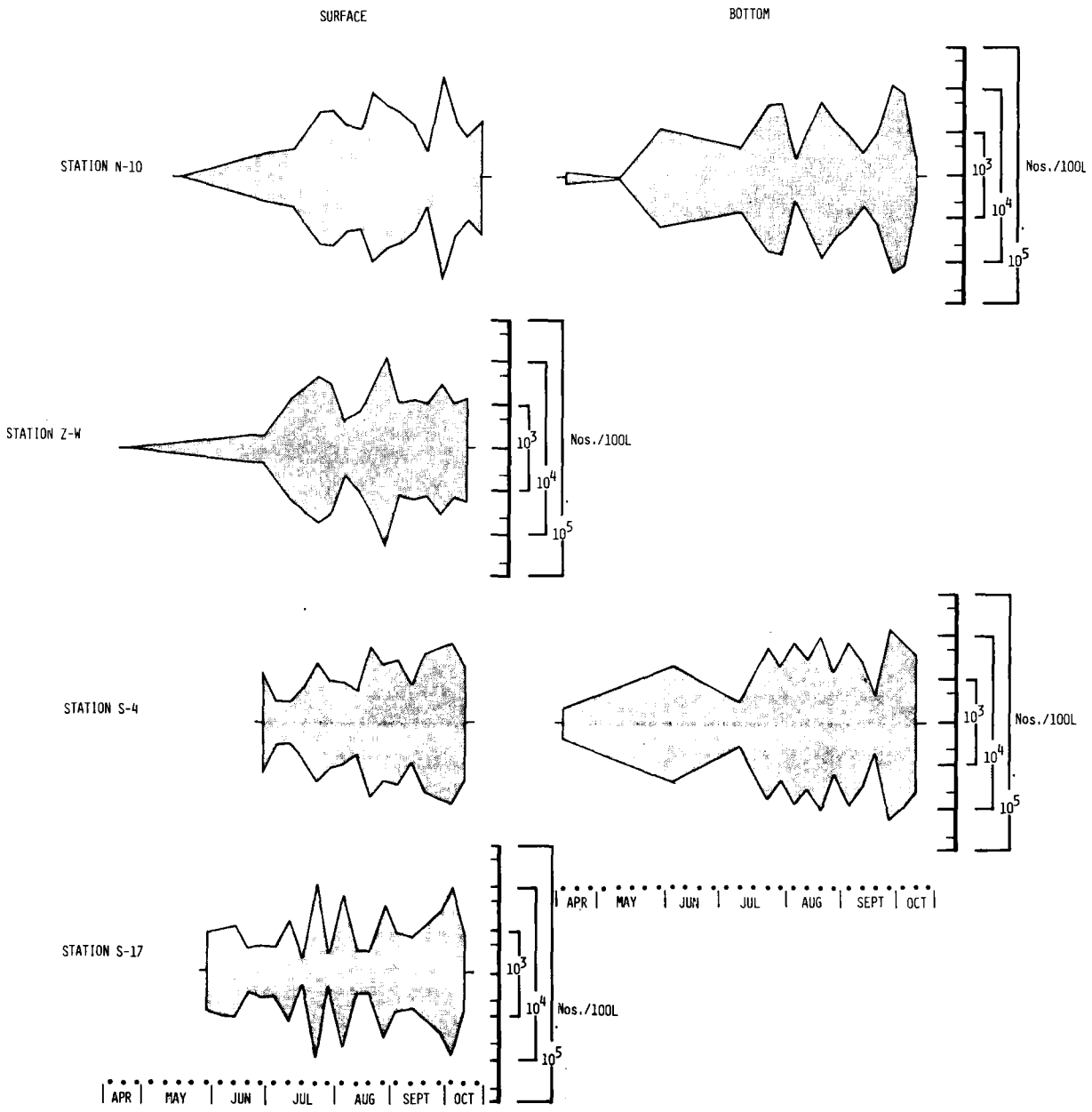


Figure 11. Weekly abundance of Pyrrhophyta (dinoflagellates) in plankton hauls taken in the Merrimack River, April - October, 1972.

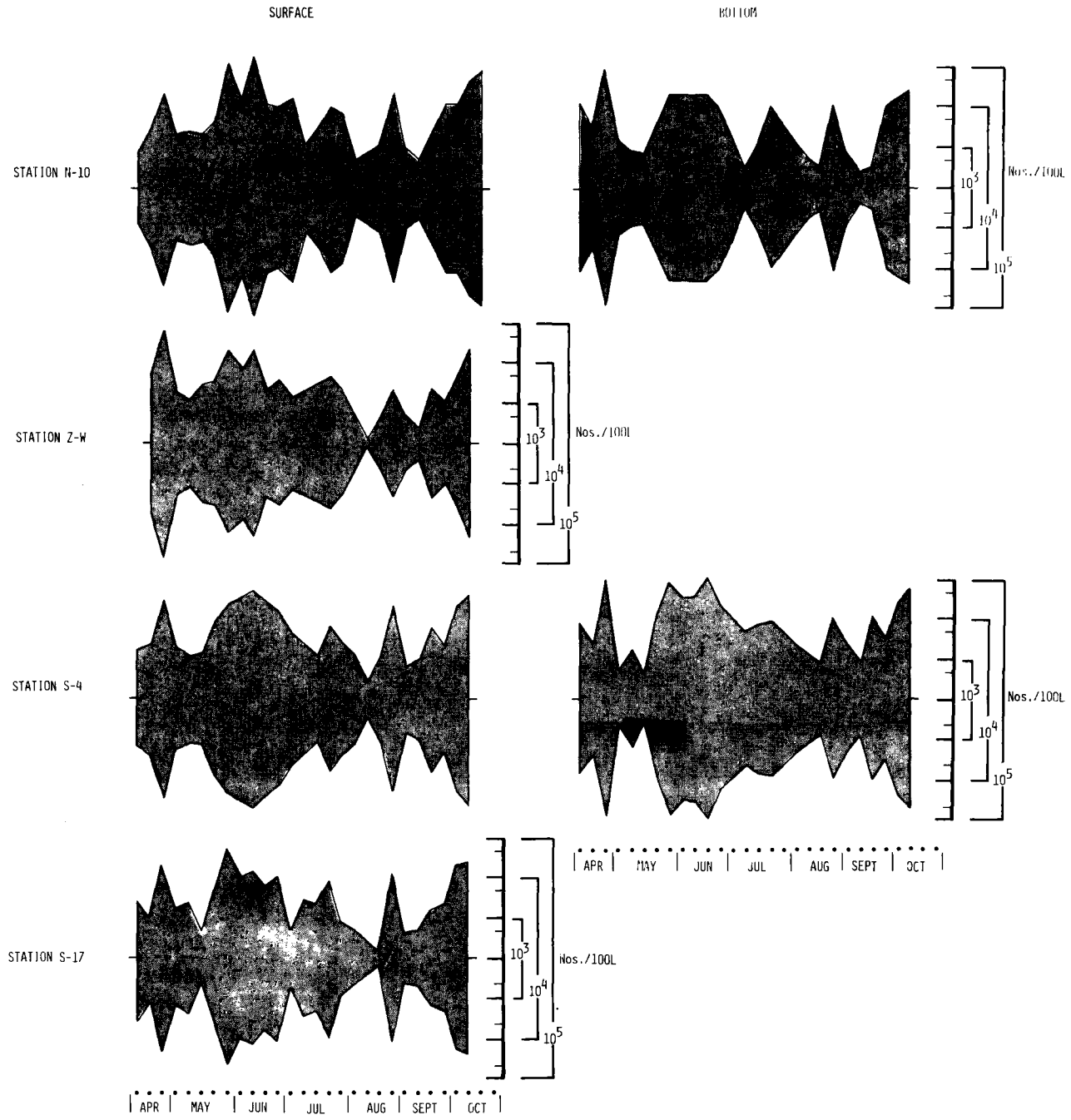


Figure 12. Weekly abundance of Chrysophyta (yellow-brown algae) in plankton hauls taken in the Merrimack River, April - October, 1972.

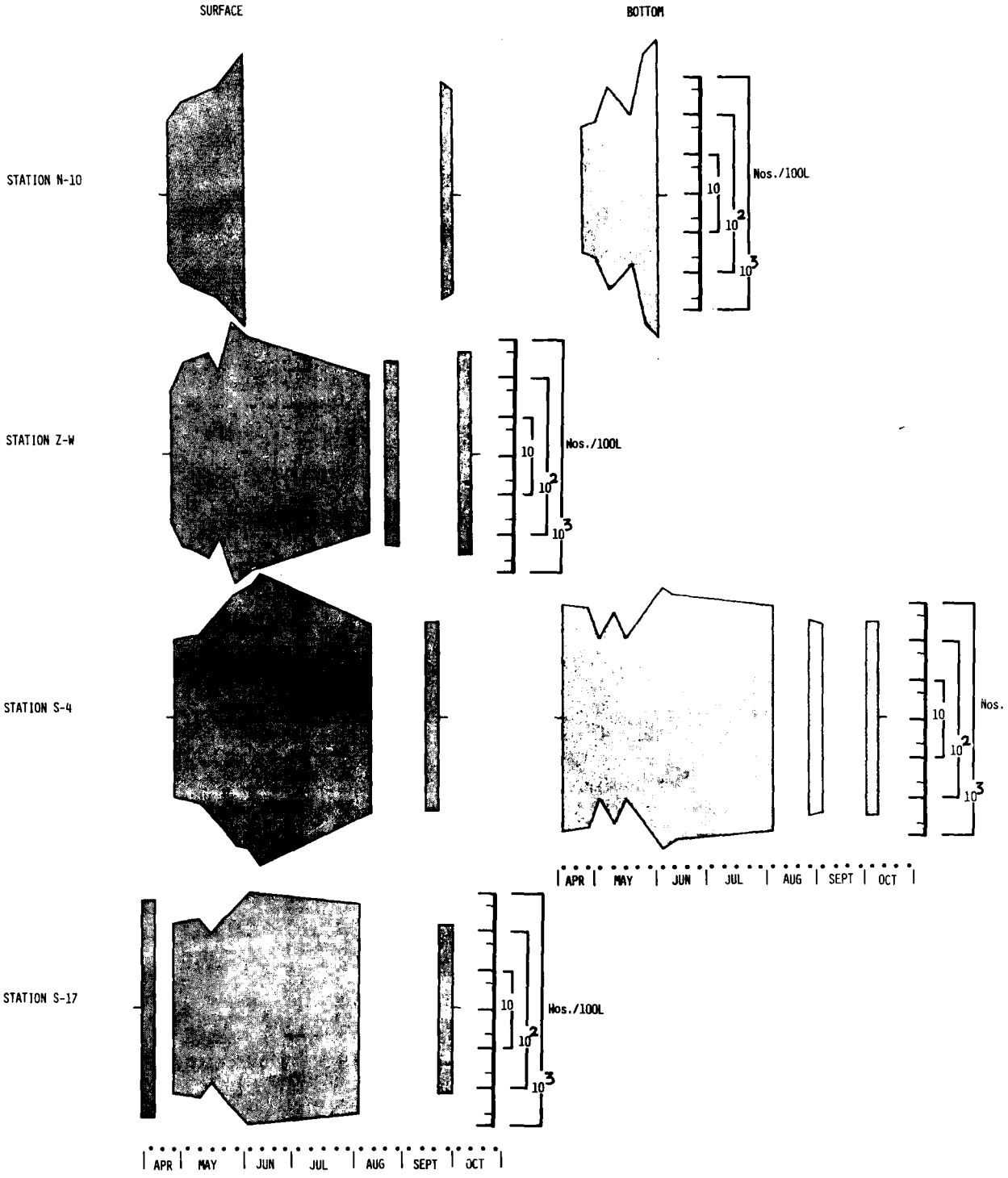


Figure 13. Weekly abundance of Rhodophyta (red algae) in plankton hauls taken in the Merrimack River, April - October, 1972.

thermal discharges from Merrimack Station, particularly at Station Zero-West. Monthly mean numbers of *Asterionella* sp., the dominant form collected, showed a reduction in numbers at all southern stations during all months but October. *Tabellaria* sp., present in samples from April through July, were also reduced in abundance at Station Zero-West and, with the exception of April, numbers downstream did not recover to levels comparable to Station N-10. Other pennate forms showed signs of similar responses throughout the year.

Surface and sub-surface concentrations of diatoms collected at Station S-4 were comparable in all months except April when higher numbers were collected in sub-surface waters.

b) GREEN ALGAE: Numbers of green algae collected during the study year are shown in Figure 8. As shown by the figure, green algae showed a steady increase from spring to fall at all stations. Commonly occurring genera were *Eudorina* sp., *Spirogyra* sp., *Cladophora* sp., *Scenedesmus* sp., *Palmodictyon* sp., *Pandorina* sp., and *Ulothrix* sp. As was true with the diatoms, individual genera reflected a thermal stress condition at Station Zero-West although total group abundances showed no readily apparent changes. Mean monthly numbers of *Ulothrix* sp. were reduced at Station Zero-West from May through September, as were numbers of *Eudorina* sp., from June through August. *Cladophora* sp. and others showed similar reductions. Numbers of these genera had not recovered to N-10

levels at Station S-17, the southern-most station sampled.

