AR-1141

MERRIMACK RIVER MONITORING PROGRAM

A Report for the Study Period 1971

Prepared for

Public Service Company of New Hampshire

by

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APRIL 1972

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ABSTRACT

The 1971 Merrimack River Monitoring Program was designed to determine any ecological effects resulting from the heated discharge of the Merrimack Generating Station. Biological parameters monitored were plankton, periphyton, aquatic plants and insects, benthic invertebrates, and fish. Physical and chemical parameters measured in conjunction with the biological were temperature, flows, transparency, nutrients, dissolved oxygen, and pH. Results of the monitoring program indicated that most thermally related adverse effects were limited to the immediate area of the discharge canal. Fish sampling indicated some limitation of populations as far south as Station S-5, although it is difficult to attribute this limitation entirely to temperature effects. Phytoplankton numbers increased in 1971 as did concentrations of dissolved oxygen, and pH, but nutrients showed a marked reduction from 1970 levels.

MERRIMACK RIVER MONITORING PROGRAM - 1971

I. INTRODUCTION

The second year of the Merrimack River Monitoring Program was initiated in April of 1971. 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.

The area of concentration of the study included the 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 84.00. Sampling stations utilized were established on transects located north and south of the mouth of the discharge canal (Station Zero) of the Generating Station, and numbered N-1 to N-10 and S-1 to S-18 respectively. The northern stations, particularly N-10, were used to represent ambient river conditions as contrasted to the thermally affected zone south of the discharge. The portion of the river studied is fairly

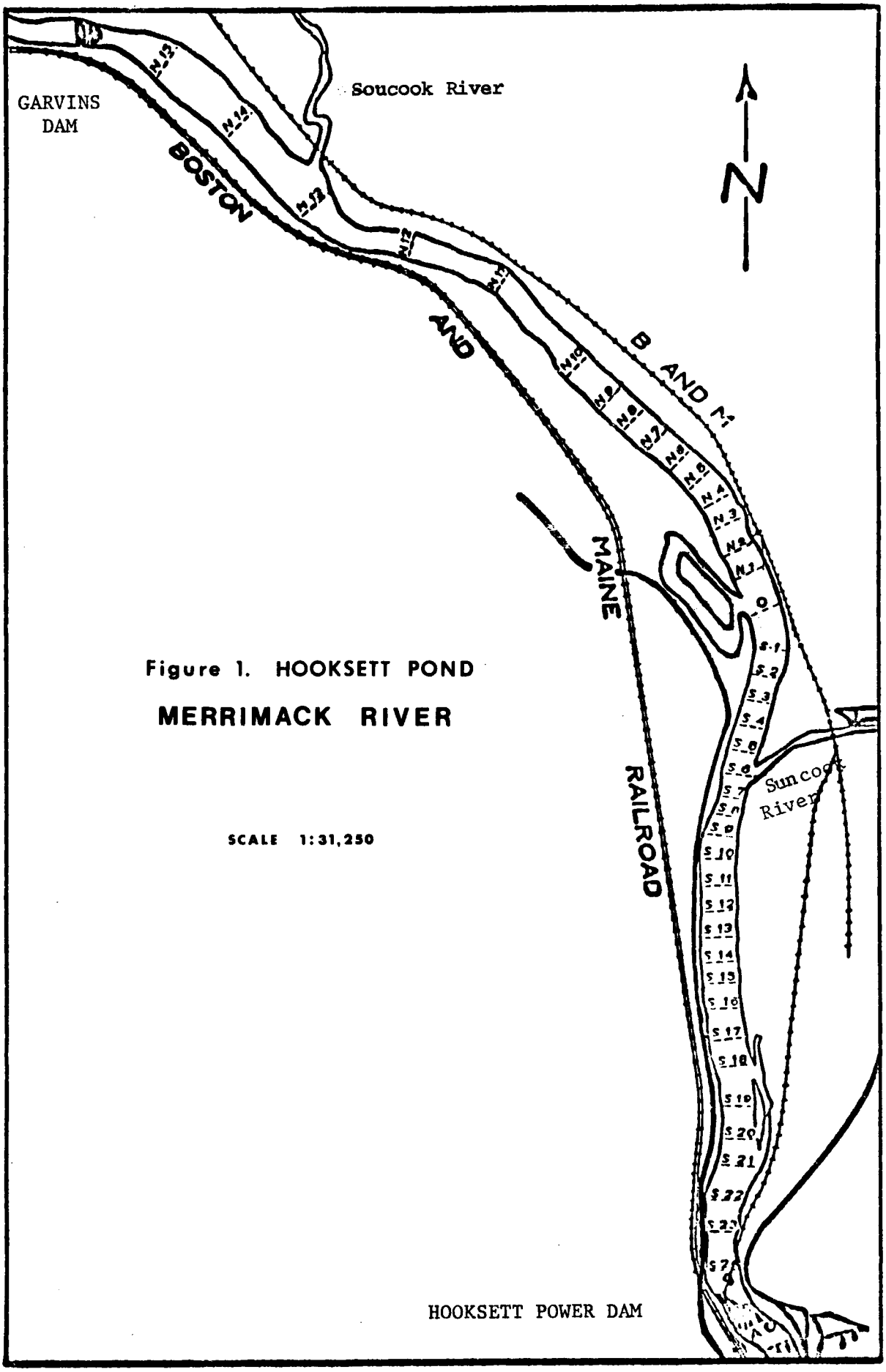

Figure 1. HOOKSETT POND

MERRIMACK RIVER

SCALE 1:31,250

uniform, with an average width of 500 to 700 feet. Much of the river is relatively shallow with most sections being less than 10 feet in depth, although depths of over 20 feet are attained.

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 personnel. Additional flows from the Soucook and Suncook Rivers entering the Merrimack below the gauging station were not studied as their flow contributions were felt to be slight.

2. Depth of Visibility

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

3. Temperature

Three types of temperature studies were completed during the 1971 project year: a) continuous monitoring of surface temperatures;

b) monitoring of surface and bottom temperatures; and c) periodic temperature profile studies.

a) CONTINUOUS MONITORING - Temperature monitoring was carried out by personnel of the Public Service Company of New Hampshire at Stations N-10, Zero, and S-4. Instruments utilized were Rustrak strip recorders with standard thermistor probe inputs. At Stations N-10 and S-4 probes were suspended near mid-channel at a depth of one foot. Due to power spray module construction activities, the Station Zero probe was suspended approximately 400 feet downstream from the plant outfall and 86 feet from the west bank of the river. Temperature monitoring was continued until winter ice conditions necessitated removal of the instruments.

b) SURFACE AND BOTTOM TEMPERATURES - Weekly surface and bottom temperature readings were taken with a Yellow Springs Instrument Company field thermistor system at Stations N-10, Zero west, S-4, and S-17. All temperatures, with the exception of those taken at Station Zero, were measured at mid-river. Periodic calibration of the field thermistor unit was done with a precision grade mercury thermometer.

c) TEMPERATURE PROFILES - Thermal stratification occurring in the Merrimack River was measured on June 8, June 28, and August 6, 1971. The instrument utilized was a Martek Model 101 temperature, depth, and conductivity meter which was checked periodically against 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 (Station N-10) was re-measured before proceeding to the southern-most stations.

B. RESULTS AND DISCUSSION

1. Flows

Flow data were analyzed by looking at cumulative frequencies using log probability paper as suggested by the U. S. Public Health Service

(1964). An example of this method is given in Figure 2. The log scale was used on the ordinate since arithmetic frequency distributions of flow data are skewed but become approximately normal through use of logarithms. From these, monthly flow graphs (Figure 3) were prepared which show mean flows ±1 standard deviation (± 34% of the mean) as determined from the probability graphs.

Flows for the year ranged from 492 cfs to 24,492 cfs. As would be expected, the spring months experienced the highest and most variable flow rates, while July exhibited the lowest consistent flows with 68% of the days falling below 1,000 cfs. Examination of the data indicates that flows in 1971 were lower than in 1970[1].

2. Depth of Visibility

Weekly visibility measurements taken throughout the study are presented in Table 1. Readings were essentially consistent between stations, with lowest readings occurring in April and May during periods of highest flows. Values ranged from a low of 3'6" in April to a high of 8'0" in September. There is a trend toward lower readings during periods of low flows and higher temperatures (July and August), with an increase during September. This same phenomenon was noted

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[1]Merrimack River Monitoring Program. A Report for the Study Period 1970.

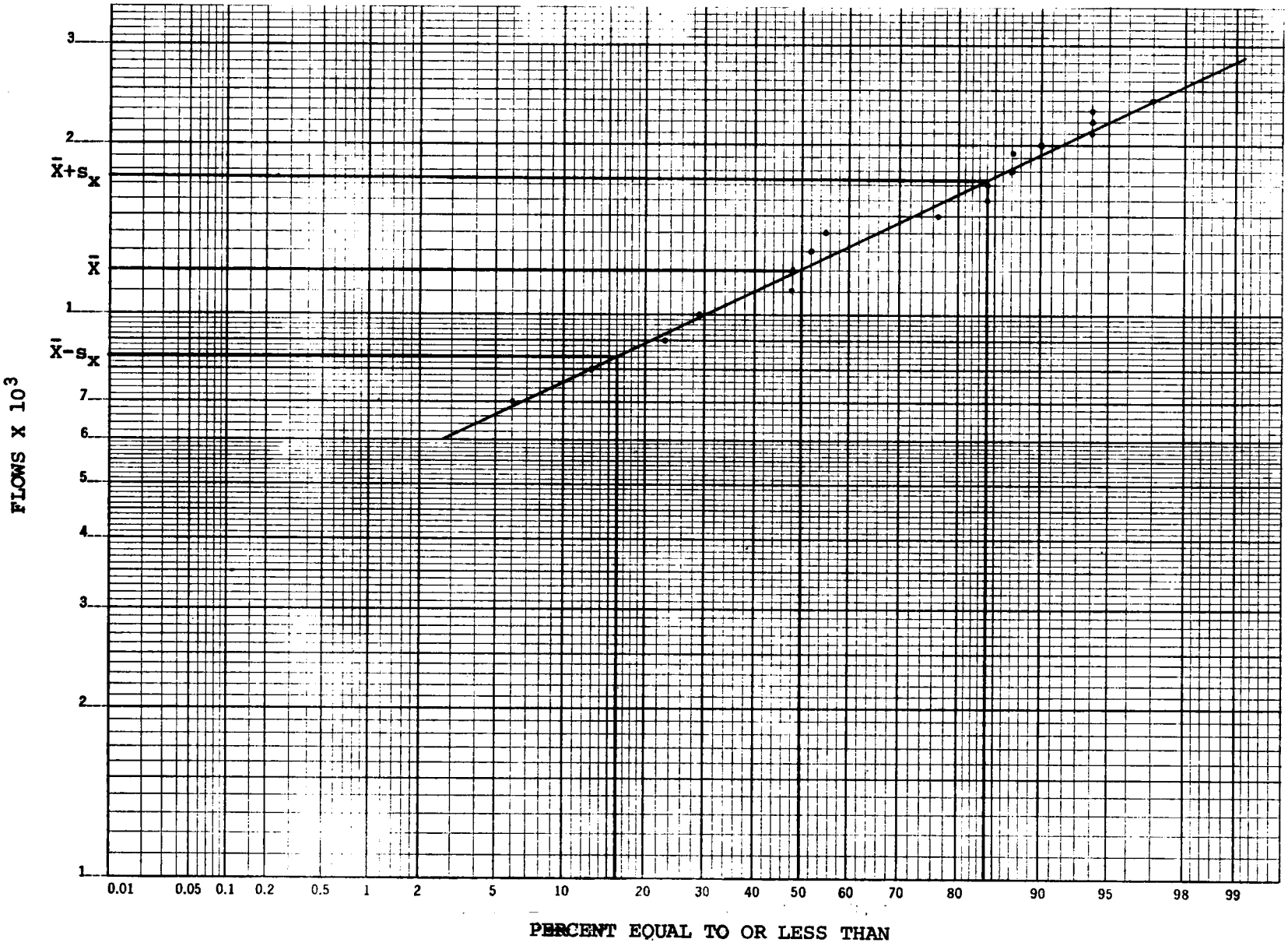

Figure 2. Log probability distribution of daily flows - Garvins Falls, Merrimack River, Bow, New Hampshire - May 1971.

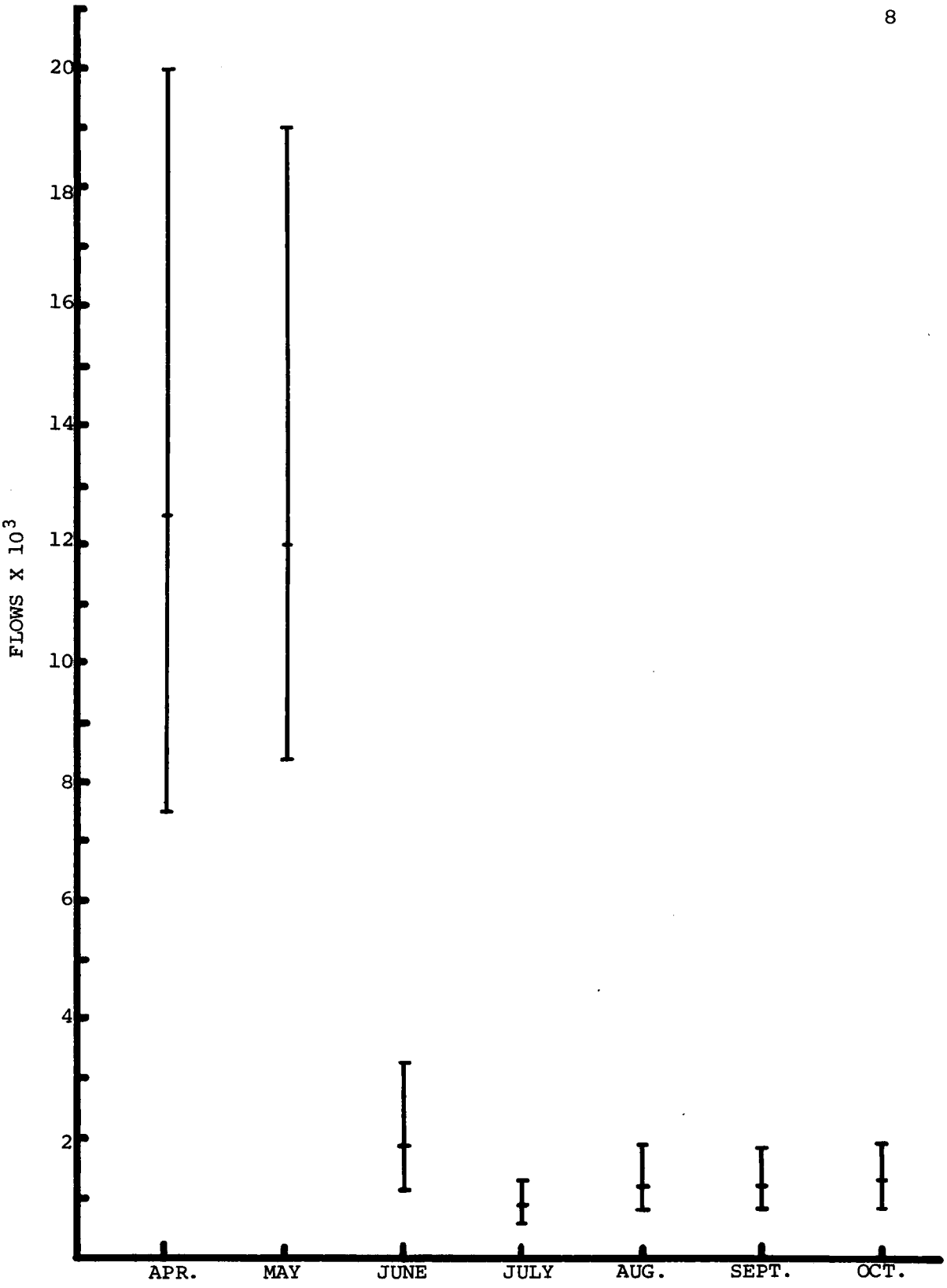

Figure 3. Mean monthly flows ± 1 standard deviation - Garvins Falls, Merrimack River, Bow, New Hampshire.