Surface and sub-surface concentrations of green algae collected at Station S-4 were comparable.

c) ZOOPLANKTON: Numbers of zooplankton collected per 100 liters of water are shown in Figure 9. Predominant groups collected were copepods and rotifers. With the exception of one sampling date (August 21), numbers of organisms were generally comparable between stations. On this date a significant decline in zooplanktor occurred at those stations south of the discharge canal. It is difficult to ascertain the cause of these declines with any certainty, although they did occur when plant start-up procedures were being implemented following a brief period when both Units I and II were down.

During the study year, Station S-4 (surface and bottom) had slightly higher numbers of zooplankton than did N-10 at the same sampling depths. Greater numbers of these organisms were found in sub-surface tows at Station S-4, than in surface samples.

d) BLUE-GREEN ALGAE: Blue-green algae (Figure 10) occurred in much less numbers than did the diatoms and green algae. Representative genera encountered during the study were *Oscillatori* sp., *Anacystis* sp., *Anabena* sp., and *Lyngbya* sp. Variability of mean monthly numbers of these predominant forms preclude any

definitive statements concerning their relationship to the thermal effluent. Greater numbers of these forms were collected in sub-surface hauls as compared to surface sampling at Station S-4.

e) OTHERS: Other taxa encountered were Pyrrhophyta (dinoflagellates), Figure 11, represented by *Ceratium* sp. and others; Chrysophyta (yellow-brown), Figure 12, represented mainly by *Dinobryon* sp. and *Synura* sp.; and Rhodyphyta (red algae), Figure 13, by *Audouinella* sp.

The Pyrrhophyta showed some declines at Station Zero-West in the latter part of July, but by September numbers were greater than at Station N-10. Station S-17 showed higher variability between sampling dates than did other stations, perhaps as a result of the influence of the Suncook River. Numbers of this group collected by surface and bottom sampling at Station N-10 were comparable, while at Station S-4 higher numbers were encountered in the deeper samples. Numbers of Chrysophyta were reduced at Station Zero-West during most of the sampling dates but showed signs of recovery at Station S-4. Sub-surface sampling at Station N-10 produced fewer numbers than did surface sampling, but at Station S-4 the opposite was true. Rhodophyta were not collected in sufficient numbers for any viable conclusions and are presented in Figure 13 only for general information.

In summary, results of the 1972 plankton study were similar to those of 1971 due to a consistent numerical reduction of forms of

diatoms, other Chrysophyta, and green algae at Station Zero-West. Chlorophyll *a* data presented earlier substantiate these findings. Bottom plankton samples at Station S-4 showed higher numbers of Pyrrhophyta, Chrysophyta (excluding diatoms), zooplankton, and Cyanophyta than did the surface samples at that station, and with the exception of the Cyanophyta, greater numbers than at similar depths at Station N-10.

3. Periphyton

a) WEEKLY SAMPLING: Weekly accumulator slides produced fewer numbers of organisms than did the monthly slides, although similar seasonal trends were evident. Diatoms predominated and showed a significant numerical reduction at Station Zero-West throughout the year. At Station S-4 diatom numbers were reduced from those at N-10 during July to October. Blue-green algae showed a trend toward increased numbers at Station Zero-West and S-4 for all but the month of October. With the exception of September and October, green algae were present in higher numbers at Station Zero-West than at N-10, while at other stations numbers were comparable. At the six-foot depth diatom numbers at Station S-4 were consistently reduced from those found at N-10. Green and blue-green algae showed no consistent trends at this depth.

b) MONTHLY SAMPLING: At the two-foot sampling depth, diatoms were generally the dominant group at all stations from June through October (Figure 14). At thermally affected stations a shift of community composition occurred resulting

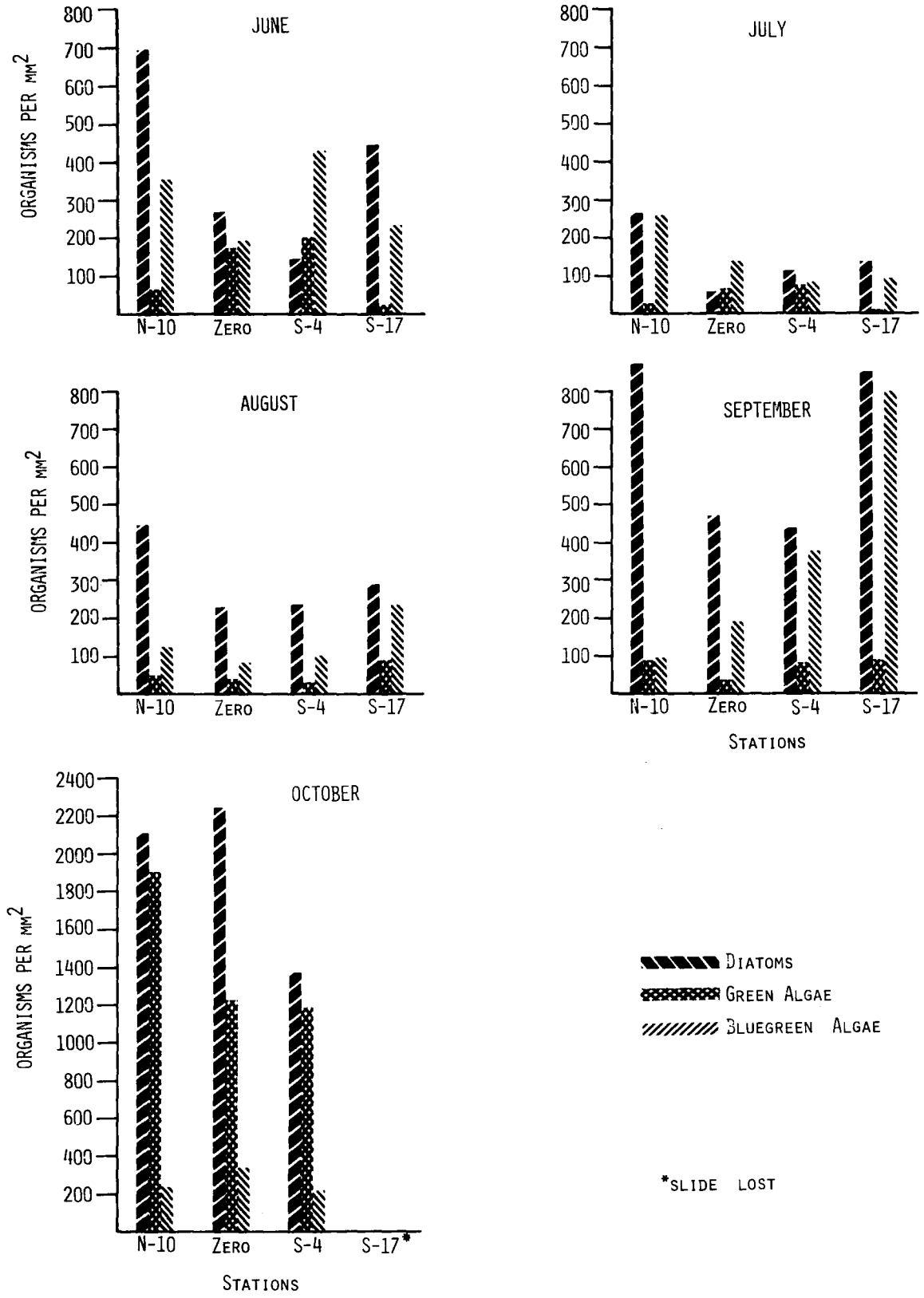


Figure 14. Periphyton organisms collected per square millimeter of slide surface at two-foot depth.

from a reduction in numbers of diatoms, except during October. Numbers of green algae increased at Zero-West and most downstream stations during June and July, were comparable to N-10 in August and September, and decreased in October. Blue-greens generally remained lower in numbers than at N-10 from June through August, they increased during September, and were comparable in October. In general, diatoms are considered the most temperature sensitive members of the periphyton community (Parker and Krenkle, 1969).

With the exception of June, diatom numbers at the six-foot accumulator depth (Stations N-10 and S-4) were comparable to those of the two-foot depth, but blue-green and green algae were somewhat reduced. As was the case with samples taken at the shallower depths, diatoms showed a marked reduction in numbers from June through August at Station S-4 (Figure 15). Numbers of green algae were also reduced at Station S-4 in all months except September and October, while blue-green algae decreased in July and August.

In general, both monthly and weekly periphyton samples indicated reductions in numbers of diatoms at downstream stations. Unlike 1971, these reductions did not appear to be limited to Station Zero-West, but were detected as far south as Station S-17 during most months sampled. It is possible that improved 1972 analysis techniques were responsible for detecting these differences, whereas in past years they were not noted. Changes in numbers of green and blue-green algae were not as pronounced as those shown by the diatoms.

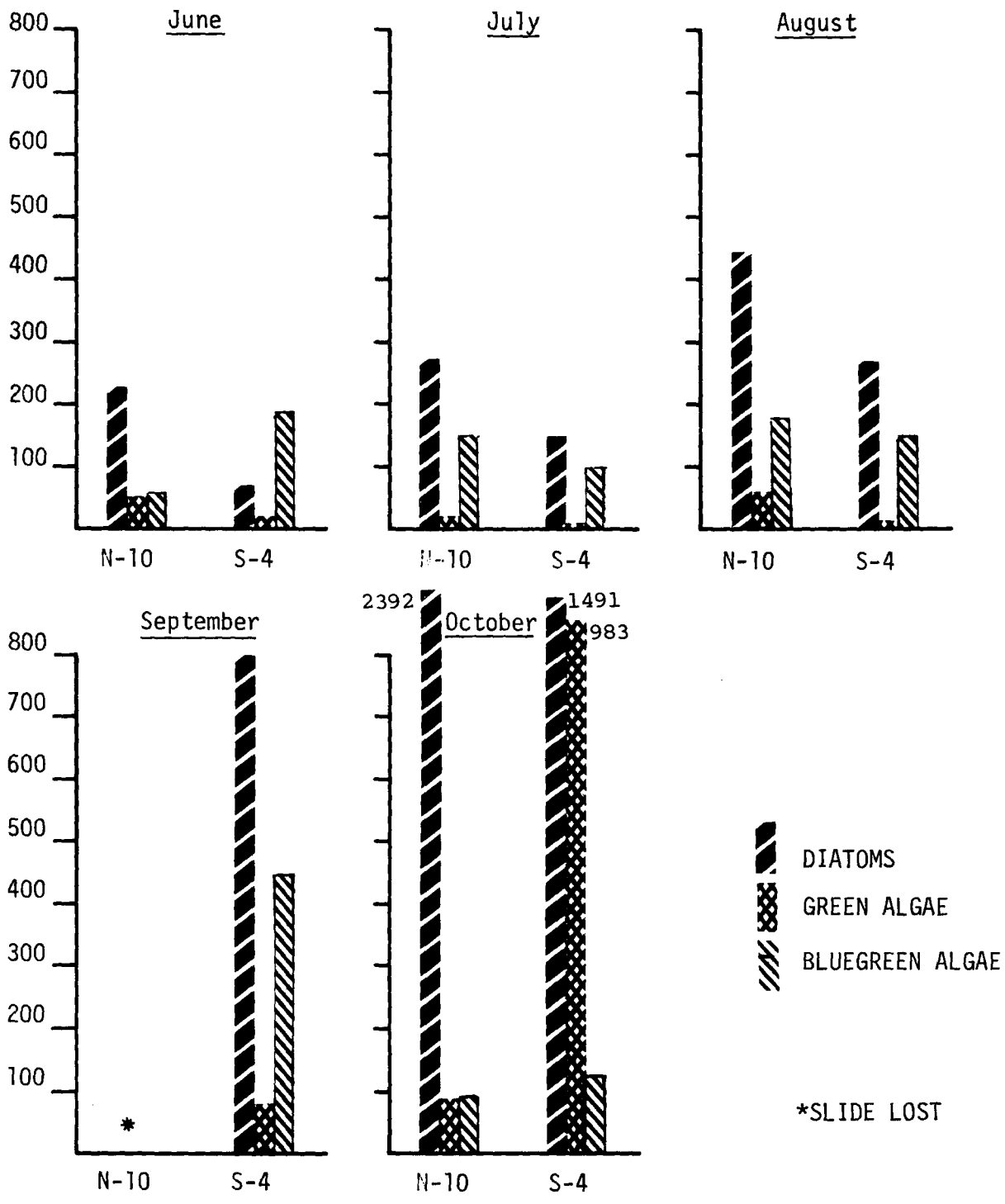


Figure 15. Periphyton organisms collected per square millimeter of slide surface at six-foot depth.