TABLE 1

DEPTH OF VISIBILITY MEASUREMENTS

HOOKSETT POND - MERRIMACK RIVER - 1971

Sampling Dates 1971	Station N-10	Zero	S-4	S-17
April 7	3' 6"	3' 6"	3' 6"	3' 6"
April 12	4' 6"	5' 0"	4' 6"	4' 6"
April 16	- - -	- - -	- - -	- - -
April 27	- - -	- - -	- - -	3' 6"
May 5	- - -	- - -	- - -	- - -
May 11	3' 6"	3' 6"	3' 6"	3' 6"
May 18	4' 6"	5' 6"	5' 6"	6' 0"
May 25	5' 0"	4' 0"	5' 0"	5' 6"
June 2	7' 6" B	5' 6"	7' 0"	7' 0"
June 9	5' 6"	5' 0"	5' 6"	5' 0"
June 16	6' 6" B	3' 6" B	7' 0"	5' 6" B
June 22	5' 0"	4' 0" B	5' 0"	5' 6"
July 1	5' 6"	5' 6" B	5' 6"	5' 6"
July 8	5' 6"	4' 6" B	5' 0"	4' 6"
July 19	5' 0"	5' 0" B	5' 0"	4' 6"
July 26	5' 0"	5' 0"	4' 6"	4' 6"
August 5	5' 6"	5' 0"	5' 6"	5' 6"
August 12	5' 0"	5' 0"	5' 0"	5' 0"
August 18	5' 0"	4' 0"	4' 0"	4' 0"
August 26	5' 0"	5' 0"	4' 6"	4' 6"
September 3	6' 0" B	5' 0" B	6' 0"	5' 6"
September 9	7' 0" B	5' 0" B	6' 0"	6' 0" B
September 16	7' 0"	8' 0"	5' 0"	6' 0"
September 23	8' 0" B	6' 0"	6' 0"	6' 6" B
September 30	6' 0" B	6' 0" B	7' 6"	6' 6" B
October 7	5' 6"	6' 0"	7' 0"	5' 0" B
October 14	5' 0"	5' 0"	5' 0"	5' 0"
October 22	6' 6"	6' 6"	7' 0"	6' 6"

B - Bottom

in the 1970 study. Chlorophyll a and plankton analyses, to be presented later, show a seasonal relationship to depth of visibility readings.

3. Temperature

a) CONTINUOUS TEMPERATURE MONITORING - Monthly means and standard deviations of daily temperature maxima are presented in Figure 4. Due to equipment malfunctions, significant gaps occurred in the data for May, June, and October which precluded their presentation in a like manner (Table 2). As indicated by the figure, peak thermal conditions occurred in July when monthly means of daily maxima at Station N-10 reached 80.3° F with a mean Δt of 22.7° F between N-10 and Station Zero[2]. At Station Zero, 77% of the July temperatures were over 100° F. During the months of July, August, and September, mean temperature differences between S-4 and N-10 remained fairly consistent, ranging from 9.0° F to 10.3° F.

b) SURFACE AND BOTTOM TEMPERATURES - Surface and bottom temperatures are presented in Figures 5 and 6. Peak ambient temperatures occurred during the July low flow period. Little or no temperature stratification occurred north of the Merrimack Power Plant as indicated by the surface to bottom temperature differential of 0.0° to 3.0° F, with a mean difference of 0.3° F over the study season. Surface temperatures at Station Zero west ranged from

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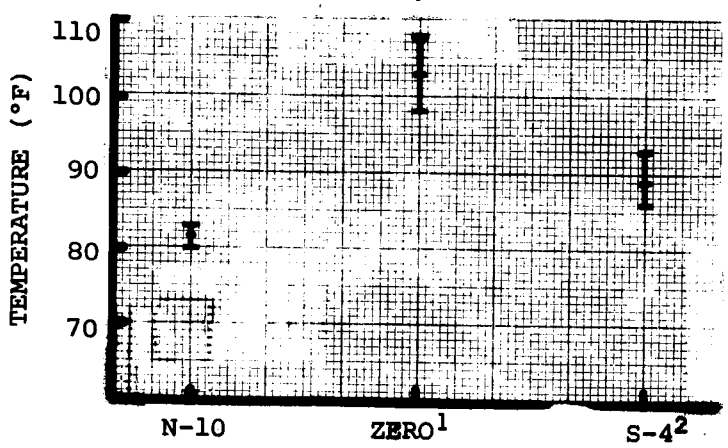
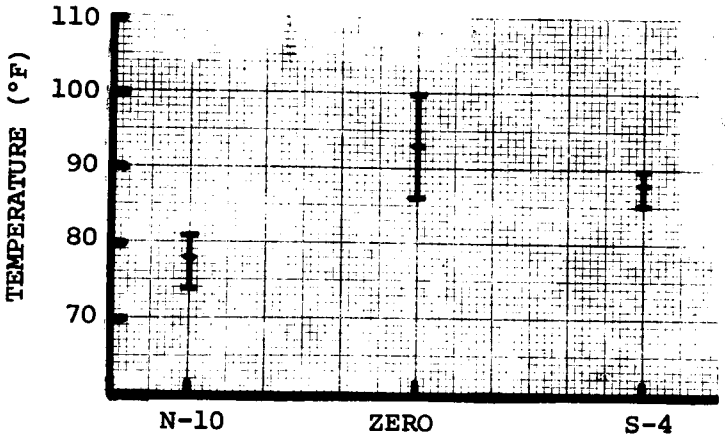
[2]This temperature change may be slightly under-estimated due to the location of the Station Zero thermistor probe.

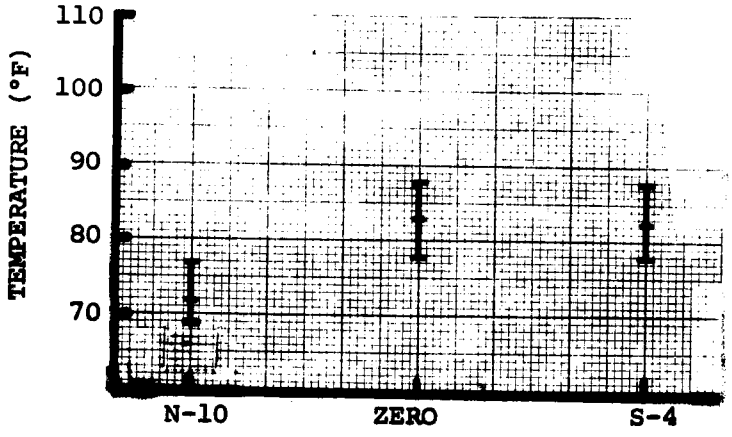


JULY 1971

[1]Twenty-two days of data.
[2]Eighteen days of data.



AUGUST 1971



SEPTEMBER 1971

Figure 4. Means and standard deviations of daily temperature maxima from July through September, 1971, at Hooksett Pond, Merrimack River.

Table 2

MONTHLY MEANS OF DAILY TEMPERATURE MAXIMA

HOOKSETT POND, MERRIMACK RIVER, 1971

(°F)

Month	N-10	Zero	S-4
May	No data	No data	53.96°[1]
June	76.00°[2]	99.29°[3]	74.89°[4]
October	58.89°[5]	No data	No data

[1] Thirty-one days
[2] Three days
[3] Thirteen days
[4] Seventeen days
[5] Thirty-one days

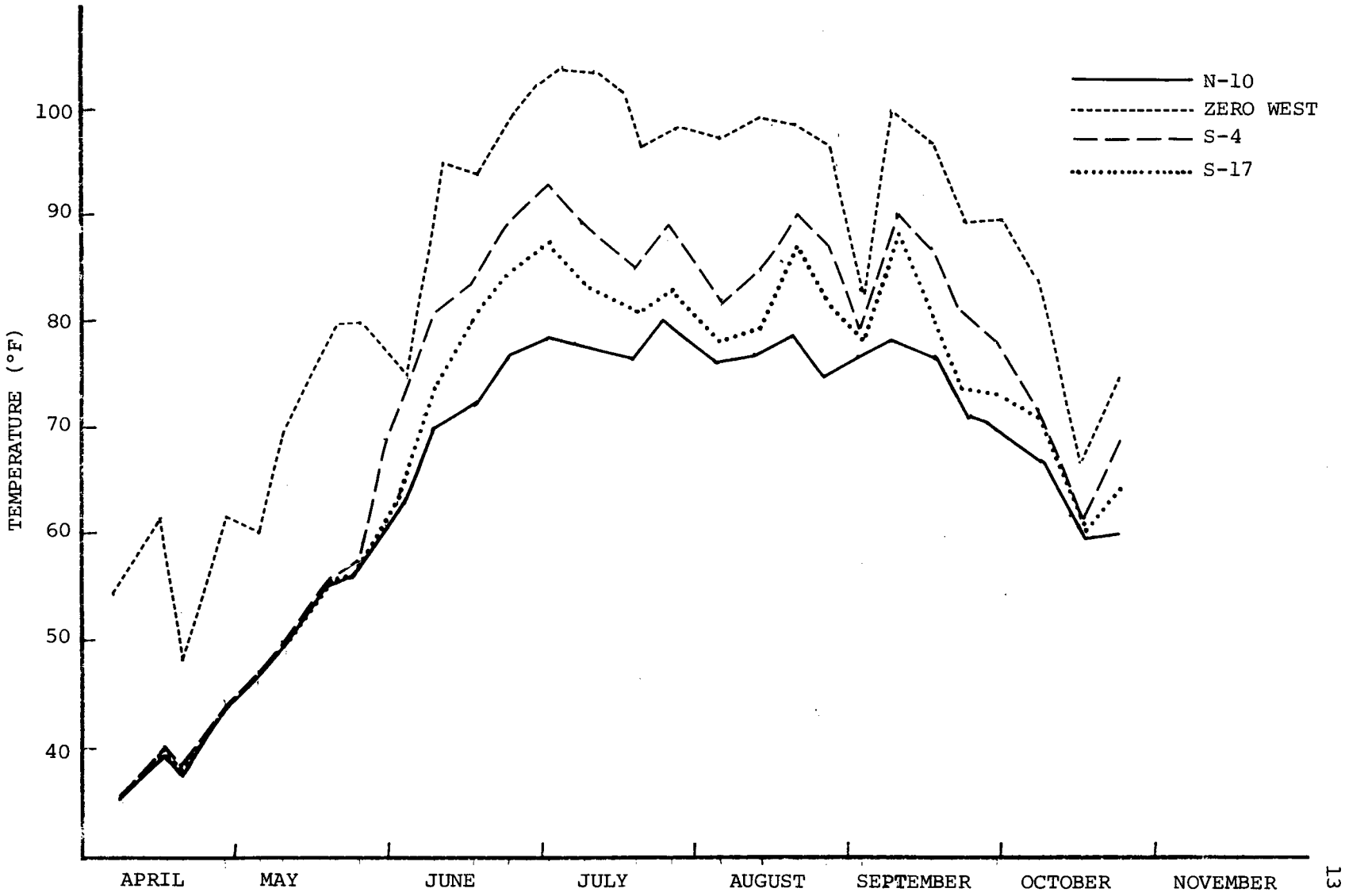


Figure 5. Surface temperatures - Hooksett Pond, Merrimack River, 1971.

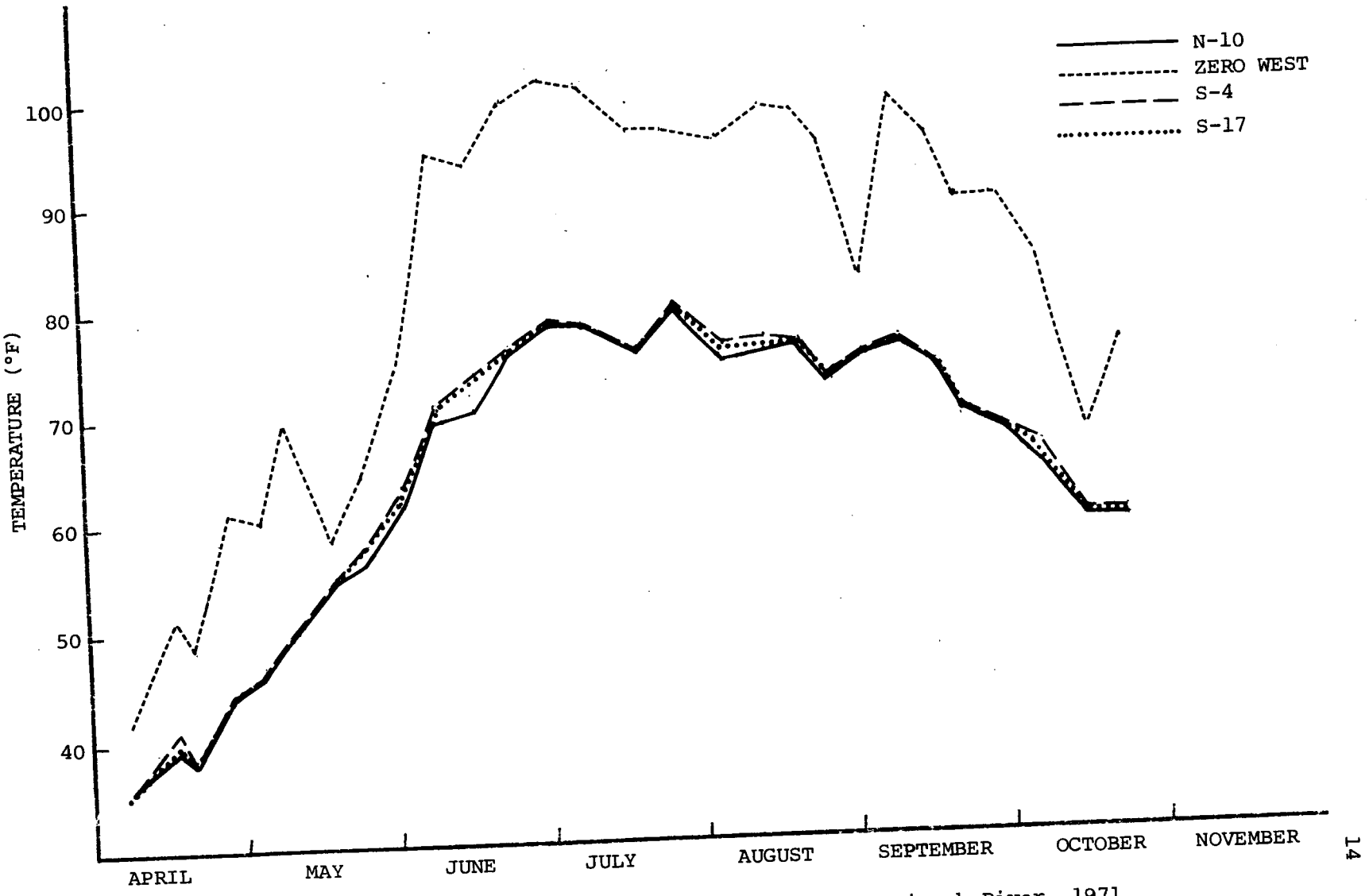


Figure 6. Bottom temperatures - Hooksett Pond, Merrimack River, 1971

7.5° F to 25.0° F with a mean of 22.5° F above ambient (N-10). Due to the lack of stratification in the discharge canal and its confluence with the river, bottom temperatures were the same or closely comparable to surface temperatures.

Thermal stratification was evident south of the generating station. At Station S-4, surface and bottom differences varied from 0.1° F to 16.0° F, with a mean of 8.3° F. By Station S-17 these differences had lessened, and were in the range of 0.0° to 10.5° F, with a mean of 3.9° F. Stratification south of the generating station was apparent in late May and persisted until sampling activities were terminated in October.

Substantial differences existed between surface temperatures at Station N-10 and those of S-4 and S-17. Station S-4 had temperature differences ranging from 0.0° F to 15.5° F, with a mean of 7.3° F, over ambient (N-10). Station S-17 exhibited a mean temperature difference of 4.3° F over ambient with a range of from 0.0° F to 10.0° F. As indicated earlier and shown clearly in Figure 6, bottom temperatures varied but slightly from ambient temperatures.

c) TEMPERATURE PROFILES[3]-

June 8, 1971 - APPENDIX A, Figures A-1 to A-9: Ambient river temperatures ranged from 67.0° F to 69.0° F and flows averaged 2,106 cfs. Stations north of the discharge canal exhibited no thermal stratification. At Station Zero west, a lens of warm water formed which was approximately five feet deep and ranged in temperature from 69.0° F to a high of 88.0° F. The maximum effect of the heated discharge was apparent on the east bank of the river from Stations S-1 to S-4, where temperatures ranged up to 83.0° F. From Stations S-5 to S-18 the lens was not as pronounced and a gradual decrease in the thermal layer occurred, with temperatures ranging from 71.0° F to 76.0° F in the upper two feet of water.

June 28, 1971 - APPENDIX A, Figures A-10 to A-18: Ambient temperatures ranged from 73.0° F to 74.0° F. Thermal stratification was noted at Station N-1 as a result of the influence of the discharge canal which caused a surface temperature increase to 81.5° F. Average flow during this survey was 1,592 cfs, approximately 500 cfs less than the July 8 survey. At Station Zero temperatures in the thermal lens ranged from 80.0° F to 94.0° F. From Stations S-1 to S-3 a five foot layer of warm water with temperatures up to 86.0° F was concentrated toward the east bank. At Stations S-4 to S-18 thermal stratification was evidenced by a two foot deep layer of water with temperatures ranging from 80.0° F to 84.0° F.

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[3]Difference in figure bottom configurations between sampling dates are due to depth sounding variability.

No return to ambient temperatures was indicated at the southern stations.

August 6, 1971 - APPENDIX A, Figures A-19 to A-27: Ambient river temperatures during the survey ranged from 71.0° F to 73.0° F. Flows averaged 2,465 cfs. No thermal stratification was evident at any of the northern stations. At Station Zero west a five foot deep thermal lens with temperatures ranging from 73.0°F to 90.0° F was noted. The lens had shifted to the east bank at Stations S-1 to S-3 where temperatures ranged up to 84.0° F. From Stations S-4 to S-18 a gradual decrease in temperature occurred until the influence of the lens was limited to the upper two feet of the river, with temperatures of 81.0° F. Once again, no return to ambient temperatures was noted.

C. SUMMARY AND CONCLUSIONS

In the spring months, reduced transparency resulted from high flows and likely increases in turbidity. During both 1970 and 1971, periods of low flows and higher temperatures were accompanied by a reduction in depth of visibility values, followed by an increase in the cooler fall months. It is felt that this is essentially a biological phenomenon which will be expanded upon in later sections.

During the 1971 study season, periods of low flows coincided with periods of peak temperatures. In July, 68% of the daily flows were below 1,000 cfs, and 77% of the daily maximum temperatures at Station Zero were

100°F. The mean monthly increase over ambient temperature, as determined by continuous monitoring, was 22.6° F. Temperature stratification during this period extended to the southern-most stations, but bottom temperatures at all stations remained essentially unaffected.

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 and nitrite analyses were performed according to techniques outlined by Stickland and Parsons (1968). The procedure for determining poly-, ortho-, and total phosphates was essentially the single reagent method as recommended by the FWPCA (1969).

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 collected was determined with an 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.

Samples were taken from surface waters and analyzed using the azide modification of the iodometric method as described in the thirteenth edition of Standard Methods for the Examination of Water and Wastewater (1971). Dissolved oxygen determinations for the 24-hour survey were done with a Yellow Springs Model 54 dissolved oxygen meter which was frequently calibrated utilizing the iodometric method described above. Stations N-10, Zero west, S-4, and S-17 were sampled at four hour intervals throughout the 24-hour period.

B. RESULTS AND DISCUSSION

1. Nutrients

Results of the 1971 nutrient study are presented in Table 3. Poly-, ortho-, and total phosphates were on the level of one-tenth to one-hundredth of the values determined for 1970 and, with the exception of a brief increase in June, exhibited very little seasonal fluctuation. Nitrate concentrations were one-sixth to one-third of those of a comparable period in 1970, while nitrites showed a drop to one-tenth of last year's level. Normal seasonal fluctuations of nitrates were apparent, with high values being associated with periods of high flows and low productivity. Concentrations of nitrites fluctuated throughout the season and exhibited a general upward trend as the season progressed. As in 1970, no important differences in nutrient concentrations were noted between stations.

TABLE 3

MEAN NUTRIENT CONCENTRATION (mg/L)

HOOKSETT POND - MERRIMACK RIVER - 1971

PARAMETER	STATIONS			
	N-10	Zero West	S-4	S-17
$T\text{-}PO_4$	.004	.005	.005	.005
$P\text{-}PO_4$	.001	.001	.001	.008
$O\text{-}PO_4$	.006	.004	.004	.004
NO_3	.393	.389	.394	.378
NO_2	.007	.008	.007	.007

2. pH

Mean pH values for Stations N-10, Zero west, S-4, and S-17 were 7.12, 7.07, 7.02, and 7.07 respectively. Values for 1971 showed a mean increase of .76 over 1970 with no major differences noted between stations.

3. Dissolved Oxygen

Mean dissolved oxygen concentrations for 1971 are presented in Table 4. Station Zero west experienced reduced levels of oxygen, while concentrations at Stations S-4 and S-17 were comparable to those measured at N-10. Periods of high spring flows were accompanied by increased dissolved oxygen levels at all stations. As was the case in 1970, during periods of low flows and higher temperatures, higher dissolved oxygen levels were obtained at Station S-17 than at N-10. The largest recorded oxygen differential between the two stations occurred in July with means of 9.1 mg/L and 8.0 mg/L at Stations S-17 and N-10 respectively. In general, dissolved oxygen concentrations in 1971 were higher than those of 1970.

4. 24-Hour Dissolved Oxygen Study

Results of the 24-hour dissolved oxygen study are presented in Table 5. Difficulties experienced with instrumentation during the study account for the data inconsistencies at 2020 hours on August 31

TABLE 4

MEAN DISSOLVED OXYGEN CONCENTRATIONS AND MEAN TEMPERATURES

HOOKSETT POND - MERRIMACK RIVER - 1971

STATION	Range (mg/L)	Mean Oxygen (mg/L)	Mean Temperatures °F
N-10	6.4 - 14.8	9.4	64.2°
Zero West	6.4 - 12.0	8.3	83.4°
S-4	5.3 - 13.6	9.3	71.5°
S-17	6.9 - 12.0	9.2	70.0°

TABLE 5

24-HOUR DISSOLVED OXYGEN PROFILE
HOOKSETT POND - MERRIMACK RIVER - 1971

0800 - August 31, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	7.1	73.4°F	7.8	91.4°F	6.6	79.5°F	7.3	69.8°F
1	7.3	73.4°F	7.9	91.4°F	6.7	79.5°F	7.3	69.8°F
2	7.5	73.4°F	7.9	91.4°F	7.6	75.2°F	7.4	69.8°F
3	7.6	72.5°F	7.9	91.4°F	7.9	72.5°F	7.5	69.8°F
4	7.7	72.5°F	7.9	91.4°F	7.9	72.5°F	7.6	69.8°F
5	7.7	72.5°F	7.9	91.4°F	7.9	71.6°F	7.6	69.8°F
6	7.8	72.5°F	7.9	91.4°F	8.0	70.7°F	7.6	69.8°F
7	7.8	72.5°F			7.9	70.7°F	7.7	69.8°F
8					7.9	70.7°F	7.7	69.8°F
9					7.8	70.7°F		
10					7.8	70.7°F		
11					7.7	70.7°F		

1200 - August 31, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	7.1	72.5°F	6.1	92.8°F	6.2	82.4°F	6.7	77.0°F
1	7.0	71.6°F	6.1	92.8°F	6.3	83.3°F	6.7	77.0°F
2	6.7	71.6°F	6.4	92.8°F	6.8	79.7°F	6.7	75.2°F
3	6.7	71.6°F	6.5	92.8°F	6.8	77.0°F	6.7	74.3°F
4	6.6	71.6°F	6.6	92.8°F	7.0	77.0°F	6.8	72.5°F
5	6.6	70.7°F	6.6	92.8°F	7.0	75.2°F	6.7	72.5°F
6	6.6	70.7°F	6.7	92.8°F	7.1	74.3°F	6.7	72.5°F
7	6.6	70.7°F			7.1	72.5°F	6.5	71.6°F
8	6.5	70.7°F			7.1	71.6°F		
9					7.0	70.7°F		
10					6.8	70.7°F		
11					6.8	70.7°F		

continued

Table 5 (cont.)

1600 - August 31, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	7.2	72.5°F	6.3	93.2°F	6.7	84.2°F	6.8	77.0°F
1	6.7	72.5°F	6.3	93.2°F	6.7	82.4°F	6.8	77.0°F
2	6.7	72.5°F	6.4	93.2°F	7.0	81.5°F	6.7	77.0°F
3	6.7	72.5°F	6.5	93.2°F	7.0	79.7°F	6.7	73.4°F
4	6.7	72.5°F	6.6	93.2°F	7.1	79.7°F	7.1	73.4°F
5	6.7	72.5°F	6.6	93.2°F	7.1	75.2°F	7.1	72.5°F
6	6.7	72.5°F			7.4	74.3°F	6.9	72.5°F
7	6.7	72.5°F			7.4	72.5°F	6.9	72.5°F
8					7.3	72.5°F		
9					7.2	72.5°F		
10					7.1	72.5°F		
11					7.0	72.5°F		

2020 - August 31, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	8.7	71.6°F	6.3	89.6°F	6.8	77.9°F	8.5	77.0°F
1	8.5	71.6°F	7.5	90.5°F	7.6	80.6°F	8.2	79.9°F
2	8.3	71.6°F	7.8	91.4°F	8.2	79.9°F	8.2	77.0°F
3	8.3	71.6°F	8.1	91.4°F	8.6	75.2°F	8.7	74.3°F
4	8.3	71.6°F	8.2	90.5°F	8.7	73.4°F	8.8	73.4°F
5	8.3	71.6°F	8.3	91.4°F	8.9	72.5°F	8.8	73.4°F
6	8.3	71.6°F	8.2	91.4°F	8.8	72.5°F	8.8	73.4°F
7	8.3	71.6°F			8.8	72.5°F	8.7	73.4°F
8	8.3	71.6°F			8.7	72.5°F	8.8	73.4°F
9					8.6	72.5°F	8.7	72.5°F
10					8.6	72.5°F		
11					8.5	72.5°F		

continued

Table 5 (cont.)