4. Aquatic Plants

Results of aquatic plant surveys (Tables 7 and 8) indicated that presence or absence of plants at any one station was largely determined by substrate and depth. During both surveys, no aquatic plants were collected at Station Zero-West, largely due to substrate modifications as a result of canal construction activities. In 1971, *Eleocharis* sp. was the only species found at that location. In the September 1972 sampling, *Eleocharis* sp. and *Ludwigia* sp. were found at the discharge weir, but in June, only *Eleocharis* sp. was observed. In general, results of the aquatic plant surveys were consistent with those of 1971.

5. Aquatic Insects

During the July and October sampling periods the predominant insect groups encountered were Diptera (midges) and Coleoptera (beetles). Other insect taxa found were Ephemeroptera (mayflies), Odonata (dragon and damsel flies), Trichoptera (caddisflies), Megaloptera (alderflies), and Hemiptera (bugs). Organisms collected at Stations sampled during the surveys are shown in Tables 9 and 10.

In July, 80.3% of the total number of insects collected were Diptera larva. Diptera predominated at all stations with the exception of S-17 West at which 75.8% of the organisms were coleopterans. Numbers of insects ranged from a high of 187 at Station S-4 West to a low of 22 at S-4 East. Station S-17 East produced the most diverse insect community. The least diverse sample was taken from Station Zero-West.

TABLE 7. RESULTS OF AQUATIC PLANT SURVEY

HOOKSETT POND - MERRIMACK RIVER - JUNE 22, 1972

Stations[1]		Temp. °F[2]	*Potamogeton* sp.	***Anacharis canadensis***	*Pontederia cordata* f. *taenia*	*Scirpus* sp.	*Eleocharis* sp.	*Sagittaria cristata*	*Nymphaea* sp.	Unknown
N-10	E	66.2								
	W	66.2						P		
N-9	E	66.2	A	A						
	W	66.2		VA						
N-8	E	66.2	A	VA						
	W	66.2	A	VA						
N-7	E	66.2	P	P		P	A			
	W	66.2		A					VA	
N-6	E	66.2	A	A						
	W	66.2		P						
N-5	E	66.2	A	VA	VA	VA	VA	P		
	W	66.2								
N-4	E	66.2	P	P			P			
	W	66.2	P	VA						
N-3	E	66.2	P							
	W	66.2		VA						
N-2	E	66.2	P				P	P		
	W	66.2	P							
N-1	E	66.2	A	P			P			
	W	66.2								
Zero	E	66.2	P				P			
	W	67.1								
S-1	E	66.2	VA						A	
	W	66.2	P							
S-2	E	67.1			A				P	
	W	66.2			VA	A				
S-3	E	67.1	P							
	W	67.1				P				
S-4	E	67.1	P	P						
	W	67.1								
S-5	E	67.1								
	W	67.1								
S-6	E	67.1	A		P					
	W	67.1	P							
S-7	E	66.2	P	P	P			P		
	W	67.1		P						
S-8	E	67.1	P							
	W	67.1	P	A						
S-9	E	67.1			A					
	W	67.1								
S-10	E	67.1	VA		VA		VA	A		
	W	67.1								
S-11	E	68.0	VA		P				P	
	W	67.1	P	P						

CONTINUED

TABLE 7. (continued)

Stations		Temp. °F	*Potamogeton* sp.	*Anacharis canadensis*	*Pontederia cordata* f. *taenia*	*Scirpus* sp.	*Eleocharis* sp.	*Sagittaria cristata*	*Nymphaea* sp.	Unknown
S-12	E	69.8	VA		P	P	P		P	
	W	67.1								
S-13	E	69.8	VA	P	P	VA				
	W	67.1								
S-14	E	68.0	VA		P	P	P			
	W	68.0								
S-15	E	68.0	VA		P	VA				
	W	68.0								
S-16	E	68.0	VA							
	W	68.0								
S-17	E	68.0	VA							
	W	68.0								
S-18	E	68.0	VA	P		VA				
	W	68.0								
S-19	E	68.0	VA	P		P				
	W	68.0								
S-20	E	68.0	VA	VA	A	A				VA
	W	68.9								
S-21	E	68.0			VA	A				
	W	68.9	A		VA					
S-22	E	68.0			P					
	W	68.9			VA	A		P		
S-23	E	68.0								
	W	69.8	P		VA					
S-24	E	68.0	P		A					
	W	69.8			VA	VA				

P = Present

A = Abundant

VA = Very Abundant

[1]Discharge canal was not sampled, however *Eleocharis* was abundant at this station at the time of sampling.

[2]Bottom temperatures.

TABLE 8. RESULTS OF AQUATIC PLANT SURVEY

HOOKSETT POND - MERRIMACK RIVER - SEPTEMBER 7, 1972

Stations		Temp. °F[1]	Potamogeton sp.	Anacharis canadensis	Pontederia cordata f. taenia	Scirpus sp.	Eleocharis sp. 1	Eleocharis sp. 2	Sagittaria cristata	Sagittaria sp.	Nymphaea sp.	Cyperaceae	Ludwigia sp.
N-10	E	67.5											
	W	69.0	P	P									
N-9	E	67.0	P	A									
	W	69.0	P	VA									
N-8	E	66.0	P	VA		P		P		P			
	W	68.5	VA	VA				P					
N-7	E	66.0	P	A									
	W	68.0	VA	VA				VA					
N-6	E	66.5	A	VA						A			
	W	68.5	P	A									
N-5	E	67.0	A	VA	VA	A	A		A				
	W	68.0	P	P					P				
N-4	E	67.0	A	A									
	W	68.0	P	P			P						
N-3	E	67.0	P	A									
	W	68.0	A	VA									
N-2	E	67.5	A	P									
	W	68.0	VA	A		P							
N-1	E	67.0		P									
	W	72.0	P										
Discharge Canal		92.0						VA					P
Zero	E	71.0	VA		P	P	P	P		VA			
	W	85.0											
S-1	E	80.0	VA							P			
	W	79.0	P	A									
S-2	E	80.5	VA		P								
	W	79.0		P	VA	A			P				
S-3	E	79.0	A		P			A		P			
	W	78.5		P		P							
S-4	E	76.5	P										
	W	79.0											

TABLE 8. (continued)

Stations		Temp. °F [1]	Potamogeton sp.	Anacharis canadensis	Pontederia cordata f. taenia	Scirpus sp.	Eleocharis sp. 1	Eleocharis sp. 2	Sagittaria cristata	Sagittaria sp.	Nymphaea sp.	Cyperaceae	Ludwigia sp.
S-5	E	75.0	P	P									
	W	80.0											
S-6	E	74.0	A	P	A				P	A			
	W	81.5		P									
S-7	E	73.0	P	A			P		A	P			
	W	80.0											
S-8	E	72.5	P	A						A			
	W	75.0	P										
S-9	E	72.0	VA		P		P		P	VA			
	W	75.5											
S-10	E	71.0	A	A	VA		A		VA	A			
	W	75.0											
S-11	E	70.0	A							A			
	W	75.0	P										
S-12	E	71.0	VA	VA	VA					VA			
	W	74.5	P										
S-13	E	72.0	VA	VA	P	P	P			VA			
	W	75.0											
S-14	E	72.5	VA		P	A			P	VA			
	W	74.0											
S-15	E	74.0	VA	A	P	P				VA			
	W	74.0											
S-16	E	73.0	VA	P						VA			
	W	74.0											
S-17	E	73.5	VA							VA			
	W	76.0	P										
S-18	E	73.0	VA	P	P	VA	P			VA		VA	
	W	75.0	P										
S-19	E	75.0	P	A									
	W	75.0											
S-20	E	75.0	A	P						A			
	W	75.0											

CONTINUED

TABLE 8. (continued)

Stations		Temp. °F[1]	Potamogeton sp.	Anacharis canadensis	Pontederia cordata f. taenia	Scirpus sp.	Eleocharis sp. 1	Eleocharis sp. 2	Sagittaria cristata	Sagittaria sp.	Nymphaea sp.	Cyperaceae	Ludwigia sp.
S-21	E	74.5	VA		VA	A	A			VA	VA		
	W	75.0	A		A								
S-22	E	75.0	P		P					P			
	W	76.0	A		VA				VA				
S-23	E	74.0			P								
	W	76.5	A		VA				A	P			
S-24	E	74.0			VA								
	W	76.0			VA	VA			P	VA			

P = Present

A = Abundant

VA = Very Abundant

[1] Surface temperatures.

TABLE 9. RESULTS OF AQUATIC INSECT SURVEY

HOOKSETT POND - MERRIMACK RIVER - JULY 11, 1972

STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS	STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS
EAST				WEST			
N-10	76.0	Diptera		N-10	63.0	Diptera	
		Tendipedidae pupae	2			Tendipedidae pupae	4
		Tendipedidae larvae	27			Tendipedidae larvae	5
		Anatopynia sp. pupa	1			Ceratopogonidae larvae	2
		Anatopynia sp. larvae	8			*Anatopynia* sp. pupae	11
		Pentaneura sp. pupa	1			*Anatopynia* sp. larvae	19
		Pentaneura sp. larvae	12			*Pentaneura* sp. larvae	4
		Cryptochironomus sp. pupae	6			*Cryptochironomus* sp. pupae	9
		Cryptochironomus sp. larvae	28			*Cryptochironomus* sp. larvae	5
		Odonata				Trichoptera	
		Lestes sp. naiad	1			Leptoceridae larvae	2
		Ephemeroptera				Ephemeroptera	
		Baetidae nymphs	2			Baetidae nymph	1
		Stenonema sp. nymphs	3			Plecoptera	
		Ephemerella sp. nymphs	3			Plecoptera larva	1
ZERO	73.0	Diptera		ZERO	74.0	Diptera	
		Tendipedidae pupae	3			Tendipedidae larvae	17
		Tendipedidae larvae	26			*Anatopynia* sp. pupa	1
		Ceratopogonidae larva	1			*Anatopynia* sp. larvae	6
		Anatopynia sp. larvae	6			*Cryptochironomus* sp. larvae	3
		Cryptochironomus sp. larvae	5			Coleoptera	
		Coleoptera				*Dubiraphia* sp. adults	2
		Dubiraphia sp. larva	1			Trichoptera	
		Trichoptera				Trichopteran case	1
		Leptoceridae larva	1			Ephemeroptera	
		Ephemeroptera				*Stenonema* sp. nymph	1
		Stenonema sp.	2			*Ephemerella* sp. nymphs	2

(continued)

TABLE 9. (continued)

STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS	STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS
EAST				WEST			
S-4	74.0	Diptera		S-4	78.0	Diptera	
		Tendipedidae larvae	14			Tendipedidae pupae	4
		Coleoptera				Tendipedidae larvae	138
		Hydroporinae larva	1			*Anatopynia* sp. pupa	1
		Elmidae larva	1			*Anatopynia* sp. larvae	38
		Trichoptera				*Pentaneura* sp. larva	1
		Trichopteran case	1			*Cryptochironomus* sp. pupa	1
		Ephemeroptera				*Cryptochironomus* sp. larvae	2
		Baetidae nymph	1			Coleoptera	
		Stenonema sp. nymphs	5			*Haliplus* sp. adult	1
						Trichoptera	
						Leptoceridae larva	1
						Trichopteran cases	2
S-17	73.0	Diptera		S-17	73.0	Diptera	
		Tendipedidae pupae	4			Tendipedidae pupae	2
		Tendipedidae larvae	17			Tendipedidae larvae	3
		Ceratopogonidae larva	1			*Cryptochironomus* sp. larva	1
		Anatopynia sp. larva	1			Coleoptera	
		Pentaneura sp. larvae	2			Hydroporinae larvae	2
		Cryptochironomus sp. larvae	10			*Dubiraphia* sp. adults	23
		Coleoptera				Trichoptera	
		Berosus sp. larva	1			Leptoceridae larva	1
		Trichoptera				Odonata	
		Leptoceridae larva	1			*Lestes* sp. naiad	1
		Trichopteran case	1				
		Unknown larva	1				
		Ephemeroptera					
		Ephemerella sp. nymphs	2				