2400 - August 31, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	6.1	68.0°F	5.6	88.7°F	5.4	78.8°F	5.9	74.3°F
1	6.3	68.0°F	5.8	88.7°F	6.0	79.7°F	6.1	74.3°F
2	6.5	68.0°F	6.0	88.7°F	6.6	79.7°F	6.4	74.3°F
3	6.6	68.0°F	6.1	88.7°F	6.7	78.8°F	6.9	73.4°F
4	6.6	68.0°F	6.3	88.7°F	7.1	76.1°F	7.0	73.4°F
5	6.7	68.0°F	6.6	88.7°F	7.4	73.4°F	7.1	72.5°F
6	6.7	68.0°F			7.4	72.5°F	7.0	72.5°F
7	6.8	68.0°F			7.4	71.6°F	7.1	72.5°F
8	6.8	68.0°F			7.3	71.6°F	7.0	72.5°F
9					7.3	71.6°F		
10					7.2	71.6°F		
11					7.3	71.6°F		

0400 - September 1, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	6.2	68.0°F	5.6	88.7°F	5.5	79.7°F	6.0	74.3°F
1	6.3	68.0°F	5.7	88.7°F	6.0	79.7°F	6.1	74.3°F
2	6.5	68.0°F	6.0	88.7°F	6.6	79.7°F	6.3	73.4°F
3	6.6	68.0°F	6.2	88.7°F	6.7	78.8°F	6.5	73.4°F
4	6.7	68.0°F	6.3	88.7°F	7.0	76.1°F	6.9	73.4°F
5	6.7	68.0°F	6.6	88.7°F	7.3	73.4°F	7.0	72.5°F
6	6.7	68.0°F			7.3	73.4°F	7.1	72.5°F
7	6.8	68.0°F			7.3	71.6°F	7.1	72.5°F
8	6.8	68.0°F			7.3	71.6°F	7.1	72.5°F
9					7.3	71.6°F		
10					7.3	71.6°F		
11					7.3	71.6°F		

continued

Table 5 (cont.)

0800 - September 1, 1971

Depth	Stations							
	N-10		Zero West		S-4		S-17	
	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.	D. O.	Temp.
S	3.3	66.2°F	3.1	86.9°F	3.6	76.1°F	3.7	70.7°F
1	3.3	67.1°F	3.3	88.7°F	3.7	76.1°F	3.7	71.6°F
2	3.4	67.1°F	3.5	88.7°F	3.8	76.1°F	3.8	71.6°F
3	3.5	68.0°F	3.8	88.7°F	3.8	74.3°F	3.9	70.7°F
4	3.6	68.0°F	3.9	88.7°F	3.9	72.5°F	3.9	70.7°F
5	3.7	68.0°F	3.9	88.7°F	4.0	70.7°F	3.9	70.7°F
6	3.7	68.0°F			4.0	69.8°F	3.9	70.7°F
7					4.0	68.9°F		
8					3.9	68.9°F		
9					3.9	68.9°F		
10					3.9	68.0°F		

and 0800 hours on September 1, 1971.

In general, Station N-10 reflected normal diurnal oxygen trends with high concentrations in the upper euphotic zone as a result of photosynthetic activity during daylight hours, and decreased concentrations at night due to respiration. Diurnal fluctuations were also evident at Stations Zero west, S-4, and S-17, although concentrations of dissolved oxygen in the heated upper waters of these stations failed to reach levels found at N-10. At Stations S-4 and S-17, concentrations of oxygen near the surface were consistently less than in the deeper near-ambient waters. As would be expected, Station Zero west exhibited the greatest departure from ambient dissolved oxygen conditions throughout the 24-hour period.

C. SUMMARY AND CONCLUSIONS

Nutrient concentrations in 1971 were greatly reduced from those of 1970. Discussions with personnel of the New Hampshire Water Supply and Pollution Control Commission provided no insight into the probable cause of this decrease, as no apparent changes in upstream conditions had occurred. Significant increases in phytoplankton numbers over 1970 levels would likely account for a portion of these reductions. Increases in dissolved oxygen concentrations and pH for 1971 are difficult to explain in the light of decreased flows at comparable temperatures unless the increased numbers of phytoplankton are considered as a possible

cause. The greatest reduction in dissolved oxygen in both weekly and 24-hour studies occurred at Station Zero west. This temperature effect was greatly reduced at Stations S-4 and S-17. Increased oxygen concentrations at S-17 during periods of low flows and high temperatures are likely the result of contributions from the Suncook River and/or increased photosynthetic activity in the area of the station.

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 Standard Methods for the Examination of Water and Wastewater, thirteenth edition (1971).

2. Phytoplankton

Metered plankton nets were used to collect plankton samples at Stations N-10, Zero west, S-4, and S-17. Samples were preserved in the field with buffered formalin and removed to the laboratory for analysis. Beginning in early July, surface sampling was supplemented with samples taken beneath the heated water layer at Stations S-4 and S-17. Subsurface sampling at Station N-10, at a similar depth, was initiated for comparison with findings at southern stations.

3. Periphyton

Periphyton accumulators were installed at Stations N-10, Zero, S-4, and S-17 approximately two feet below the surface of the water. The glass slides in each accumulator were numbered one through thirty, where number one was a short-term slide which was removed weekly and replaced with a clean slide. Slides two through thirty were sampled consecutively from week 2 through week 30, and indicated long-term periphyton accumulations. Following sampling, each slide was brought to the laboratory and accumulated periphyton groups (blue-green algae, green algae, and diatoms) were counted within 24 hours.

4. Aquatic Plants

Aquatic plants were sampled on June 23 and August 11, 1971 at the discharge canal and Stations N-10 through S-24. Data on relative abundance were noted, and specimens collected were returned to the laboratory for identification.

5. Aquatic Insects

Qualitative samples were taken on June 24 and August 16, 1971 from the east and west banks of Stations N-10, Zero, S-4, and S-17. Organisms were preserved in 10% formalin and removed to the laboratory for identification.

6. Benthic Invertebrates

Stations N-8, S-8, and S-20 were sampled with a Ponar grab in June, August, and October of 1971. One sample was taken at mid-river and two from the west bank of each station. Samples were returned to the laboratory where five 200 cc aliquots of each "grab" were examined and benthic invertebrates identified.

7. Fish Surveys

Both larval and adult fish were studied in 1971. Larval forms were collected with fine mesh seines and dip nets at eight stations (N-10, N-8, N-6, N-3, Zero, S-5, S-10, and S-18). Collections and observations of larvae were made throughout the study period. Young-of-the-year and adult forms were collected on May 20, July 6, and August 24 by shocking prescribed 150 foot areas on both east and west banks of the stations listed above.

B. RESULTS AND DISCUSSION

1. Chlorophyll *a*

Analysis of chlorophyll *a* data by two-way analysis of variance (Steel and Torrie, 1961) revealed significant concentration differences among stations and months. No significance was found for the month by station interaction (Table 6), which would indicate that stations

TABLE 6

ANALYSIS OF VARIANCE TABLE FOR MEAN MONTHLY CONCENTRATIONS OF CHLOROPHYLL *a* AT STATIONS N-10, ZERO WEST, S-4 and S-17

HOOKSETT POND - MERRIMACK RIVER - 1971

SOURCE	DEGREES OF FREEDOM	F-RATIO	PROBABILITY OF OBTAINING AN F-VALUE THIS LARGE OR LARGER
Month	5	139.30	$P < .001$
Station	3	15.66	$P < .001$
Month x Station Interaction	15	0.94	$.50 < P < .75$
Error	325		

responded similarly with respect to time. Scheffe's Multiple Comparison Procedure (Bancroft, 1968) was used to determine where the spatial and temporal differences existed. As is shown in Table 7, significant differences occurred between Stations S-17 and all other stations. Higher concentrations at Station S-17 are related to greater productivity at that station, which may be in part due to the influence of the Suncook River. While Station Zero west exhibited lower concentrations throughout the study season, these differences were not statistically significant.

Seasonal differences are shown in Table 8. July, the month characterized by lowest seasonal flows and highest temperatures, showed the highest chlorophyll *a* concentrations. In general, monthly data correspond well with transparency data presented earlier, indicating an inverse relationship between chlorophyll *a* concentration and transparency.

2. Phytoplankton

Results of the 1971 plankton survey are presented in Table 9. These will be discussed by treating each major group of algae in turn.

a) BLUE-GREEN ALGAE - Throughout the study season, blue-green algae showed erratic fluctuations in numbers which did not relate to temperature or flow conditions noted at the time of sampling. For example, in July, one of the sampling days produced significant numbers of blue-greens, while the other produced none at all under seemingly similar conditions. At other times during the study, blue-green algae were found only at

TABLE 7

MEAN CHLOROPHYLL *a* VALUES OVER ALL MONTHS AT STATIONS N-10, ZERO WEST, S-4, AND S-17

(mg/L)

MEAN	16.74	13.31	13.14	11.62
STATION*	S-17	S-4	N-10	ZERO WEST

* Stations which were not significantly different at the .05 level of significance are grouped and underscored.

TABLE 8

MEAN CHLOROPHYLL *a* CONCENTRATIONS OVER ALL STATIONS

FROM MAY THROUGH OCTOBER

(mg/L)

MEAN	19.15	19.13	16.26	7.27	3.77	2.00
MONTHS*	July	August	June	September	October	May

*Months which were not significantly different at the .05 level of significance are grouped and underscored.

TABLE 9

MONTHLY MEANS (Cells per Liter) OF MAJOR PHYTOPLANKTON GROUPS

HOOKSETT POND - MERRIMACK RIVER - 1971

Month	Station	$\bar{x}$ Temp. (°F)	Green Algae	Blue-green Algae	Diatoms
April	N-10	38.8°	66,923	7,525	9,542
	Zero	56.0°	42,827	18,800	26,785
	S-4	39.5°	45,689	28,321	12,743
	S-17	39.5°	10,955	8,866	16,151
May	N-10	51.3°	5,361	0	6,291
	Zero	72.0°	1,038	15,924	3,923
	S-4	52.1°	8,116	10,684	10,638
	S-17	51.6°	3,764	5,698	10,309
June	N-10	69.7°	11,312	6,022	4,607
	Zero	90.4°	5,525	27,368	3,567
	S-4	79.3°	10,361	4,125	3,974
	S-17	75.5°	10,298	784	4,833
July	N-10	77.8°	15,465	5,325	3,050
	Zero	98.9°	13,525	2,957	2,443
	S-4	89.3°	20,210	3,026	1,736
	S-17	81.8°	20.824	236	5,131
August	N-10	75.3°	34,697	1,233	5,062
	Zero	96.6°	32,875	0	3,362
	S-4	86.1°	30,804	0	6,264
	S-17	81.9°	35,968	664	7,236
September*	N-10	72.8°	22,741	6,782	4,378
	Zero	90.0°	6,638	0	327**
	S-4	83.2°	18,387	5,790	5,466
	S-17	81.9°	37,267	17,778	6,629
October **	N-10	63.5°	15,180	3,159	2,601
	Zero	75.0°	14,896	3,774	2,021
	S-4	66.3°	17,486	2,668	4,362
	S-17	66.3°	20,563	7,044	3,629

* Five samples collected
** Two samples collected

southern stations. In general, no consistent differences were noted between sampling stations, but numbers did decrease at all stations during periods of low flows and high temperatures.

b) GREEN ALGAE - Green algae were found in significant numbers throughout the sampling period. Of the genera found, *Eudorina* sp., *Pediastrum* sp., *Closterium* sp., *Mougeotia* sp., *Ulothrix* sp., *Scenedesmus* sp., and *Stigeoclonium* sp. were most common. From May through August green algae increased in numbers at all stations, then declined in the fall months. During this same period, both Stations S-17 and N-10 had higher mean numbers of green algae than were found at Station Zero. From July through October, slightly higher mean numbers of green algae were present at Station S-17 than at other stations.

c) DIATOMS - Numbers of diatoms remained fairly stable at all stations throughout the sampling period. Of the genera collected, *Tabellaria* sp., *Fragilaria* sp., *Asterionella* sp., and *Diatoma* sp. were the most common. As was true of green algae, a slight decline in mean diatom abundances per month was noted at Station Zero.

Results of surface and subsurface samplings failed to indicate any consistent depth-related differences during the 1971 study.

Numbers of phytoplankton in all major groups studied showed

significant increases over 1970 levels. As was the case in 1970, abundance of blue-green algae fluctuated throughout the study period and showed no differences between stations. Both diatoms and green algae showed slight reductions in numbers at Station Zero. These reductions did not appear to increase in magnitude during July and August, and then, as in previous months, recovery downstream from the discharge canal was rapid.

3. Periphyton

a) SHORT-TERM - Algal groups collected on weekly periphyton accumulators were analyzed by parametric two-way analyses of variance of percent composition data using an angular transformation (Steel and Torrie, 1960). Results of these analyses indicated a significant reduction in the percentages of green algae at Station Zero, as compared to Stations N-10, S-4, and S-17. (Table 10). No significant differences were noted among stations for blue-green algae or diatoms (Tables 11 and 12). Total numbers of accumulated periphyton groups were compared using a Friedman non-parametric analysis of variance (Siegle, 1956). No significant differences were found between stations.

From April to June, green algae maintained similar numbers at all stations. As temperatures increased to 90° - 100° F at Station Zero (mid-June to September) numbers of green algae dropped

TABLE 10

ANALYSIS OF VARIANCE TABLE FOR PERCENTAGES OF GREEN ALGAE ON WEEKLY ACCUMULATOR SLIDES

HOOKSETT POND - MERRIMACK RIVER - 1971

SOURCE	DEGREES OF FREEDON	F-RATIO	PROBABILITY OF OBTAINING AN F-VALUE THIS LARGE OR LARGER
Among Stations	3	3.13	.025 < P < .05
Among Months	5	8.49	P < .005
Month x Station Interaction	15	1.11	.10 < P
Error	72		

TABLE 11

ANALYSIS OF VARIANCE TABLE FOR PERCENTAGES OF BLUE-GREEN ALGAE ON WEEKLY ACCUMULATOR SLIDES

HOOKSETT POND - MERRIMACK RIVER - 1971

SOURCE	DEGREES OF FREEDOM	F-RATIO	PROBABILITY OF OBTAINING AN F-VALUE THIS LARGE OR LARGER
Among Stations	3	1.14	.10 < P
Among Months	5	7.88	P < .005
Month x Station Interaction	15	1.17	.10 < P
Error	72		

TABLE 12

ANALYSIS OF VARIANCE TABLE FOR PERCENTAGES OF DIATOMS ON WEEKLY ACCUMULATOR SLIDES

HOOKSETT POND - MERRIMACK RIVER - 1971

SOURCE	DEGREES OF FREEDOM	F-RATIO	PROBABILITY OF OBTAINING AN F-VALUE THIS LARGE OR LARGER
Among Stations	3	0.56	.10 < P
Among Months	5	0.95	.10 < P
Month x Station Interaction	15	1.30	.10 < P
Error	72		

noticeably. During the same period, diatoms also decreased at Station Zero, although to a lesser and insignificant extent. In general, blue-green algae failed to exhibit any consistent trends.

b) LONG-TERM - In the long-term samples green algae generally dominated the slides at all locations. During the peak temperature months, both diatoms and green algae showed reductions at Station Zero, with diatoms showing the greater reduction of the two. As in the weekly slides, blue-green algae failed to show any consistent trend, although they did appear to be more resistant to the thermal effects at Station Zero. A Friedman two-way analysis of variance indicated a significant spatial difference in total numbers of cells, with Station Zero showing less productivity.

Both long and short-term samples indicated a thermal effect on periphyton organisms. This effect was largely confined to Station Zero, with southern stations showing a rapid recovery even during peak temperature months. Green algae and diatoms, the more sensitive groups, showed definite reductions at Station Zero as temperatures approached 90° F. In the long-term samples, blue-green algae showed greater resistance to thermal effects. These organisms are generally more heat tolerant (Cairns, 1956 in Parker and Krenkle, 1968).

4. Aquatic Plants

Results of aquatic plant surveys (Tables 13, 14) indicated that presence or absence of plants at any one station was largely dependent on flows, substrate, and depth. During both surveys, only at Station Zero and the canal, were direct effects of heated effluent noticeable by the presence of only one species of aquatic plant *(Eleocharis* sp.). Results of the 1971 survey were consistent with those of 1970.

5. Aquatic Insects

Data presented in Tables 15 and 16 show that Stations N-10 east and west, and S-17 east and west had the largest numbers of aquatic insects in the June and August surveys. Both of these stations provide diverse habitats in the form of vegetation, rocks, and logs. Station Zero east and S-4 east and west produced diverse populations, but numbers were not as great as those at N-10 and S-17 due to their lack of vegetation and greater depths. Inhabitants of Zero west included only one representative, *Helochares* sp., of the Order Coleoptera, which could withstand the effects of 95.5° F and 99.0° F temperatures measured at the time of sampling. This particular genus utilizes atmospheric oxygen which might in part account for its presence there.

With the exception of Station Zero west, all stations sampled

TABLE 13

AQUATIC PLANTS

HOOKSETT POND - MERRIMACK RIVER - JUNE 23, 1971

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
N-10	76.0°F	NONE	
N-9	76.0°F	*Potamogeton* sp.	VA
		Anacharis canadensis	VA
		Sagittaria cristata	MA
N-8	76.0°F	*Potamogeton* sp.	VA
		Anacharis canadensis	VA
		Sagittaria cristata	MA
N-7	76.0°F	*Potamogeton* sp.	VA
		Anacharis canadensis	VA
		Sagittaria cristata	MA
N-6	76.0°F	*Pontederia cordata taenia*	VA
		Anacharis canadensis	VA
		Sagittaria cristata	VA
		Vallisneria americana	MA
		Eleocharis sp.	VA
N-5	76.0°F	*Pontederia cordata taenia*	A
		Anacharis canadensis	P
		Scirpus sp.	A
		Sagittaria cristata	P
WEST			
N-10	76.0°F	*Potamogeton* sp.	VA
N-9	76.0°F	NONE	
N-8	76.0°F	*Potamogeton* sp.	VA
		Anacharis canadensis	VA
N-7	76.0°F	*Anacharis canadensis*	MA
		Potamogeton sp.	VA
		Eleocharis sp.	VA
N-6	76.0°F	*Anacharis canadensis*	A
		Potamogeton sp.	MA
INTAKE			

(continued)

TABLE 13 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
N-4	76.0°F	*Vallisneria americana*	MA
		Anacharis canadensis	P
N-3	76.5°F	*Potamogeton* sp.	P
		Anacharis canadensis	P
N-2	78.5°F	*Anacharis canadensis*	P
N-1	84.0°F	NONE	
Canal	98.0°F	*Eleocharis* sp.	VA
Zero	88.0°F	NONE	
S-1	91.0°F	*Potamogeton* sp.	P
S-2	92.0°F	NONE	
S-3	91.0°F	*Potamogeton* sp.	MA
		Sagittaria cristata	A
S-4	90.0°F	NONE	
S-5	89.5°F	NONE	
S-6	89.0°F	*Pontederia cordata taenia*	A
		Sagittaria cristata	A

STATIONS	SURFACE TEMPERATURE	SPECIES	*
WEST			
N-4	76.5°F	NONE	
N-3	76.5°F	*Potamogeton* sp.	P
N-2	81.0°F	NONE	
N-1	86.5°F	*Potamogeton* sp.	A
Zero	98.0°F	NONE	
S-1	89.5°F	NONE	
S-2	87.0°F	*Pontederia cordata taenia*	VA
		Scirpus sp.	VA
S-3	87.5°F	NONE	
S-4	87.5°F	NONE	
S-5	87.5°F	NONE	
S-6	86.0°F	NONE	

(continued)

TABLE 13 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
S-7	89.0°F	*Potamogeton* sp.	MA
S-8	88.5°F	*Potamogeton* sp.	A
S-9	87.5°F	*Sagittaria cristata*	MA
S-10	85.0°F	*Sagittaria cristata*	MA
S-11	85.0°F	*Pontederia cordata taenia*	VA
		Anacharis canadensis	A
		Potamogeton sp.	A
		Sagittaria cristata	A
S-12	85.0°F	*Potamogeton* sp.	A
S-13	85.0°F	*Scirpus* sp.	A
		Potamogeton sp.	A
		Anacharis canadensis	A
S-14	85.0°F	*Scirpus* sp.	A
		Sagittaria cristata	VA
S-15	84.5°F	*Sagittaria cristata*	A
		Anacharis canadensis	A
		Potamogeton sp.	A
S-16	84.5°F	*Sagittaria cristata*	A
		Anacharis canadensis	A

STATIONS	SURFACE TEMPERATURE	SPECIES	*
WEST			
S-7	86.0°F	*Potamogeton* sp.	P
S-8	86.5°F	*Potamogeton* sp. (2 types)	A
		Anacharis canadensis	MA
S-9	86.5°F	NONE	
S-10	85.5°F	NONE	
S-11	85.5°F	NONE	
S-12	85.0°F	NONE	
S-13	85.0°F	NONE	
S-14	85.0°F	NONE	
S-15	84.5°F	NONE	
S-16	84.5°F	NONE	

(continued)

TABLE 13 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
S-17	84.5°F	*Anacharis canadensis*	A
		Sagittaria cristata	A
		Potamogeton sp.	P
S-18	84.5°F	*Scirpus* sp.	A
		Sagittaria cristata	A
		Anacharis canadensis	A
S-19	84.0°F	NONE	
S-20	84.0°F	*Sagittaria cristata*	A
S-21	84.0°F	*Sagittaria cristata*	A
		Anacharis canadensis	A
		Pontederia cordata taenia	P
S-22	84.0°F	*Pontederia cordata taenia*	A
		Sagittaria cristata	VA
		Potamogeton sp.	A
		Anacharis canadensis	MA
S-23	84.0°F	*Pontederia cordata taenia*	MA
S-24	84.0°F	NONE	

STATIONS	SURFACE TEMPERATURE	SPECIES	*
WEST			
S-17	84.5°F	NONE	
S-18	84.5°F	NONE	
S-19	84.5°F	NONE	
S-20	84.5°F	NONE	
S-21	84.5°F	*Pontederia cordata taenia*	A
		Potamogeton sp.	A
		Sagittaria cristata	P
S-22	84.5°F	*Pontederia cordata taenia*	MA
		Sagittaria cristata	MA
S-23	84.0°F	*Pontederia cordata taenia*	MA
S-24	84.0°F	*Scirpus* sp.	MA
		Pontederia cordata taenia	MA

KEY: VA = Very Abundant A = Abundant
MA = Moderately Abundant P = Present

TABLE 14

AQUATIC PLANTS

HOOKSETT POND - MERRIMACK RIVER - AUGUST 11, 1971

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
N-10	76.5°F	NONE	
N-9	76.5°F	*Potamogeton* sp.	MA
		Anacharis canadensis	VA
		Sagittaria cristata	MA
N-8	76.5°F	*Anacharis canadensis*	VA
		Sagittaris cristata	MA
N-7	76.5°F	*Potamogeton* sp.	VA
		Anacharis canadensis	VA
		Sagittaria cristata	MA
N-6	76.5°F	*Pontederia cordata taenia*	VA
		Anacharis canadensis	VA
		Sagittaria cristata	VA
		Vallisneria americana	VA
		Eleocharis sp.	VA
WEST			
N-10	76.5°F	*Potamogeton* sp.	VA
		Sagittaria cristata	MA
		Callitriche sp.	P
		Vallisneria americana	MA
		Nitella sp.	MA
N-9	76.5°F	NONE	
N-8	76.5°F	*Potamogeton* sp.	VA
		Anacharis canadensis	VA
N-7	76.5°F	*Potamogeton* sp.	VA
		Anacharis canadensis	MA
		Eleocharis sp.	VA
		Sagittaria cristata	MA
N-6	76.5°F	*Anacharis canadensis*	A
		Potamogeton sp.	MA

(continued)

TABLE 14 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
N-5	76.5°F	*Pontederia cordata taenia*	A
		Anacharis canadensis	P
		Scirpus sp.	A
		Sagittaria cristata	P
N-4	76.5°F	*Vallisneria americana*	MA
		Anacharis canadensis	P
N-3	76.5°F	*Potamogeton* sp.	P
		Anacharis canadensis	P
N-2	76.5°F	*Anacharis canadensis*	P
N-1	76.5°F	NONE	
CANAL	94.0°F	*Eleocharis* sp.	VA
ZERO	76.5°F	NONE	
S-1	89.0°F	*Potamogeton* sp.	P
S-2	87.0°F	NONE	
S-3	87.0°F	*Potamogeton* sp.	MA
		Nitella sp.	VA
		Sagittaria cristata	VA
WEST			
INTAKE			
N-4	76.5°F	NONE	
N-3	76.5°F	*Potamogeton* sp.	A
N-2	76.5°F	NONE	
N-1	76.5°F	*Potamogeton* sp.	P
ZERO	94.0°F	*Eleocharis* sp.	VA
S-1	82.0°F	NONE	
S-2	78.0°F	*Pontederia cordata taenia*	VA
		Scirpus sp.	VA
		Nitella sp.	VA
S-3	78.0°F	*Nitella* sp.	MA

(continued)

TABLE 14 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
S-4	83.0°F	NONE	
S-5	82.0°F	NONE	
S-6	82.0°F	*Pontederia cordata taenia*	A
		Sagittaria cristata	A
		Nitella sp.	A
S-7	81.0°F	*Pontederia cordata taenia*	MA
		Nitella sp.	MA
S-8	80.5°F	*Potamogeton* sp.	A
		Nitella sp.	MA
S-9	80.5°F	*Sagittaria cristata*	MA
		Nitella sp.	MA
S-10	80.5°F	*Sagittaria cristata*	MA
		Nitella sp.	MA
S-11	80.0°F	*Pontederia cordata taenia*	VA
		Potamogeton sp.	A
		Anacharis canadensis	A
		Sagittaria cristata	A
		Nitella sp.	MA
S-12	80.0°F	*Potamogeton* sp.	MA

STATIONS	SURFACE TEMPERATURE	SPECIES	*
WEST			
S-4	78.0°F	NONE	
S-5	78.0°F	NONE	
S-6	78.0°F	NONE	
S-7	78.0°F	*Potamogeton* sp.	P
S-8	78.0°F	*Anacharis canadensis*	A
		Potamogeton sp.	A
S-9	78.0°F	NONE	
S-10	78.0°F	NONE	
S-11	78.0°F	NONE	
S-12	78.0°F	NONE	

(continued)

TABLE 14 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
S-13	79.5°F	*Scirpus* sp.	A
		Potamogeton sp.	A
		Anacharis canadensis	A
S-14	79.5°F	*Scirpus* sp.	A
		Sagittaria cristata	MA
		Nitella sp.	A
S-15	79.0°F	*Sagittaria cristata*	A
		Anacharis canadensis	A
		Potamogeton sp.	A
		Nitella sp.	MA
S-16	79.0°F	*Sagittaria cristata*	A
		Anacharis canadensis	A
		Nitella sp.	MA
S-17	79.0°F	*Anacharis canadensis*	A
		Sagittaria cristata	A
		Potamogeton sp.	A
S-18	79.0°F	*Scirpus* sp.	A
		Sagittaria cristata	A
		Anacharis canadensis	A
S-19	78.0°F	NONE	
S-20	78.0°F	*Sagittaria cristata*	A
		Nitella sp.	A

STATIONS	SURFACE TEMPERATURE	SPECIES	*
WEST			
S-13	78.0°F	NONE	
S-14	78.0°F	NONE	
S-15	78.0°F	NONE	
S-16	78.0°F	NONE	
S-17	78.0°F	NONE	
S-18	78.0°F	NONE	
S-19	78.0°F	NONE	
S-20	78.0°F	NONE	

(continued)

TABLE 14 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	*
EAST			
S-21	78.0°F	*Sagittaria cristata*	A
		Anacharia canadensis	A
		Pontederia cordata taenia	P
S-22	78.0°F	*Pontederia cordata taenia*	A
		Potamogeton sp.	VA
		Sagittaria cristata	VA
		Anacharis canadensis	MA
S-23	78.0°F	*Pontederia cordata taenia*	MA
S-24	78.0°F	NONE	
WEST			
S-21	78.0°F	*Sagittaria cristata*	P
		Potamogeton sp.	P
		Pontederia cordata taenia	A
S-22	78.0°F	*Pontederia cordata taenia*	MA
		Sagittaria cristata	MA
S-23	78.0°F	*Pontederia cordata taenia*	MA
S-24	78.0°F	*Scirpus* sp.	MA
		Pontederia cordata taenia	MA