TABLE 10. RESULTS OF AQUATIC INSECT SURVEY

HOOKSETT POND - MERRIMACK RIVER - OCTOBER 4, 1972

STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS	STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS
EAST				WEST			
N-10	58.3	Diptera		N-10	59.0	Diptera	
		Tendipedidae larvae	42			Dipteran adult	1
		Cryptochironomus sp. larvae	29			Tendipedidae larvae	36
		Anatopynia sp. larvae	12			Tipulidae larva	1
		Trichoptera				*Cryptochironomus* sp. larvae	9
		Psychomyiidae larva	1			*Anatopynia* sp. pupae	2
		Hydropsychidae larva	1			*Anatopynia* sp. larvae	26
						Coleoptera	
						Ancyronyx sp. adults	3
						Hydroporinae adult	1
						Elmidae larvae	5
						Dubiraphia sp. adults	135
						Dubiraphia sp. larvae	16
						Berosus sp. larvae	2
						Trichoptera	
						Hydroptilidae larvae	4
						Leptoceridae larva	1
						Unknown larvae	2
						Psychomyiidae larvae	3
						Odonata	
						Aeschnidae naiad	1
						Lestes sp. naiads	2
						Ephemeroptera	
						Baetidae nymph	1
ZERO	60.2	Diptera		ZERO	62.9	Diptera	
		Dipteran adult	1			Tendipedidae pupae	6
		Tendipedidae pupae	3			Tendipedidae larvae	119
		Tendipedidae larvae	19			*Cryptochironomus* sp. larvae	3
		Ceratopogonidae larvae	2			*Anatopynia* sp. pupae	14
		Cryptochironomus sp. larvae	14			*Anatopynia* sp. larvae	66
		Anatopynia sp. adult	1			*Pentaneura* sp. larvae	2
		Anatopynia sp. pupae	8			Coleoptera	
		Anatopynia sp. larvae	18			*Dubiraphia* sp. adults	3
		Coleoptera				*Dubiraphia* sp. larva	1
		Elmidae larva	1			Trichoptera	
		Dubiraphia sp. adults	2			Hydroptilidae cases	10
		Dubiraphia sp. larva	1			Hydroptilidae larvae	25
		Berosus sp. larvae	7				

(continued)

TABLE 10. (continued)

STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS	STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS
EAST ZERO		Trichoptera		WEST ZERO			
		Hydroptilidae larvae	3				
		Psychomyiidae larvae	3				
		Hemiptera					
		Hemipteran larva	1				
		Ephemeroptera					
		Baetidae adult	1				
S-4	62.0	Diptera		S-4	63.2	Diptera	
		Tendipedidae larvae	11			Tendipedidae pupae	2
		Cryptochironomus sp. larvae	2			Tendipedidae larvae	109
		Anatopynia sp. pupa	1			Ceratopogonidae larvae	6
		Anatopynia sp. larvae	10			*Cryptochironomus* sp. larvae	28
		Coleoptera				*Anatopynia* sp. pupae	2
		Elmidae larva	1			*Anatopynia* sp. larvae	20
		Dubiraphia sp. adult	1			*Pentaneura* sp. larvae	3
		Trichoptera				Coleoptera	
		Unknown larva	1			*Ancyronyx* sp. adults	2
		Odonata				Elmidae larvae	16
		Lestes sp. naiad	1			*Dubiraphia* sp. adults	104
						Dubiraphia sp. larvae	129
						Berosus sp. larvae	24
						Trichoptera	
						Trichopteran cases	11
						Hydroptilidae cases	36
						Hydroptilidae larvae	73
						Megaloptera	
						Sialis sp. larva	1
						Odonata	
						Lestes sp. naiads	15
						Ephemeroptera	
						Stenonema sp. nymph	1
						Ephemerella sp. nymph	1

(continued)

TABLE 10. (continued)

STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS	STATION	TEMPERATURE AT SAMPLING DEPTH (°F)	TAXA	NUMBERS
EAST				WEST			
S-17	63.9	Diptera		S-17	60.1	Diptera	
		Dipteran adult	1			Tendipedidae larvae	59
		Tendipedidae larvae	118			*Cryptochironomus* sp. larvae	8
		Ceratopogonidae larva	1			*Anatopynia* sp. larvae	5
		Cryptochironomus sp. larvae	12			Coleoptera	
		Anatopynia sp. pupae	2			*Ancyronyx* sp. adults	105
		Anatopynia sp. larvae	19			Elmidae larvae	31
		Coleoptera				*Heterelmis* sp. adult	1
		Ancyronyx sp. adults	2			*Dubiraphia* sp. adults	279
		Elmidae larva	1			*Dubiraphia* sp. larvae	44
		Dubiraphia sp. adults	5			Trichoptera	
		Dubiraphia sp. larvae	3			Trichopteran cases	7
		Berosus sp. larva	1			Brachycentridae larvae	2
		Trichoptera				Hydroptilidae cases	80
		Trichopteran cases	2			Hydroptilidae larvae	160
		Hydroptilidae larva	1			Leptoceridae larva	1
		Unknown larvae	3			Molannidae larvae	3
		Odonata				Psychomyiidae larvae	2
		Lestes sp. naiad	1			Hydropsychidae larva	1
						Hemiptera	
						Hemipteran nymph	4
						Odonata	
						Lestes sp. naiads	2
						Ephemeroptera	
						Stenonema sp. nymphs	2
						Ephemerella sp. nymphs	2

In October, as in July, Diptera were the most common organisms collected, but formed only 34.4% of the total insect fauna. Coleopterans made up 37.3% of the samples and again dominated at Station S-17 West. However, unlike July, they also formed the highest percentages at S-4 West and N-10 West. The largest numbers of insects (798) were collected at Station S-17 West and the least number (28) at Station S-4 East. Highest community diversity was noted at Station S-17 West, and the lowest at N-10 East.

In general, substrate composition appeared to be the primary determinant of insect diversity and abundance. Temperatures recorded during the 1972 survey did not appear to be a significant limiting factor at the stations sampled.

6. Benthic Invertebrates

Results of the 1972 benthic invertebrate surveys are presented in Tables 11 to 13. As in 1970 and 1971, Dipterans and Oligochaetes were dominant during all sampling dates. With the exception of August when Oligochaetes predominated, the Tendipedidae (primarily *Cryptochironomous* sp.) were the most abundant forms encountered. Total numbers of all organisms collected ranged from 1009 (June) to 4863 (October) with the largest numbers being found in the shallow, more productive littoral zone stations.

A Friedman two-way analysis of variance [Siegle, 1956] ($P \leq .04$) showed that in June Station N-10 produced the largest numbers of benthic

TABLE 11. RESULTS OF BENTHIC INVERTEBRATE SURVEY

HOOKSETT POND - MERRIMACK RIVER - JUNE 8, 1972.

STATION		TEMP. °F	Oligochaeta	Hirudinea	Hydracarina	Ephemerella sp.	Coenagrionidae	Gomphus sp.	Libellulidae	Leptoceridae	Hydropsychidae	Trichopteran	Elmidae	Cryptochironomus sp.	Pentaneura sp.	Ceratopogonidae	Tendipes sp.	Tendipedidae	Dipteran pupae	Campeloma decisum	Melisoma sp.	Elliptio complanatus
N-10 W	a	63.0	18	1							1			49		1		8	3	6	1	
	b	63.0	15								2			66				12	4			
N-10 M	a	62.5												2						1		
	b	62.5												8								
N-10 E	a	62.5	50	5		1	2		1	1				15	5	1		1		5		6
	b	62.5	5											110		1		5	5	2		
Zero W	a	67.0	6											75		3		5	1			
	b	67.0	11									1		3				4	1			
Zero M	a	63.0	1		2							1		1				1				
	b	63.0												2								
Zero E	a	63.0	4											8		2			1	6		
	b	63.0	11											4	1			1		4		
S-4 W	a	63.0	16	1									1	9	1		1	1		2		1
	b	63.0	22	1				1			1			30	1	1		5	5			
S-4 M	a	63.0			1																	
	b	63.0	5										1	1				2				
S-4 E	a	66.0	2					2						46	6			6	1	3		
	b	66.0	20											10		2		1		4		2
S-17 W	a	63.0	14										3	22		7		1		5		
	b	63.0	14	1										25		3		2		1		
S-17 M	a	64.0			3									1				2	1	3		1
	b	64.0	1	1	1									1				1		2		
S-17 E	a	64.5	14										3	1		2				9		8
	b	64.5	29	7										5		2				5	1	4

TABLE 12. RESULTS OF BENTHIC INVERTEBRATE SURVEY

HOOKSETT POND - MERRIMACK RIVER - AUGUST 31, 1972

STATION	TEMP. °F	Nematoda	Oligochaeta	Hirudinea	Isopoda	Amphipoda	Hydracarina	Baetidae	Ephoron sp.	Epicordulia sp.	Trichopteran	Ancyronyx sp. adults	Dubiraphia sp.	Dubiraphia sp. adults	Cryptochironomus sp.	Cryptochironomus sp. pupae	Pentaneura sp.	Tendipes sp.	Anatopynia sp.	Anatopynia pupae	Ceratopogonidae	Tendipedidae	Tendipedidae pupae	Campeloma decisum	Helisoma sp.	Elliptio complanatus	Sphaeriidae	
N-10 W a	76.0			267	1											6		3				36	5	1				
b	76.0			58	3								1		1	1						12	2	1				
N-10 M a	74.9			1						1												3				1		
b	74.9			1				2		3											1	1	1	1				
N-10 E a	76.0			106												14		4	4		1	14	8	5				
b	76.0			235	1					1						50			9			25	5	1				
Zero W a	83.1			18	1											3		2		2	1	12	1	1				
b	83.1			3	1													2			1	3	1					
Zero M a	75.0							1																				
b	75.0									8														1				1
Zero E a	88.0			247					1									3			5	15	5	10				
b	88.0			14												14		4			5	51	7					
S-4 W a	85.0		5	545												54	6											
b	85.0			115				2						1		22					2		5					
S-4 M a	74.9									2																2		
b	74.9			1						2						1												1
S-4 E a	79.5			110		1	1									75							3	2				
b	79.5			51	3		1				1					43							4	2				
S-17 W a	75.5			53	3									2	1	9					1			1		7		
b	75.5		2	61	4	1									1	33							1	1		5		
S-17 M a	75.5			4				1		5				1		10							3	2				
b	75.5			12						3						6					3		1					
S-17 E a	81.0			6	4							4				14					8		1		1			
b	81.0			71	10							4	1		1	11					2	3		3	1			

TABLE 13. RESULTS OF BENTHIC INVERTEBRATE SURVEY

HOOKSETT POND - MERRIMACK RIVER - OCTOBER 12, 1972.

STATIONS		TEMP. °F	Dugesia sp.	Nemertea	Oligochaeta	Hirudinea	Isopoda	Amphipoda	Hydracarina	Ephoron sp.	Gomphus sp.	Hydropsychidae	Psychomyiidae	Molannidae	Dubiraphia sp. larvae	Dubiraphia sp. adults	Cryptochironomus sp.	Cryptochironomus sp. larvae	Cryptochironomus sp. adult	Tendipes sp.	Pentaneura sp.	Anatopynia sp.	Ceratopogonidae	Tendipedidae	Dipteran adult	Campeloma decisum	Helisoma sp.	Physidae	Elliptio complanatus	Anodontinae	Sphaeriidae
N-10 W	a	54.4			53	5			1						1			264					1	4		3			1		
	b	54.4			60	2			3											37				151		4			3		1
N-10 M	a	54.3		1																						1					
	b	54.3		1	2				2																						
N-10 E	a	54.0			44										1			259	1				1			4	1				
	b	54.0			29	1									1			241						1		6					
Zero W	a	56.0			37													119						11		1					
	b	56.0			4							1						4					1	3							
Zero M	a	54.2		6	1				1									2								1			1		
	b	54.2																								2			1		5
Zero E	a	57.5			86													327					19							1	
	b	57.5			91													91					8							1	3
S-4 W	a	63.9			231							1						74			8		5	59		1					
	b	63.9			201													53			6		7	29		1					
S-4 M	a	54.6			3																								1		
	b	54.6			4																1								1		2
S-4 E	a	56.0	7		70	1	7	8	2	1								169			1	1	1	166		3					
	b	56.0			77	3			1							1		309			3		1	106		3			1		2
S-17 W	a	58.0			78	4								1				41			1		4	8		7			1		
	b	58.0			192	2	1	4	2			1			21	2		347			5		14	152		23	2	1	8		6
S-17 M	a	56.0			1				2																1	5			3		
	b	56.0			6				1									1			1			2		2			2		1
S-17 E	a	57.0	2		21	8		1	7				1		1	5	1	1	23			1		10	42	1	9	2				3
	b	57.0	3		10	3		1	3					2		2			9					5	9		2		1			
New Canal		71.3		3	6				5									15						5							

invertebrates, while in August and October Station S-4 was most productive. The least numbers of organisms were found at Station Zero in June and October, and at Station S-17 in August. Reduced populations at Station Zero were likely attributable to the coarse, sandy substrate deposited as a result of dredging operations in the discharge canal.

In general, numbers and diversity of benthic organisms at individual stations appeared to be more of a response to substrate characteristics and seasonal change than to thermal discharge.

7. Fish Surveys

a) ELECTROFISHING: Fish populations were sampled by electrofishing in June, August, and October at Stations N-9 and N-10, N-6 and N-7, Zero and S-1, S-4 and S-5, and S-17 and S-18. Data on species diversity and total numbers of fish collected are shown in Figures 16 - 17. An enumerative species list is presented in Tables 14 - 16.