KEY: VA = Very Abundant
A = Abundant
MA = Moderately Abundant
P = Present

TABLE 15

AQUATIC INSECTS

HOOKSETT POND - MERRIMACK RIVER - JUNE 24, 1971

STATION	SURFACE TEMPERATURE	ORDER/GENERA	*
EAST			
N-10	76.5°F	Ephemeroptera (Mayfly)	
		Stenonema sp.	P
		Ephemerella sp.	A
		Siphloplecton sp.	P
		Diptera (Fly)	
		Tendipedidae larvae	P
		Plecoptera	
		Perlesta placida	P
ZERO	81.0°F	Coleoptera (Beetle)	
		Helochares sp.	P
		Ephemeroptera (Mayfly)	
		Ephemerella sp.	A
		Diptera (Fly)	
		Calopsectra sp.	MA
		Tendipedidae larvae	A
S-4	88.5°F	Ephemeroptera (Mayfly)	
		Stenonema sp.	MA
		Ephemerella sp.	MA
		Coleoptera (Beetle)	
		Ancyronyx sp.	P
		Berosus sp. larvae	P
WEST			
N-10	76.5°F	Coleoptera (Beetle)	
		Haliplus sp.	MA
		Odonata (Damselfly & Dragonfly)	
		Gomphus sp.	P
		Trichoptera (Caddisfly)	
		Limnephilus sp.	MA
		Ephemeroptera (Mayfly)	
		Siphloplecton sp.	MA
ZERO	99.0°F	Coleoptera (Beetle)	
		Helochares sp.	VA
S-4	88.5°F	Diptera (Fly)	
		Tendipedidae larvae	A
		Ephemeroptera (Mayfly)	
		Siphloplecton sp.	P
		Odonata (Damselfly)	
		Lestes sp.	P
		Coleoptera (Beetle)	
		Heterelmis larvae	P
		Helochares sp.	P

(continued)

TABLE 15 (continued)

STATIONS	SURFACE TEMPERATURE	ORDER/GENERA	*
EAST			
S-17	84.0°F	Odonata (Damselfly)	
		Ischnura sp.	P
		Coleoptera (Beetle)	
		Berosus sp. larvae	P
		Trichoptera (Caddisfly)	
		Leptocella sp.	MA
		Diptera (Fly)	
		Calopsectra sp.	MA
WEST			
S-17	84.0°F	Coleoptera (Beetle)	
		Ancyronyx sp.	VA
		Neuroptera	
		Climacia areolaris (abundant on sponge)	VA
		Ephemeroptera (Mayfly)	
		Ameletus sp.	MA
		Ephemerella sp.	A
		Diptera (Fly)	
		Calpsectra sp.	A
		Trichoptera (Caddisfly)	
		Limnephilus sp.	A
		Diptera (Fly)	
		Tendipedidae larvae	A

KEY: VA = Very Abundant A = Abundant
MA = Moderately Abundant P = Present

TABLE 16

AQUATIC INSECTS

HOOKSETT POND - MERRIMACK RIVER - AUGUST 16, 1971

STATION	SURFACE TEMPERATURE	ORDER/GENERA	*
EAST			
N-10	75.0°F	Ephemeroptera (Mayfly)	
		Stenonema sp.	P
		Ephemerella sp.	A
		Diptera (Fly)	
		Tendipedidae larvae	A
ZERO	85.0°F	Ephemeroptera (Mayfly)	
		Ephemerella sp.	P
		Diptera (Fly)	
		Calopsectra sp.	MA
		Tendipedidae larvae	MA
S-4	85.5°F	Ephemeroptera (Mayfly)	
		Stenonema sp.	MA
		Ephemerella sp.	P
		Coleoptera (Beetle)	
		Ancyronyx sp.	P
WEST			
N-10	75.0°F	Coleoptera (Beetle)	
		Haliplus sp.	P
		Odonata (Damselfly & Dragonfly)	
		Lestes sp.	P
		Trichoptera (Caddisfly)	
		Limnephilus sp.	MA
		Ephemeroptera (Mayfly)	
		Stenonema sp.	A
ZERO	95.5°F	Coleoptera (Beetle)	
		Helochares sp.	VA
S-4	87.0°F	Diptera (Fly)	
		Tendipedidae larvae	A
		Odonata (Damselfly & Dragonfly)	
		Lestes sp.	P
		Ephemeroptera (Mayfly)	
		Ephemerella sp.	P

(continued)

TABLE 16 (continued)

STATION	SURFACE TEMPERATURE	ORDER/GENERA	*
EAST			
S-17	80.5°F	Diptera (Fly)	
		Calopsectra sp.	A
		Trichoptera (Caddisfly)	
		Leptocella sp.	MA
		Coleoptera (Beetle)	
		Berosus sp. larvae	MA
		Ephemeroptera (Mayfly)	
		Ephemerella sp.	P

STATION	SURFACE TEMPERATURE	ORDER/GENERA	*
WEST			
S-17	80.5°F	Neuroptera	
		Climacia areolaris (abundant on sponges)	VA
		Coleoptera (Beetle)	
		Ancyronyx	VA
		Ephemeroptera (Mayfly)	
		Ephemerella sp.	MA
		Diptera (Fly)	
		Calopsectra sp.	MA
		Tendipedidae larvae	A
		Trichoptera (Caddisfly)	
		Limnephilus sp.	A

KEY: VA = Very Abundant
A = Abundant
MA = Moderately Abundant
P = Present

produced insect populations which appeared to be determined largely by environmental niche diversity. Also, stations north and south of the canal had representatives of what are generally referred to as "clean water" forms, which included Ephemeroptera (Mayflies), Trichoptera (Caddisflies), and Odonata (Dragonflies). Fewer Plecoptera (Stoneflies) were noted during 1971 than in the 1970 survey.

6. Benthic Invertebrates

Results of the 1971 benthic survey are presented in Tables 17 through 19. As shown by the data, shore areas were in all cases more productive than mid-channel areas. This is largely a result of substrate type, as sand predominated in mid-channel areas and clay-like substrates at the more productive littoral sites. The family Tendipedidae (*Tendipes* sp.) accounted, as it did in 1970, for the largest percentages of invertebrates collected. The largest numbers of organisms were found at stations south of the discharge canal throughout the year, and August was the month of highest productivity at all stations. The greater productivity at southern stations (S-8 and S-20) was probably due to the silt-like substrate and large amounts of organic detritus at these locations. Both of the two dominate genera, *Tendipes* sp. and *Limnodrilus* sp., are known as pollution tolerant forms (Bartsch and Ingram, 1959).

In general, numbers and diversity of benthic organisms did not

TABLE 17

BENTHIC INVERTEBRATES
JUNE
HOOKSETT POND - MERRIMACK RIVER - 1971

(Numbers per Liter Sample)

	Bottom Temp.	*Campeloma decisum* Snail	*Tendipes* sp. Midge Larvae	*Limnodrilus claparedianus* Aquatic earthworm	*Elliptio complanatus* Clam	Hirudinea Leech	*Dugesia tigrina* Planarian
N-8							
Mid-River	69.5°F	2	19	1			
Shore Sample #1	69.5°F	42	15	11	6	2	1
Shore Sample #2	69.5°F	1	22	11	4		
S-8							
Mid-River	70.5°F		25	2			
Shore Sample #1	75.5°F	8	24	6	1		
Shore Sample #2	75.5°F	2	8	20	4		
S-20							
Mid-River	73.0°F		17	3	1		
Shore Sample #1	73.0°F	1	48	10	3		
Shore Sample #2	73.0°F		44	10	6		

TABLE 18

BENTHIC INVERTEBRATES
AUGUST
HOOKSETT POND - MERRIMACK RIVER - 1971

(Numbers per Liter Sample)

	Bottom Temp.	*Campeloma decisum* Snail	*Tendipes* sp. Midge Larvae	*Limnodrilus claparedianus* Aquatic earthworm	*Elliptio complanatus* Clam	Hirudinea Leech	*Dugesia tigrina* Planarian
N-8							
Mid-River	76.5° F		8	1			
Shore Sample #1	76.5° F	5	41	7		1	
Shore Sample #2	76.5° F	7	54	18			
S-8							
Mid-River	77.0° F	2	24	7	1		
Shore Sample #1	79.5° F	39	40	31	5	6	25
Shore Sample #2	79.5° F	10	75	21	2	6	5
S-20							
Mid-River	77.0° F	1	27	13	1		
Shore Sample #1	80.0° F	4	149	50		1	2
Shore Sample #2	80.5° F	3	209	61			

TABLE 19

BENTHIC INVERTEBRATES
OCTOBER
HOOKSETT POND - MERRIMACK RIVER - 1971

(Numbers of Liter Sample)

	Bottom Temp.	*Campeloma decisum* Snail	*Tendipes* sp. Midge Larvae	*Limnodrilus claparedianus* Aquatic earthworm	*Elliptio complanatus* Clam	Hirudinea Leech	*Dugesia tigrina* Planarian
N-8							
Mid-River	58.0° F	11					
Shore Sample #1	58.0° F	4	21	3	1		
Shore Sample #2	58.0° F	9	11	8			
S-8							
Mid-River	59.5° F	2	9	1			
Shore Sample #1	61.0° F	23	20		2	1	
Shore Sample #2	61.5° F	34	3	4	4	1	
S-20							
Mid-River	57.5° F	1	12	1			
Shore Sample #1	60.0° F	7	62	17	5	1	5
Shore Sample #2	60.0° F	2	24	5	3		

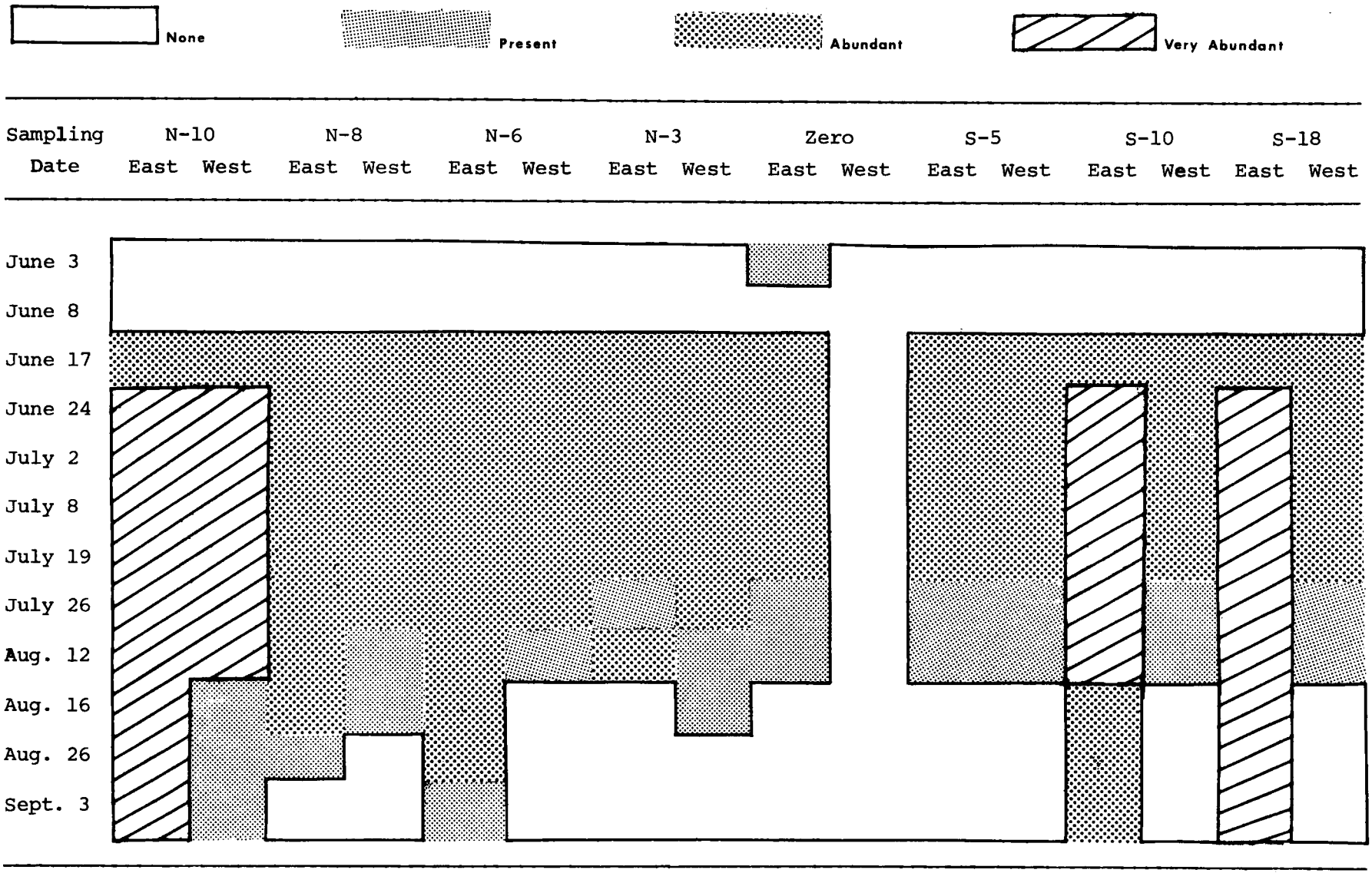
appear to be negatively affected by slightly increased temperatures south of the discharge canal. While the cause of increased numbers of organisms at S-8 and S-20 is most likely substrate differences, the influence of the Suncook River and the slightly warmed waters in these areas should not be overlooked.

7. Fish Surveys

a) LARVAL FISH - Results of the larval fish survey are presented in Figure 7. Seasonal trends are clearly shown by the near absence of fish in the early spring prior to reproductive activity, and during the early fall after its cessation. During the late spring and throughout the summer, numbers of larval fish increased markedly. *Catostomus commersoni* (white sucker) and *Notropis cornutus* (common shiner) were predominant through mid-July, but centrarchids (bass and sunfish) were most abundant during the rest of the season. At no time during the year were nests or larval fish present in the discharge canal, probably due to temperature extremes and turbulence created by testing of spray modules.

Larval fish were not observed at Station Zero west at any time during the period of their occurrence at other stations. In general, temperatures in excess of 93.0° F appeared to be limiting to populations at this location. Stations N-10, S-10, and S-18,

Figure 7. Larval fish relative abundance - Hooksett Pond - Merrimack River - 1971.



which provided the best habitat, had the greatest numbers of fish. The temperature regime, in terms of maximum and minimum temperatures recorded at each station, are shown in Figure 8. Cluster analysis, a means by which larger sets of data are grouped into smaller, more manageable units on the basis of overall similarities and/or differences, was used to study these temperature regimes. In particular, an algebraic difference measure described by Hartigan (1971) was used to establish cluster boundaries indicated in Figure 8. Mean monthly temperatures of each cluster are shown in Table 20. As a result of the cluster analysis, three groups of stations stood out as having essentially the same "climate". As would be expected, stations located north and south of the discharge canal appeared as clusters, and Station Zero west, the area under the greatest thermal influence, comprised another quite distinct entity. While there appeared to be an inverse relationship between larval fish observations (see Figure 8) and temperatures at the stations sampled, it would be difficult to separate temperature effects from those of habitat differences.

b) NON-LARVAL FISH - The May electro-fishing survey revealed *Catostomus commersoni* (white sucker) and *Notropis cornutus* (common shiner) to be the predominant species (Table 21). The most diverse population at this time was found at Station Zero west, probably as a result of warming of the seasonally cool waters. The July survey (Table 22) indicated a shift in the community structure,

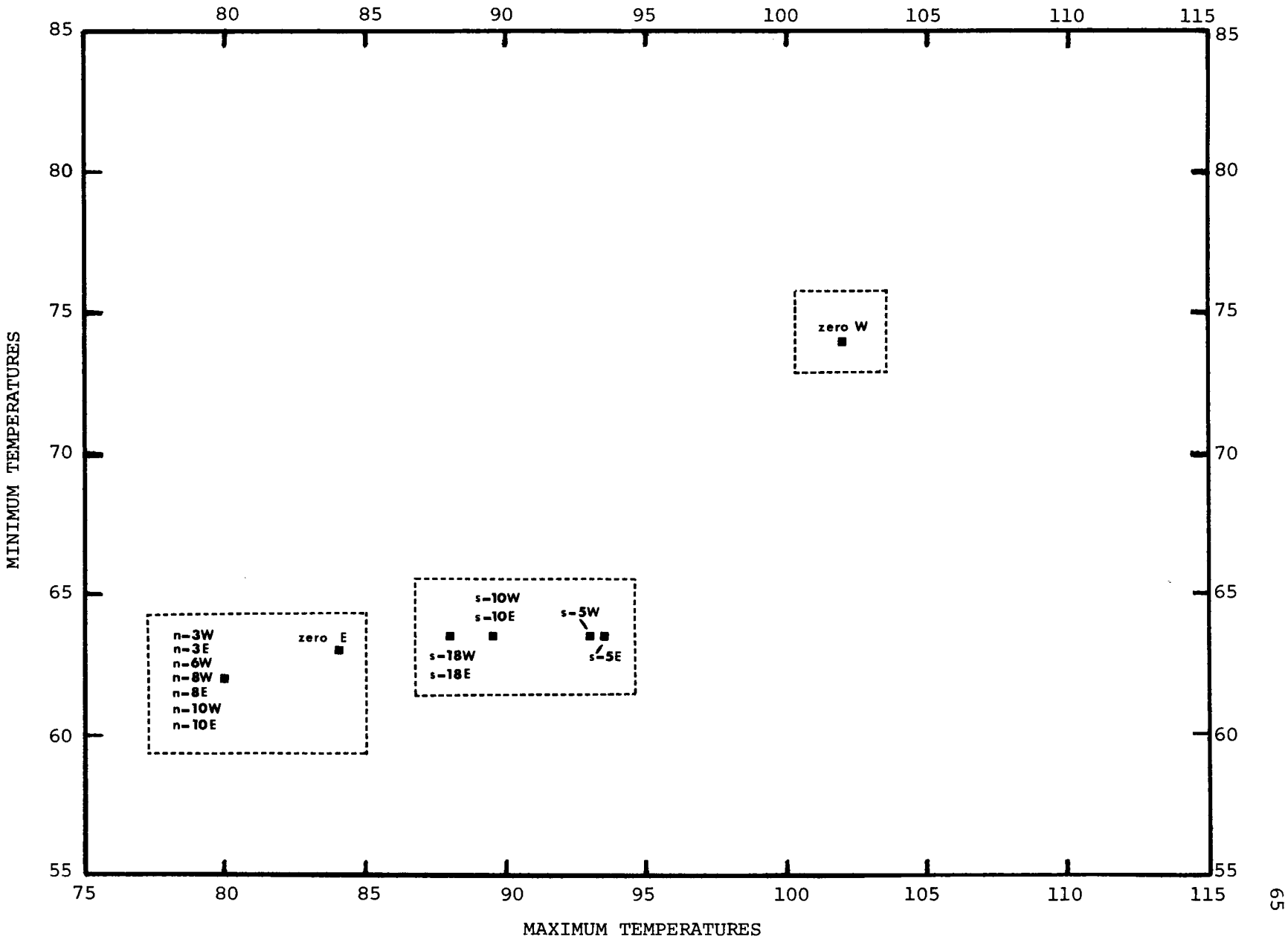


Figure 8. Maximum and minimum temperature (°F) recorded at fish larvae sampling stations illustrating clusters of similar stations.

TABLE 20

MEAN MONTHLY TEMPERATURE (°F) FOR THREE GROUPS OF STATIONS SHOWN TO BE SIMILAR WITHIN THEMSELVES - HOOKSETT POND - MERRIMACK RIVER - 1971

MONTH	NORTH AND ZERO EAST	ZERO WEST	SOUTH
June	69.8°F	90.4°F	77.1°F
July	78.3°F	98.9°F	86.2°F
August	75.1°F	96.8°F	85.1°F
*September	75.5°F	**82.0°F	78.5°F

*based on readings taken only on September 3, 1971
**one observation

TABLE 21

ELECTRO-FISHING SURVEY[4]
HOOKSETT POND - MERRIMACK RIVER

MAY 20, 1971

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
EAST			
N-10	55.0°F	*Catostomus commersoni*	9
		Notropis cornutus	14
		Lepomis gibbosus	1
		Perca flavescens	9
		Roccus americanus	1
N-8	55.0°F	*Catostomus commersoni*	5
		Notropis cornutus	23
		Ictalurus nebulosus	2
		Lepomis gibbosus	1
		Perca flavescens	7
N-6	55.0°F	*Catostomus commersoni*	5
		Notropis cornutus	8
		Perca flavescens	4
N-3	55.0°F	*Catostomus commersoni*	3
		Notropis cornutus	23
		Notropis umbratilis	1
		Ictaurus nebulosus	1
		Perca flavescens	2
Zero	55.0°F	*Notropis cornutus*	31
WEST			
	55.0°F	*Catostomus commersoni*	19
		Notropis cornutus	8
		Ictalurus nebulosus	1
		Micropterus dolomieui	3
		Lepomis gibbosus	1
		Perca flavescens	7
N-8	55.0°F	*Catostomus commersoni*	3
		Notropis cornutus	19
		Ictalurus nebulosus	1
		Lepomis gibbosus	2
		Perca flavescens	10
N-6	55.0°F	*Catostomus commersoni*	1
		Notropis cornutus	3
N-3	55.0°F	*Catostomus commersoni*	4
		Notropis cornutus	1
		Perca flavescens	7
Zero	79.0°F	*Catostomus commersoni*	1
		Notropis cornutus	1
		Semotilus corporalis	3
		Ictalurus nebulosus	1

(continued)

Table 21 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
EAST			
S-5	57.0°F	*Catostomus commersoni*	3
		Lepomis gibbosus	1
		Perca flavescens	4
S-10	57.0°F	*Catostomus commersoni*	4
		Notropis cornutus	20
		Lepomis gibbosus	7
		Lepomis auritus	2
		Perca flavescens	7
S-18	55.0°F	*Lepomis gibbosus*	1
		Perca flavescens	1
		Esox niger	1

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
WEST			
Zero (continued)		*Lepomis gibbosus*	10
		Lepomis auritus	1
		Perca flavescens	12
		Anguilla rostrata	2
S-5	57.0°F	*Lepomis gibbosus*	1
		Perca flavescens	3
S-10	57.0°F	*Catostomus commersoni*	1
S-18	55.0°F	*Catostomus commersoni*	1
		Lepomis gibbosus	2
		Perca flavescens	4

[4]See GLOSSARY for common names.

TABLE 22

ELECTRO-FISHING SURVEY
HOOKSETT POND - MERRIMACK RIVER

JULY 6, 1971

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
EAST			
N-10	74.5°F	*Catostomus commersoni*	1
		Notropis cornutus	1
		Lepomis gibbosus	1
N-8	75.0°F	*Perca flavescens*	3
		Lepomis gibbosus	12
		Catostomus commersoni	1
		Micropterus salmoides	2
		Ictalurus nebulosus[1]	100+
		Notropis cornutus	20+
N-6	75.0°F	*Ictalurus nebulosus*	1
		Catostomus commersoni	1
		Lepomis auritus	1
		Perca flavescens	3
		Lepomis gibbosus	8
N-3	76.0°F	*Anguilla rostrata*	1
		Perca flavescens	5
		Lepomis gibbosus	4

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
WEST			
N-10	74.5°F	*Salmo gairdneri*	1
		Micropterus dolomieui	2
		Perca flacescens	5
		Notropis cornutus	1
		Salvelinus fontinalis	1
N-8	75.5°F	*Catostomus commersoni*	1
		Perca flavescens	2
		Lepomis gibbosus	2
N-6	76.0°F	*Ictalurus nebulosus*	1
		Catostomus commersoni	3
		Perca flavescens	4
		Lepomis gibbosus	5
N-3	76.0°F	*Perca flavescens*	3
		Lepomis auritus	1
		Lepomis gibbosus	7

[1]larvae

(continued)

Table 22 (continued)

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
COMBINED N-1, Zero and S-1	81°-100°F	*Micropterus salmoides*	1
		Micropterus dolomieui	3
		Perca flacescens	3
		Lepomis auritus	1
		Lepomis gibbosus	15
EAST			
ZERO	91.0°F	*Micropterus dolomieui*	1
		Lepomis auritus	1
		Lepomis gibbosus	4
S-5	91.0°F	*Micropterus dolomieui*	2
		Lepomis gibbosus	3
S-10	89.0°F	*Micropterus salmoides*	2
		Ictalurus nebulosus	5
		Perca flavescens	4
		Lepomis auritus	2
		Lepomis gibbosus	16
S-18	83.0°F	*Ictalurus nebulosus*	8
		Ictalurus nebulosus[1]	100+
		Ictalurus natalis	1
		Perca flavescens	8
		Lepomis auritus	2
		Lepomis gibbosus	32

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
WEST			
S-5	91.0°F	NO FISH	
S-10	86.0°F	NO FISH	
S-18	82.0°F	*Lepomis gibbosus*	2

[1]larvae

with centrarchids becoming prevalent at most stations. At Station Zero west temperatures of 100° F apparently prohibited habitation by fish, and downstream temperatures at Station S-5 (91.0° F) appeared to cause reduced numbers and diversity. High winds during the August survey were responsible for a reduction in numbers of fish collected at all stations (Table 23). The centrarchids were predominant and increased temperatures at Stations Zero west and S-5 still appeared to result in fish avoidance.

Mean catch per unit effort statistics for game and non-game fish north and south of the discharge canal are presented in Table 24. As shown by the data, no major differences existed in any of the months sampled.

Results of the 1971 fish survey indicated that Station Zero west attained summer temperatures sufficiently high to cause an avoidance by both larval and non-larval forms of fish. With the exception of this station, it is difficult to determine what constitutes temperature effects and what are caused by habitat differences. However, both larval and non-larval forms showed reduced numbers at Station S-5, a station which did not appear to be significantly different from the majority of other stations in habitat type. Seasonal trends in the composition of fish populations were similar both north and south of the canal (see GLOSSARY for common names of species collected during 1971 electro-fishing surveys).

TABLE 23

ELECTRO-FISHING SURVEY
HOOKSETT POND - MERRIMACK RIVER

AUGUST 24, 1971

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
EAST			
N-10	72.5°F	*Catostomus commersoni*	1
N-8	72.5°F	*Notropis cornutus*	1
		Perca flavescens	1
N-6	72.0°F	*Lepomis gibbosus*	1
		Perca flavescens	1
		Esox niger	1
N-3	72.0°F	*Lepomis gibbosus*	4
		Lepomis auritus	1
COMBINED N-1, Zero and S-1	82°-92°F	*Micropterus salmoides*	1
		Lepomis gibbosus	3
EAST			
Zero	84.0°F	*Lepomis gibbosus*	1
S-5	85.0°F	NO FISH	
S-10	84.0°F	*Notropis cornutus*	20+
		Lepomis gibbosus	1
		Perca flavescens	1
S-18	80.5°F	*Micropterus salmoides*	1
		Lepomis gibbosus	2
		Perca flavescens	1

STATIONS	SURFACE TEMPERATURE	SPECIES	NUMBER
WEST			
N-10	72.5°F	*Lepomis gibbosus*	2
		Anguilla rostrata	2
N-8	72.5°F	*Lepomis gibbosus*	2
N-6	72.0°F	*Micropterus salmoides*	2
		Lepomis gibbosus	2
		Perca flavescens	2
N-3	72.0°F	*Lepomis gibbosus*	6
		Perca flavescens	1
S-5	84.0°F	NO FISH	
S-10	85.0°F	NO FISH	
S-18	81.0°F	NO FISH	

TABLE 24

ELECTRO-FISHING MEAN CATCH PER UNIT EFFORT

HOOKSETT POND - MERRIMACK RIVER - 1971[1]

	SPECIES			
	GAME FISH		NON-GAME FISH[2]	
SAMPLING DATE	North	South	North	South
May 20	.046	.037	.152	.032
July 6	.060	.081	.026	.015
August 24	.021	.006	.003	.022

[1]Larvae and/or fish collected at Station Zero were not utilized in computations.

[2]Eels, catfish, shiners, and suckers were considered to be non-game fish.

C. SUMMARY AND CONCLUSIONS

Concentrations of chlorophyll *a* corresponded to seasonal trends in plankton numbers and were found to be highest at Station S-17. Increased numbers of phytoplankton contributed to a reduction in nutrient concentration, and to an increase in dissolved oxygen and pH. A mean Δt of 22.7° F, possibly combined with mechanical/chemical effects of the circulating water system, resulted in slightly reduced numbers of planktonic green algae and diatoms at Station Zero. Periphyton and aquatic plants and insects all showed the effects of increased temperatures at Station Zero. These effects appeared to be limited to the immediate discharge area and recovery downstream was rapid. Fish appeared to avoid increased temperatures at both Station Zero west and S-5. Catch per unit effort data showed no major differences between the areas north and south of the discharge canal. Benthic invertebrate sampling indicated the littoral areas both north and south of the canal to be more productive than the mid-channel areas, and the southern stations to be more productive than the northern stations.