During June, Station N-6 and N-7 yielded the largest numbers and the greatest diversity of fish of the stations sampled. Yellow perch (*Perca flavescens*) was the most abundant form followed by white sucker (*Catostomus commersoni*). Lowest diversity and numbers were encountered at Stations S-17 and S-8, and S-4 and S-5, respectively. Yellow perch populations south of the discharge canal had an unusually high incidence of skin fungus (likely *Saprolengia* sp.) as compared to upstream stations. Of the 48 perch collected south of the canal,

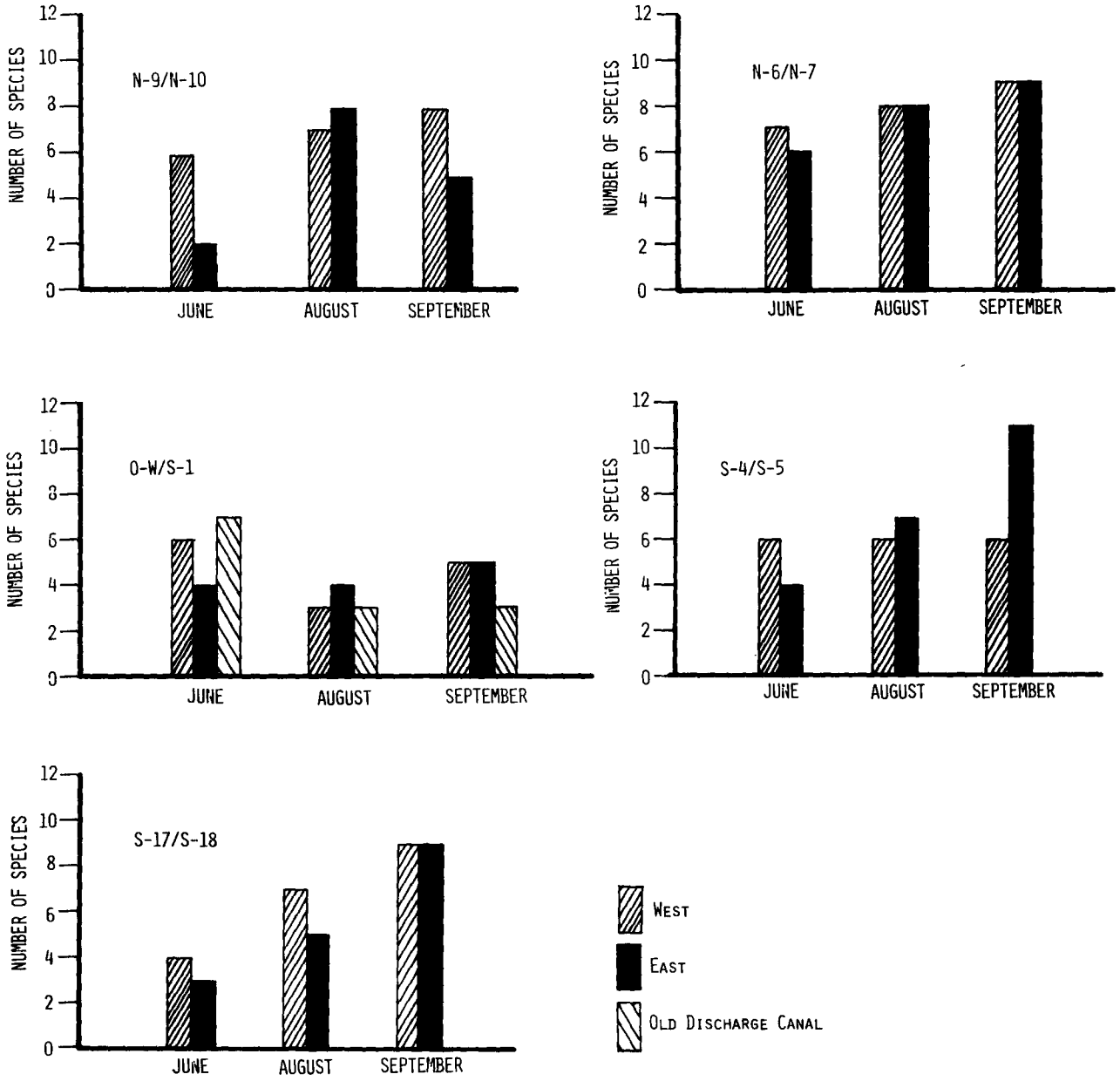


Figure 16. Numbers of species of fish collected by electrofishing at five stations, during June, August and September -- Hooksett Pond, Merrimack River.

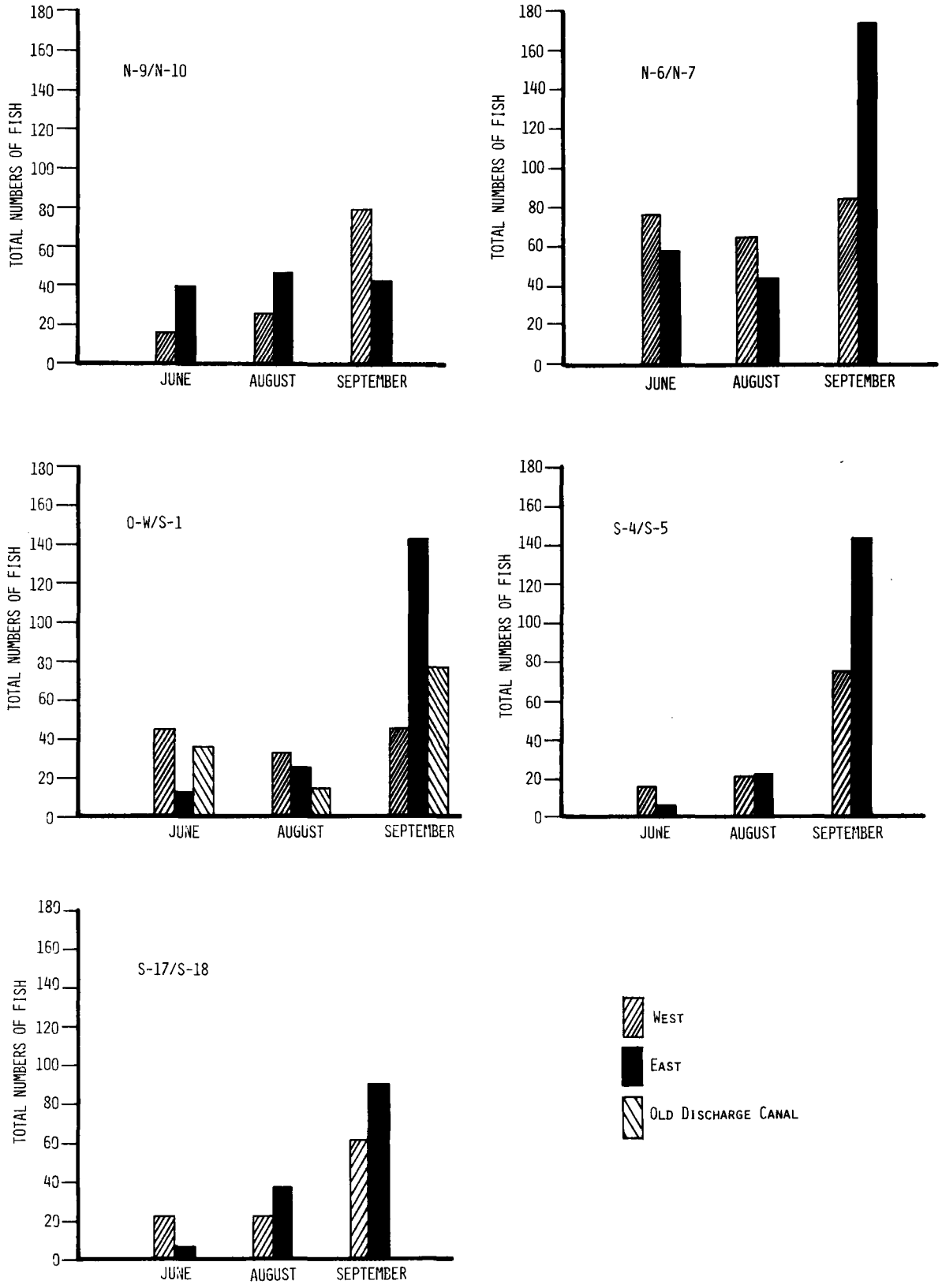


Figure 17. Numbers of fish collected by electrofishing at five stations during June, August, and September - Hooksett Pond, Merrimack River.

TABLE 14. RESULTS OF ELECTROFISHING SURVEY

HOOKSETT POND - MERRIMACK RIVER - JUNE 14-15, 1972

STATIONS		TEMP. °F	Pumpkinseed	Yellow Perch	Redbreast Sunfish	White Sucker	Brown Bullhead	Fallfish	Shiners	Smallmouth Bass	American Eel	Chain Pickerel	Largemouth Bass	Golden Shiner	Bluegill	White Perch	Yellow Bullhead
N-9/N-10	West	65.0		8		1			3		1			2	1		
	East	65.0				40			Many								
N-6/N-7	West	65.0	6	20	13	3	17	19			1						
	East	65.0	10	13		1			31	3	1						
Zero-S1	West	81.0	10	10		7			15	1	1						
	East	71.0	2	6		3									1		
Old Canal		85.5	21	2			8						2	1	1	2	
S-4/S-5	West	71.0	3	8	2	3			1		1						
	East	70.0	1	3		1	1										
S-17/S-18	West	64.5	4	16		2		1									
	East	64.5		3		1		2									

TABLE 15. RESULTS OF ELECTROFISHING SURVEY

HOOKSETT POND - MERRIMACK RIVER - AUGUST 1-2, 1972

STATIONS		TEMP. °F	Pumpkinseed	Yellow Perch	Redbreast Sunfish	White Sucker	Brown Bullhead	Fallfish	Shiners	Smallmouth Bass	American Eel	Chain Pickerel	Largemouth Bass	Golden Shiner	Bluegill	White Perch	Yellow Bullhead
N-9/N-10	West	75.4	8	12	2	2	1	1					1				
	East	75.5	21	18	1	3	2				1	1	1				
N-6/N-7	West	75.2	21	19	1	2	3	17		2		1					
	East	75.2	20	13	1	1	6			1			1				1
Zero-S1	West	77.0	25	6	1												
	East	82.0	12	2	7		4										
Old Canal		82.0	10	1									2				
S-4/S-5	West	80.0	13	4	1	1				1			1				
	East	78.0	11	5	2				Many		1	1	1				
S-17/S-18	West	73.0	7	9	3			1		1	1	1					
	East	73.0	19	12	3	2	3										

TABLE 16 . RESULTS OF ELECTROFISHING SURVEY

HOOKSETT POND - MERRIMACK RIVER - SEPTEMBER 12-13, 1972

STATIONS		TEMP. °F	Pumpkinseed	Yellow Perch	Redbreast Sunfish	White Sucker	Brown Bullhead	Fallfish	Shiners	Smallmouth Bass	American Eel	Chain Pickerel	Largemouth Bass	Golden Shiner	Bluegill	White Perch	Yellow Bullhead
N-9/N-10	West	66.6	41	17	3	1		1		2		2	13				
	East	66.6	34	3		1		1					3				
N-6/N-7	West	66.6	41	10	2	2	1	13				1	15	1			
	East	66.0	107	15	1	10	2				4	2	31				1
Zero-S1	West	78.1	23	3	4					3			12				
	East	78.6	104		20		11			1			5				
Old Canal		79.5	65		4								8				
S-4/S-5	West	75.6	59	1	14		1				1		1				
	East	76.5	96	6	15	1	Many			4	4	1	10	3			
S-17/S-18	West	72.7	28	8	8	1	4				3	2	5	2			
	East	71.1	63	3	1	1	5			1	2	1	13				

12% (6) were infected, while north of the canal none of the 41 fish showed symptoms. The majority of the fish afflicted (4) were taken in the area from Station Zero-West to S-5 West. A total of 340 fish were collected during the June survey.

In August, pumpkinseed sunfish (*Lepomis gibbosus*) and yellow perch were the predominant species collected. Stations N-6 and N-7 again showed the greatest species diversity and total numbers probably due to substantial amounts of aquatic vegetation at that location. The smallest sample diversity was noted at Stations Zero and S-1 and lowest numbers were found at Stations S-4 and S-5. The total number of fish collected during the August electrofishing survey was 259.

The September survey produced 1,013 fish with the greatest diversity encountered at stations N-6/N-7, S-4/S-5, and S-17/S-18 and the highest numbers at N-6/N-7. Increased amounts of aquatic vegetation at Stations S-4 and S-5 undoubtedly contributed to the diversity of fish species at that location. Higher numbers of fish were also associated with greater aquatic plant production at most stations. As in August, the least diverse sample was collected at Stations Zero and S-1. Station N-9 and N-10 produced the lowest numbers of fish during the survey. The predominant species collected in September were pumpkinseed sunfish and largemouth bass (*Micropterus salmoides*).

On each of the three electrofishing dates both the old discharge canal and the spray module canal were sampled. No fish were collected in the new spray module canal, but under essentially the same thermal conditions the old canal produced significant numbers and diversity of fish (Figures 16 - 17; Tables 14 - 16).

In general, either Station Zero to S-1, or S-4 to S-5 showed reduced diversity and/or numbers on all electrofishing dates. Fish habitat at these two stations was different from that found at most other stations. Consequently, as was the case in 1971, it is difficult to separate potential temperature effects from those of habitat on all dates sampled. Seasonal composition of fish populations was similar both north and south of the discharge canal.

b) FYKE NETTING: Length frequency and age range data for pumpkinseed sunfish, yellow perch, and smallmouth bass are presented in Figures 18 - 20. Additional information on various age classes collected is shown in Table 17. As shown by the figures, in certain instances small sample sizes limited in-depth analysis of the fish community age structure. As expected, stations with more extensive littoral zones (N-10 West and S-2 West) were the most productive.

During the August samplings southern stations produced the largest numbers of fish as shown by Figure 18 and Table 18. The

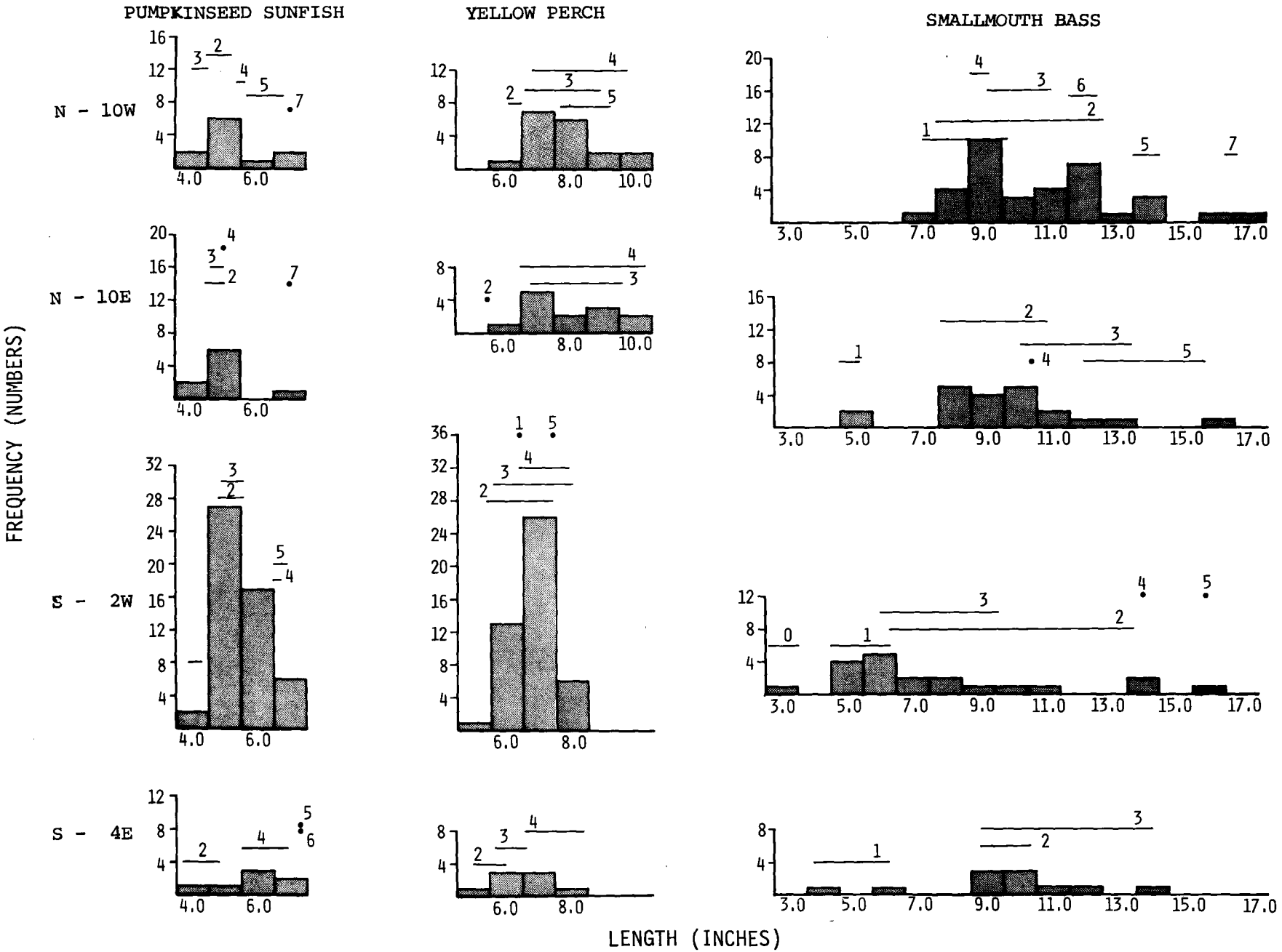


Figure 18. Length frequency distributions and age ranges for three species of fish collected by fyke

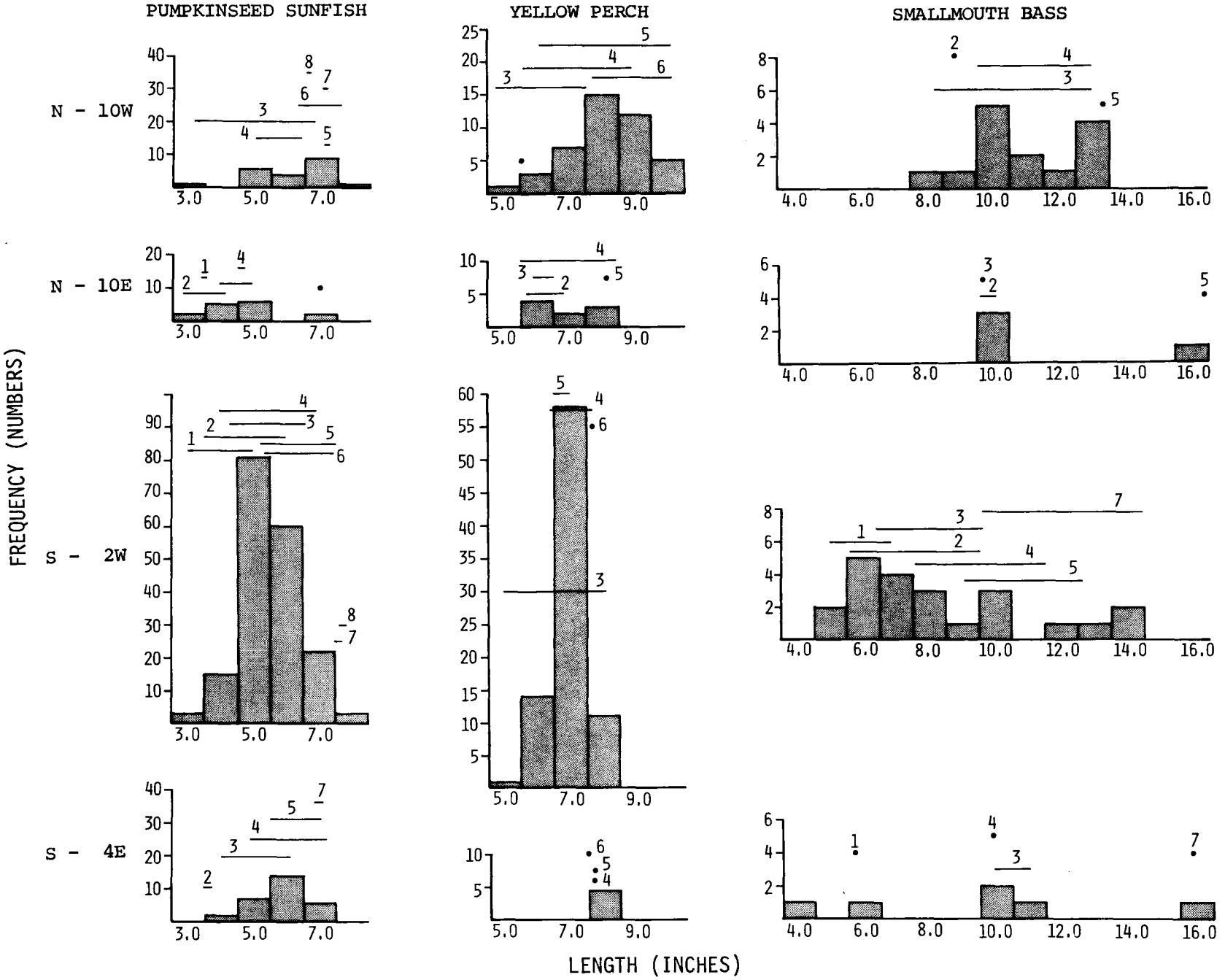
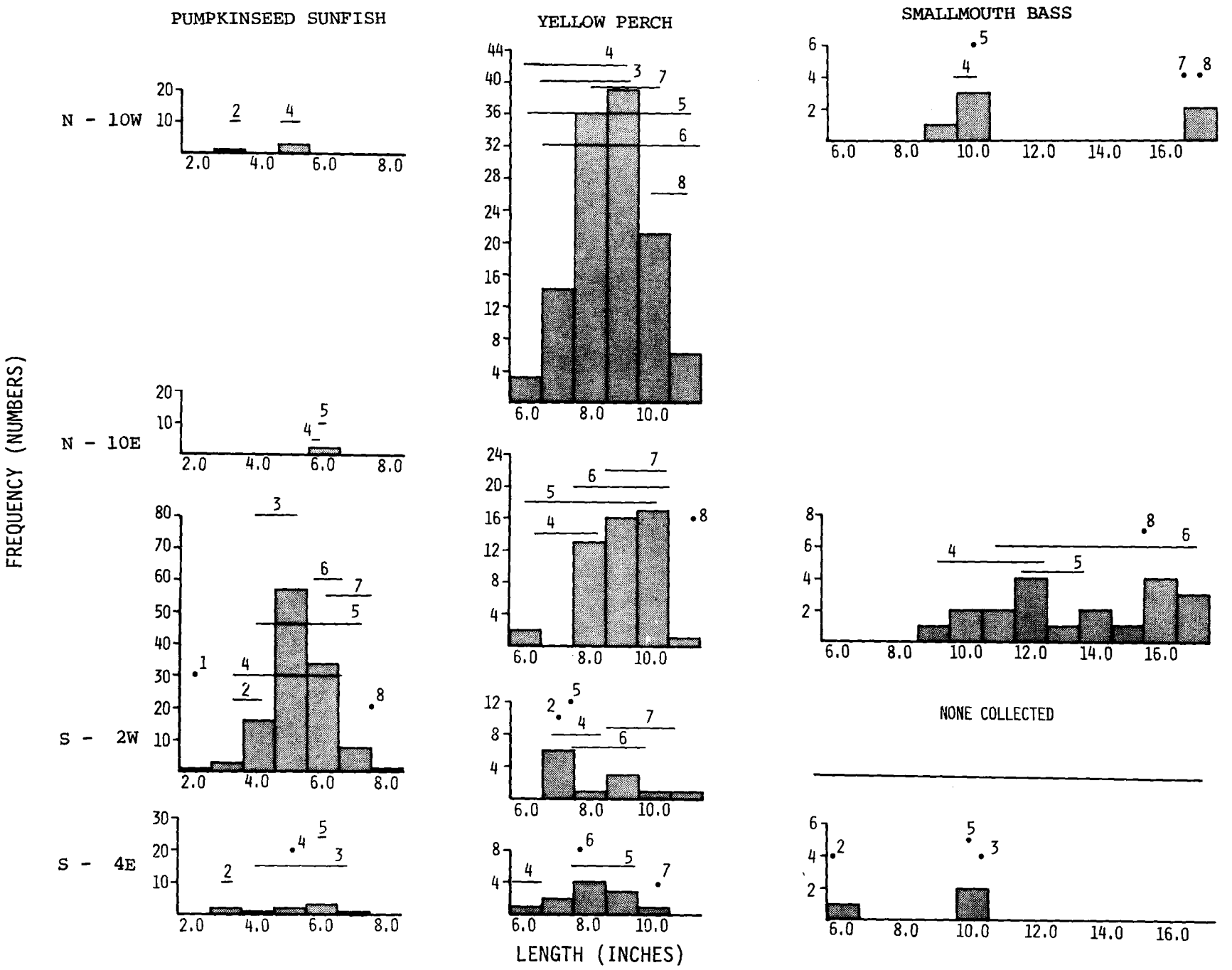


Figure 19. Length frequency distributions and age ranges for three species of fish collected by fyke netting, September, 1972.



...th frequency distributions and age ranges for three species of fish collected by fyke

TABLE 17. NUMBERS OF VARIOUS AGE CLASSES OF FISH COLLECTED BY FYKE NETS NORTH AND SOUTH OF THE DISCHARGE CANAL.

PUMPKINSEED SUNFISH

Station	Date	Age Class								
		1	2	3	4	5	6	7	8	Total
N-10E	Aug. 1972		4	2	2			1		9
	Sept.	1	5	5	1	2				14
	Oct.				1	1				2
N-10W	Aug.		4	2	1	2		1		10
	Sept.			4	6	3	5	1	1	20
	Oct.		1		3					4
S-4E	Aug.		2		3	1	1			7
	Sept.		1	8	12	4		1		26
	Oct.		2	3	1	3				9
S-2W	Aug.	3	5	17	7	4	2			38
	Sept.	6	7	26	21	12	3	1		76
	Oct.	1	3	8	19	26	3	3	1	64

SMALLMOUTH BASS

Station	Date	Age Class								
		1	2	3	4	5	6	7	8	Total
N-10E	Aug.	2	14	2	1	2				21
	Sept.		2	1		1				4
	Oct.				7	2	10		1	20
N-10W	Aug.	5	17	3	2	3	3	2		35
	Sept.		1	6	6	1				14
	Oct.				3	1		1	1	6
S-4E	Aug.	2	2	7						11
	Sept.	1		2	1			1		5
	Oct.		1	1		1				3

100

60 by Oct 5.

TABLE 17. (CONT.)

SMALLMOUTH BASS (cont.)

Station	Date	Age Class								
		1	2	3	4	5	6	7	8	Total
S-2W	Aug.	7	7	3	1	1				19
	Sept.	6	5	3	4	2		2		22

YELLOW PERCH

Station	Date	Age Class								
		1	2	3	4	5	6	7	8	Total
N-10E	Aug.		1	2	8	1				12
	Sept.		2	3	3	1				9
	Oct.				4	13	20	10	1	48
N-10W	Aug.		2	7	7	2				18
	Sept.		1	4	11	17	9			42
	Oct.			5	7	22	21	6	2	63
S-4E	Aug.		2	3	3					8
	Sept.				2	1	1			4
	Oct.				2	7	1	1		11
S-2W	Aug.	1	10	13	10	1				35
	Sept.			18	16	5	1			40
	Oct.		1		3	2	4	2		12

TABLE 18. FISH SPECIES COLLECTED BY FYKE NETTING NORTH AND SOUTH OF THE DISCHARGE CANAL DURING AUGUST, SEPTEMBER, AND OCTOBER 1973

SPECIES	AUGUST		SEPTEMBER		OCTOBER	
	NORTH	SOUTH	NORTH	SOUTH	NORTH	SOUTH
Redbreast sunfish	9	5	2	2	---	---
Largemouth bass				2		2
Chain pickerel	4	3	17	7	8	3
Brown bullhead	62	319	106	398	388	324
Yellow bullhead			4	2	23	15
White sucker	44	88	11	46	51	104
White perch	9	38	4	19	0	6
Golden shiners			9	1		1
Eel	7			5	1	3

dominant species collected both north and south of the discharge canal was the brown bullhead (*Ictalurus nebulosus*). Productivity in terms of the three principal species studied (pumpkinseed sunfish, smallmouth bass, and yellow perch) was also greater at the southern stations as a result of high numbers of pumpkinseeds and yellow perch. Smallmouth bass populations appeared to be higher at the northern stations with the deep water station (N-10 West) producing the largest numbers. During one occasion at Station N-10 East, difficulties with the net probably reduced total numbers of fish collected.

Total-length classes of pumpkinseed sunfish collected both north and south of the discharge canal consistently ranged from 4.0 to 7.0 inches, with five inch fish being dominant at most stations. Fish of this length were largely of age groups II and III. Six-inch fish collected at Station S-2 West were representative of age groups III and IV.

Total-length classes of yellow perch sampled north of the discharge canal ranged from 6.0 to 10.0 inches. Seven and eight inch fish predominated at most stations and for the most part represented age groups III and IV. The majority of six-inch fish collected at all stations were from age groups II and III.

Smallmouth bass collected during August displayed a wider variation of total lengths (ranging from 3.0 to 17.0 inches) than did other species. Fish nine to twelve inches in length at all

stations largely represented age groups II and III. At stations south of the discharge canal, where smaller bass were collected, four to six inch fish were largely representative of age group I, and one three-inch specimen was aged as a young of the year (Age Group 0).

As is obvious from the August data, the three species studied did not include sufficient numbers to make possible rigid age/length comparisons. Generally, with the exception of the smallmouth bass, the distributions were comparable.

In September the southern stations produced the greatest numbers of fish. These were primarily brown bullhead, yellow perch, and pumpkinseed sunfish (Figure 19 and Table 18). Unlike August, greater numbers of smallmouth bass were collected south of the discharge canal than at the northern stations largely due to high abundances in collections made at Station S-2 West.

Total lengths of pumpkinseed sunfish collected during September ranged from three to eight inches. Five and six inch fish from stations north and south of the canal largely represented age groups III and IV, and seven inch fish were predominately IV and V year-olds.

Yellow perch ranged from 5.0 to 10.0 inches. Limited numbers of this species were collected at Stations S-4 and N-10 East. In comparing the two remaining stations, six and seven inch fish represented age groups III and IV, while eight inch fish compared

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age groups IV and V. As was true with the pumpkinseed, little difference in size and age structure was noted among stations.

In September, and to a lesser degree in August, the majority of smallmouth bass collected south of the discharge canal were younger than those of northern stations. Total lengths south of the canal ranged from 4.0 to 16.0 inches, while those at the northern stations ranged from 8.0 to 16.0 inches. The five to seven inch fish at the southern stations represented mostly age groups I and II. These groups were not strongly represented north of the discharge canal. Eight and ten inch fish at all locations were predominately from age groups III and IV.

In October, greater numbers of fish were collected at stations north of the discharge canal. Brown bullheads remained the dominant species collected, followed by yellow perch and pumpkinseed sunfish (Figure 20 and Table 18). For the first time during the three-month fyke-netting period, numbers of brown bullhead at both north and south stations were approximately equal. Total numbers of fish collected were likely limited by difficulties encountered with the nets on two occasions at N-10 East and at S-4 East.

Total lengths of pumpkinseed sunfish ranged from 2.0 to 8.0 inches. Comparisons between stations were not possible due to limited numbers of this species collected at all locations with the exception of S-2 West. As was true in other months, five and six inch fish were most common and in October appeared largely

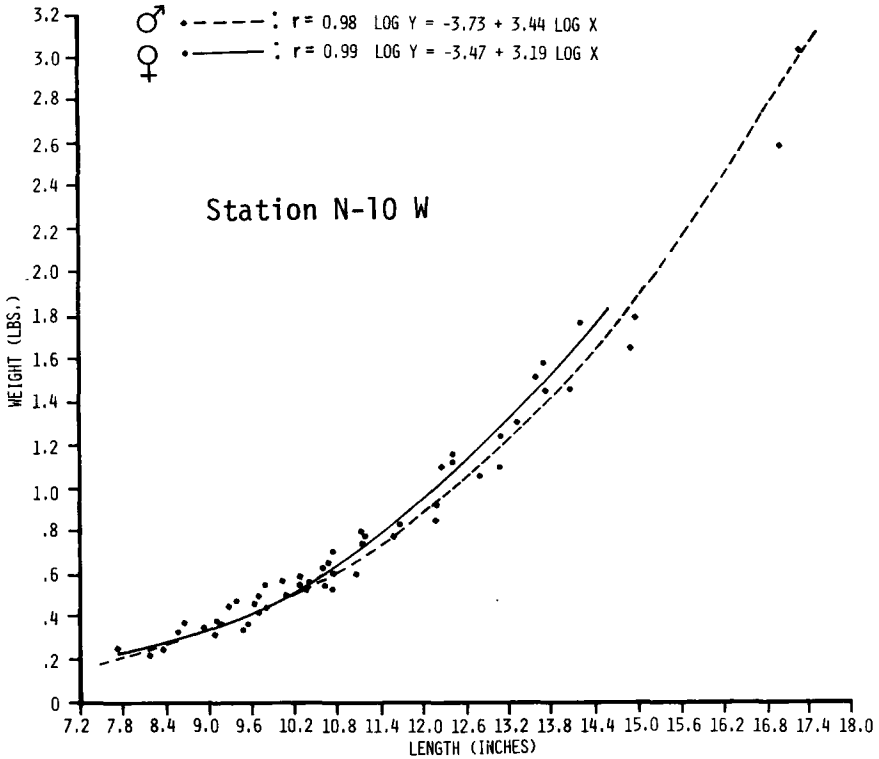
representative of age groups III to V.

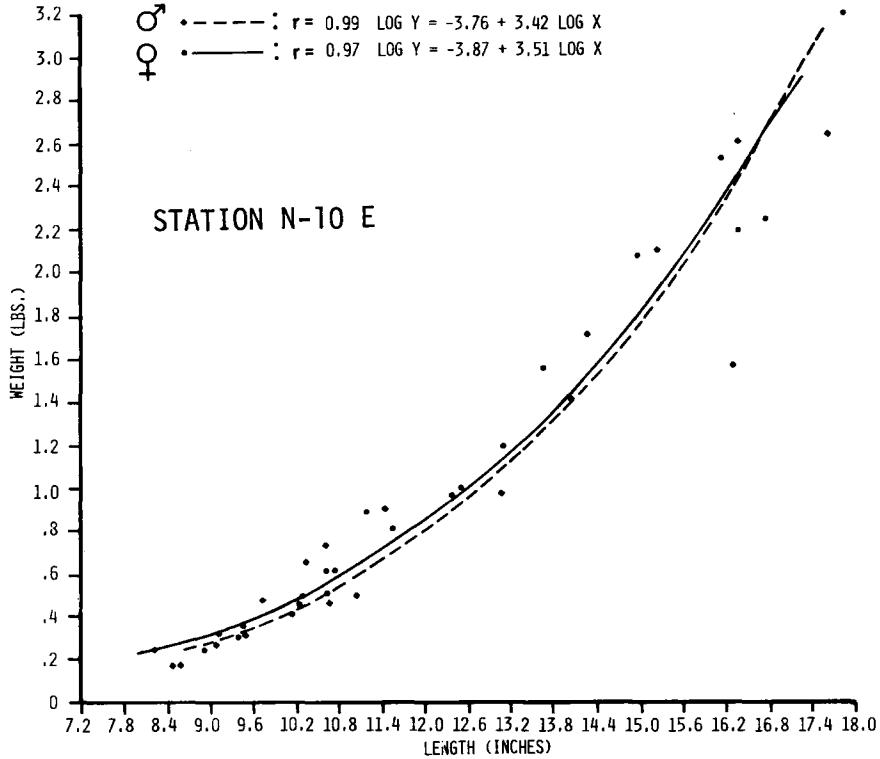
Yellow perch had total lengths ranging from 6.0 to 11.0 inches and were found in greatest numbers at Station N-10 West. Eight and nine inch fish, which were most common, were largely from age groups IV to VI. Ten inch fish represented age groups VI to VII.

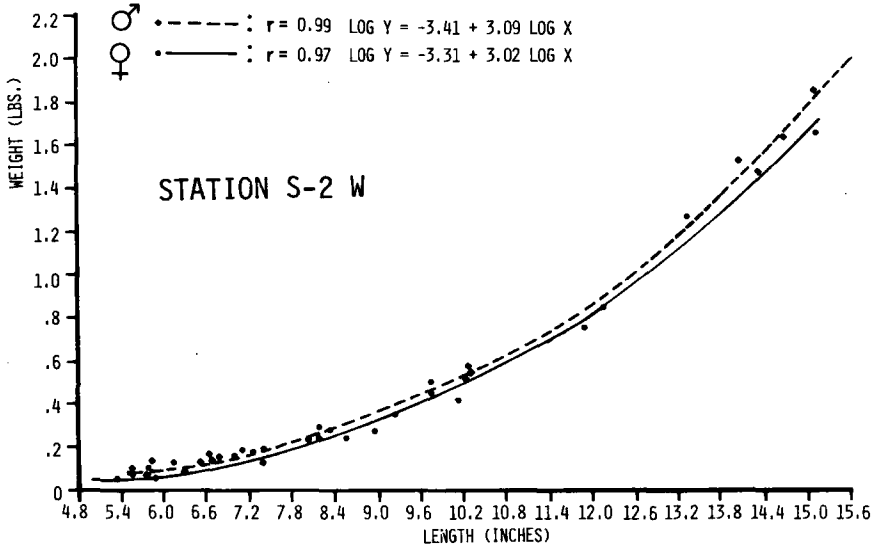
Catches of smallmouth bass were also small in October. Total lengths and ages of fish collected at Station N-10 East were comparable to those encountered from earlier samples.

Length/weight relationships for smallmouth bass, pumpkinseed sunfish, and yellow perch caught over the entire study year are shown in Figures 21, 22, and 23. Separate calculations were made for the sexes. It was not feasible to produce seasonal relationships for females within the study year. However, since female condition did not change markedly within the study period, viz. -- the majority of females of all species were gravid most of the season, -- this was thought not to impart a bias.

Correlation coefficients (r) were high in all cases, indicating low dispersion of sample points around each line. Slopes of the general logarithmic relationships centered about a value of 3.0, indicative of the "cubic relationship" characteristic of many species where weight equals the cubed length times some constant. Length/weight relationships were generally comparable among stations within the limits of precision set by sample sizes. Female yellow perch and smallmouth bass had an apparently lower rate of weight increase per







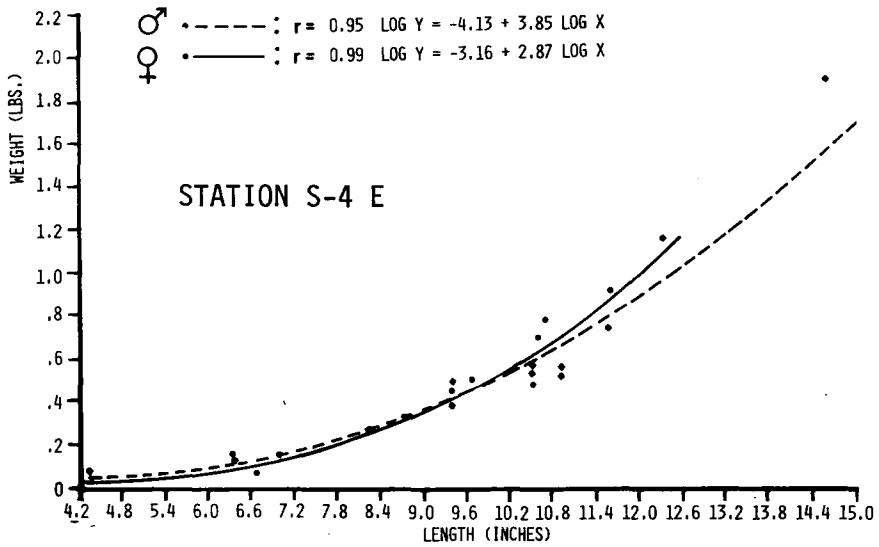


Figure 21. Length/weight relationships of smallmouth bass collected by fyke netting -- Hooksett Pond, Merrimack River, 1972.

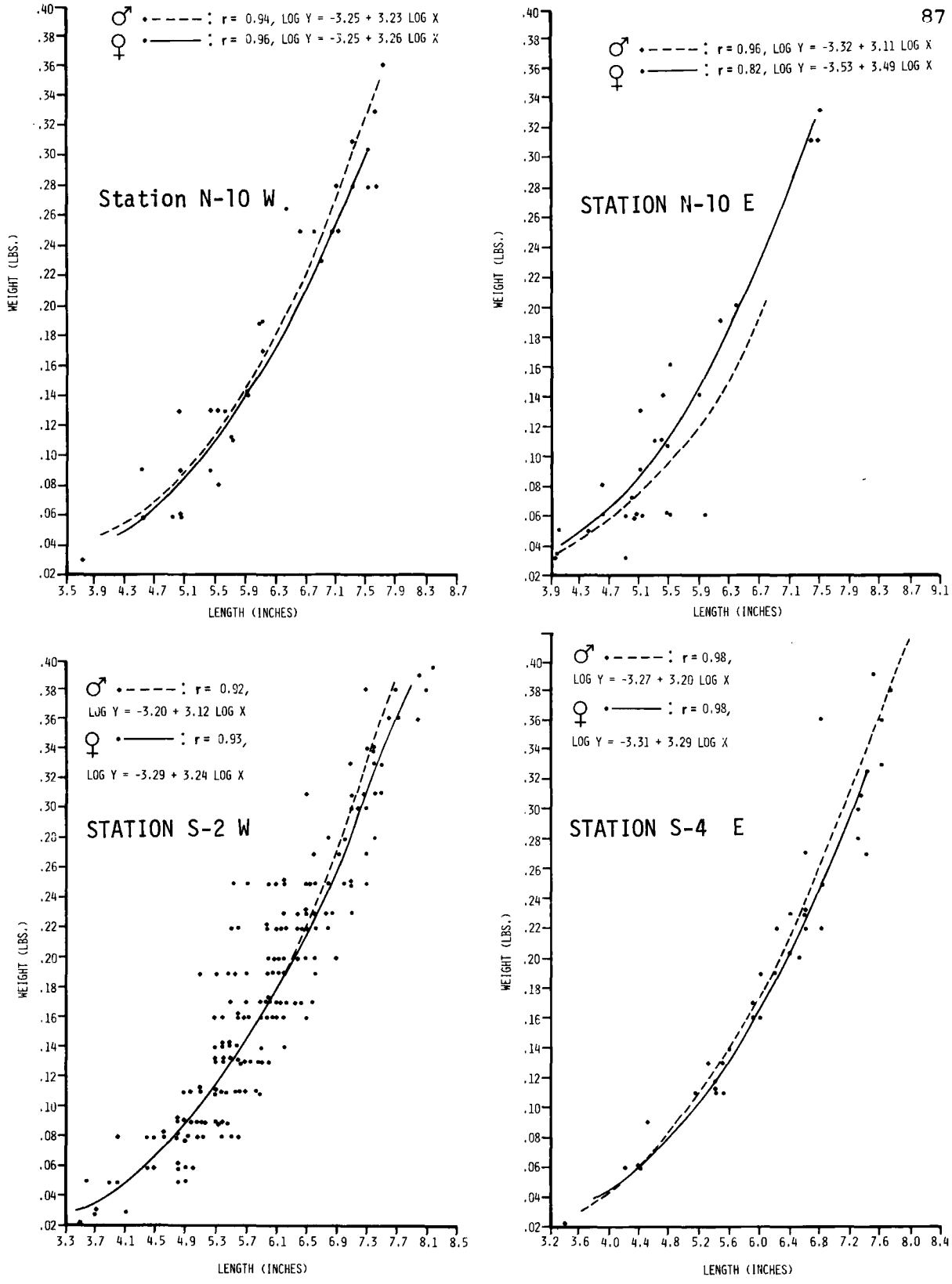


Figure 22. Length/weight relationships of pumpkinseed sunfish collected by fyke netting -- Hooksett Pond, Merrimack River, 1972.

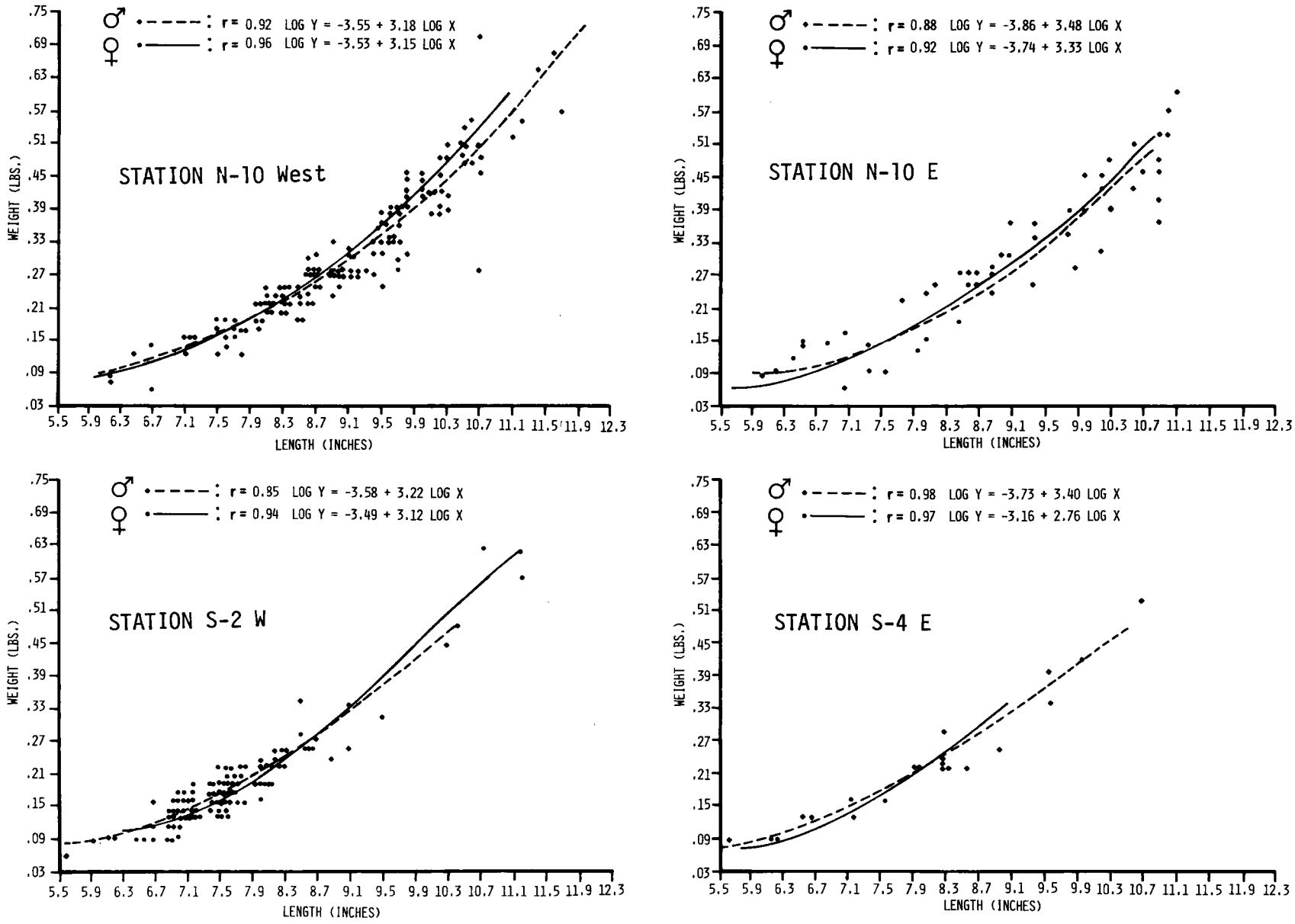


Figure 23. Length/weight relationships of yellow perch collected by fyke netting -- Hooksett Pond, Merrimack River, 1972.

unit length at Station S-4 East, but only 18 and 12 fish, respectively, were available for inclusion in the calculations.

In summary, results of the 1972 fyke netting program indicated no substantial differences between age structure or length/weight relationships in populations of smallmouth bass, yellow perch, or pumpkinseed sunfish north and south of the discharge canal. Examination of length/weight relationships for populations of pumpkinseed sunfish did indicate a slight trend toward greater weight south of the canal when compared to fish of comparable length at northern stations. August and September collections of smallmouth bass at Station S-2 West indicated the presence of a population comprised of younger age groups than found north of the canal. It is probable that this was the result of the abundance of vegetative cover and the shallow littoral zone at this station. The predominant species at both the upstream and downstream stations was the brown bullhead (Table 18). Wightman's intensive Merrimack River fyke-netting program (1971) found pumpkinseed sunfish to be the most common species at southern stations and either yellow perch, pumpkinseed, or white sucker to dominate northern stations. Chain pickerel (*Esox niger*) and yellow bullhead (*Ictalurus natalis*) tended to occur in larger numbers north of the canal, while white sucker (*Catostomus commersoni*), white perch (*Morone americana*), and brown bullhead (*Ictalurus nebulosus*) tended to be more common south of the canal.

V. SUMMARY AND CONCLUSIONS

As in past years, pH and nutrient concentrations showed little or no differences among stations, while dissolved oxygen concentrations were slightly reduced at stations south of the discharge canal. Concentrations of chlorophyll *a* corresponded to seasonal trends in plankton numbers and were less at Station Zero-West than at other stations sampled. Numbers of planktonic yellow-brown and green algae were reduced at Station Zero-West. These reductions were still evident at Station S-17. Periphyton communities showed similar responses at Zero-West and all stations south of the discharge canal with numbers of diatoms (yellow-brown algae) being reduced at these locations. Some signs of recovery were noted at Stations S-4 and S-17, however. Fisheries studies revealed no apparent negative effects of the thermal effluent. An incidence of skin fungus was found among yellow perch populations south of the discharge canal. It is not known whether this condition was attributable to power plant operations. Length/weight relationships of yellow perch, pumpkinseed sunfish, and smallmouth bass at four stations sampled were generally comparable, although female yellow perch and smallmouth bass, from the data at hand, had lesser rates of weight increment per unit length at Station S-4 East. Results of aquatic plant, insect, and benthic sampling indicated that numbers and diversities were largely dependent on habitat suitability.

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