V. LITERATURE CITED

V. LITERATURE CITED

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APPENDIX A

JUNE 8, 1971

SAMPLING CONDITIONS:

Mean Flow:	2,106 cfs
Mean Daily Air Temperature:	77.0° F
Weather:	Cloudy with rain

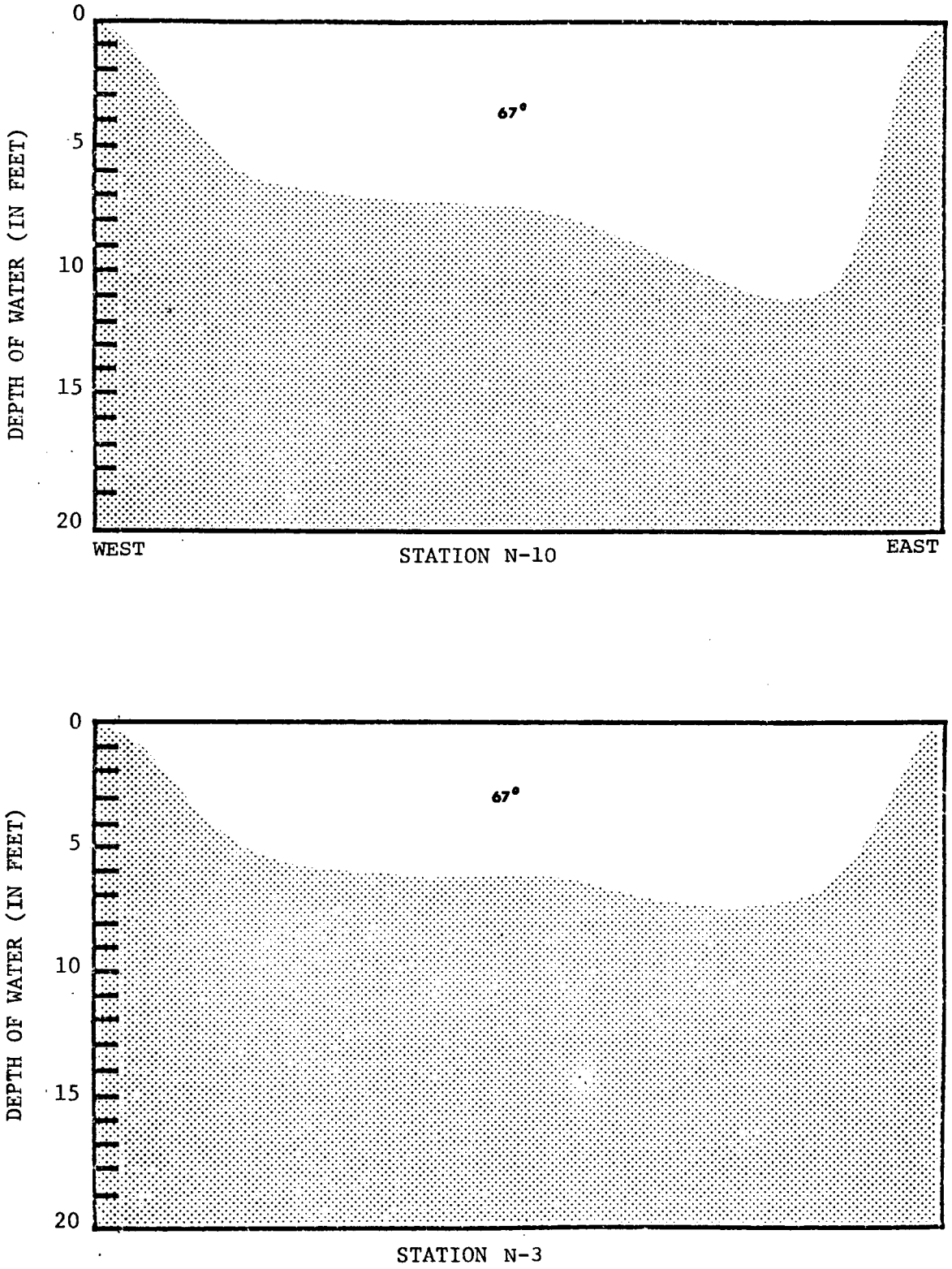
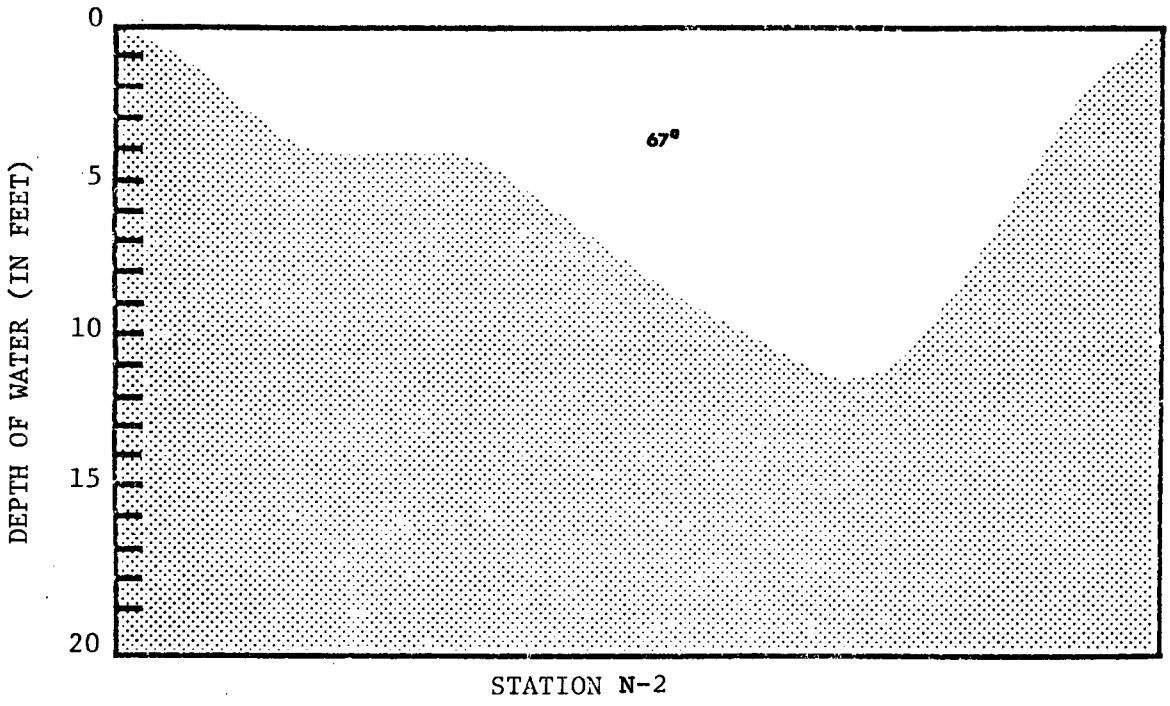


Figure A-1. Temperature Profile - June 8, 1971



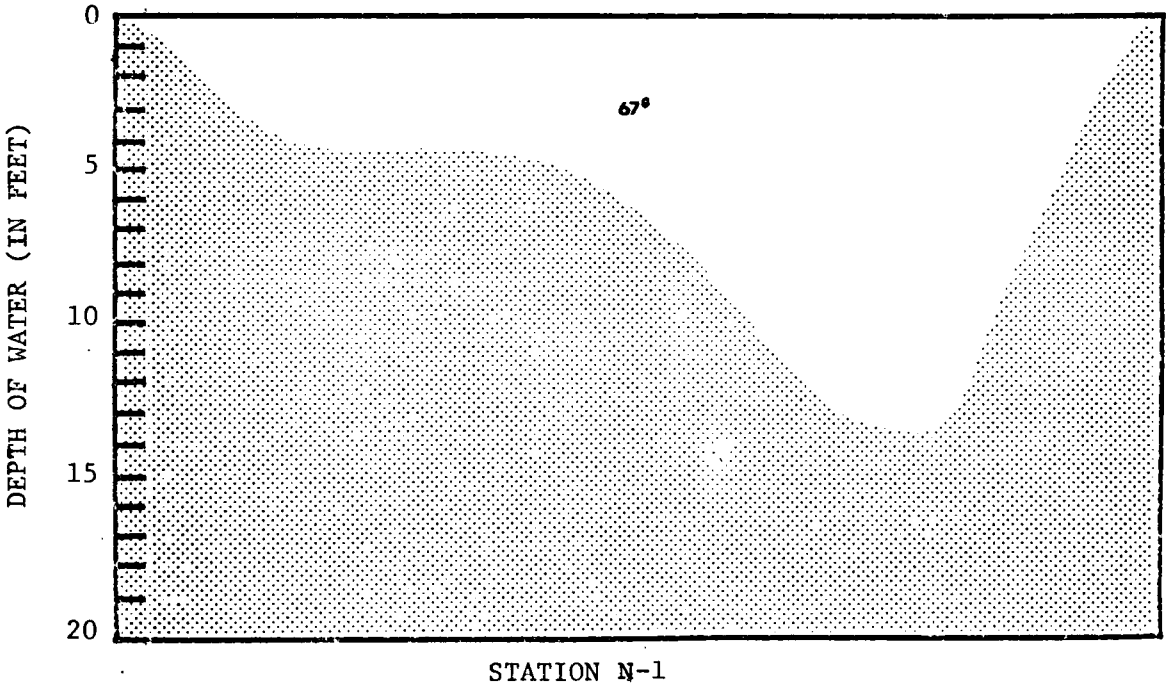
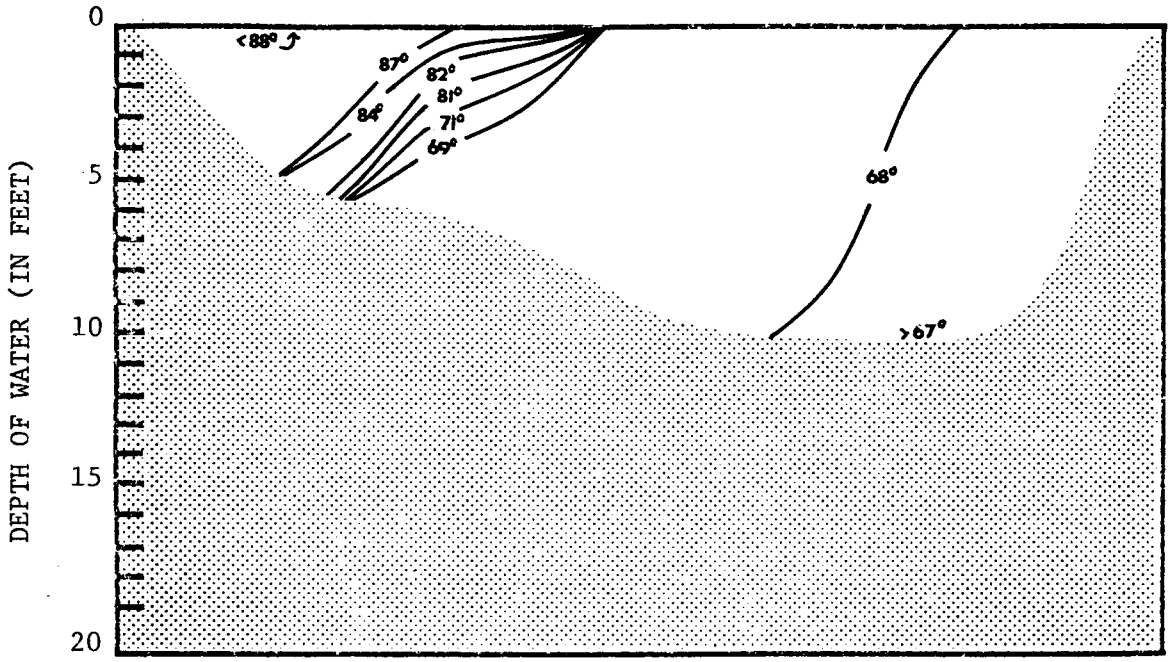


Figure A-2. Temperature Profile - June 8, 1971.



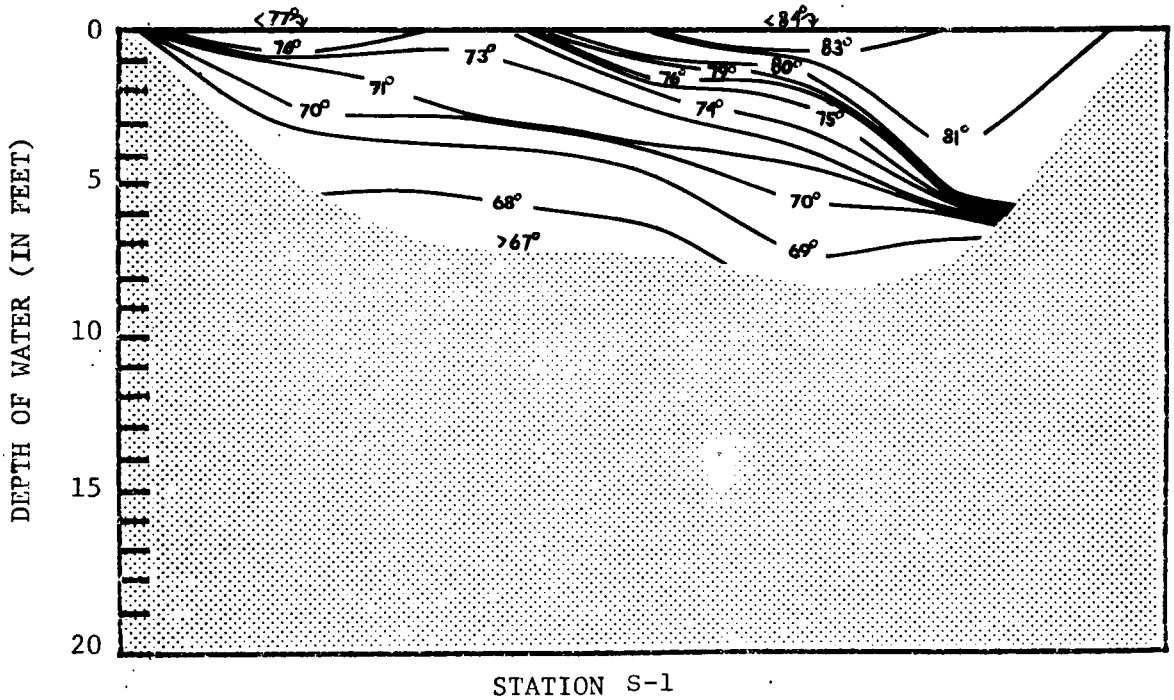


Figure A-3. Temperature Profile - June 8, 1971.

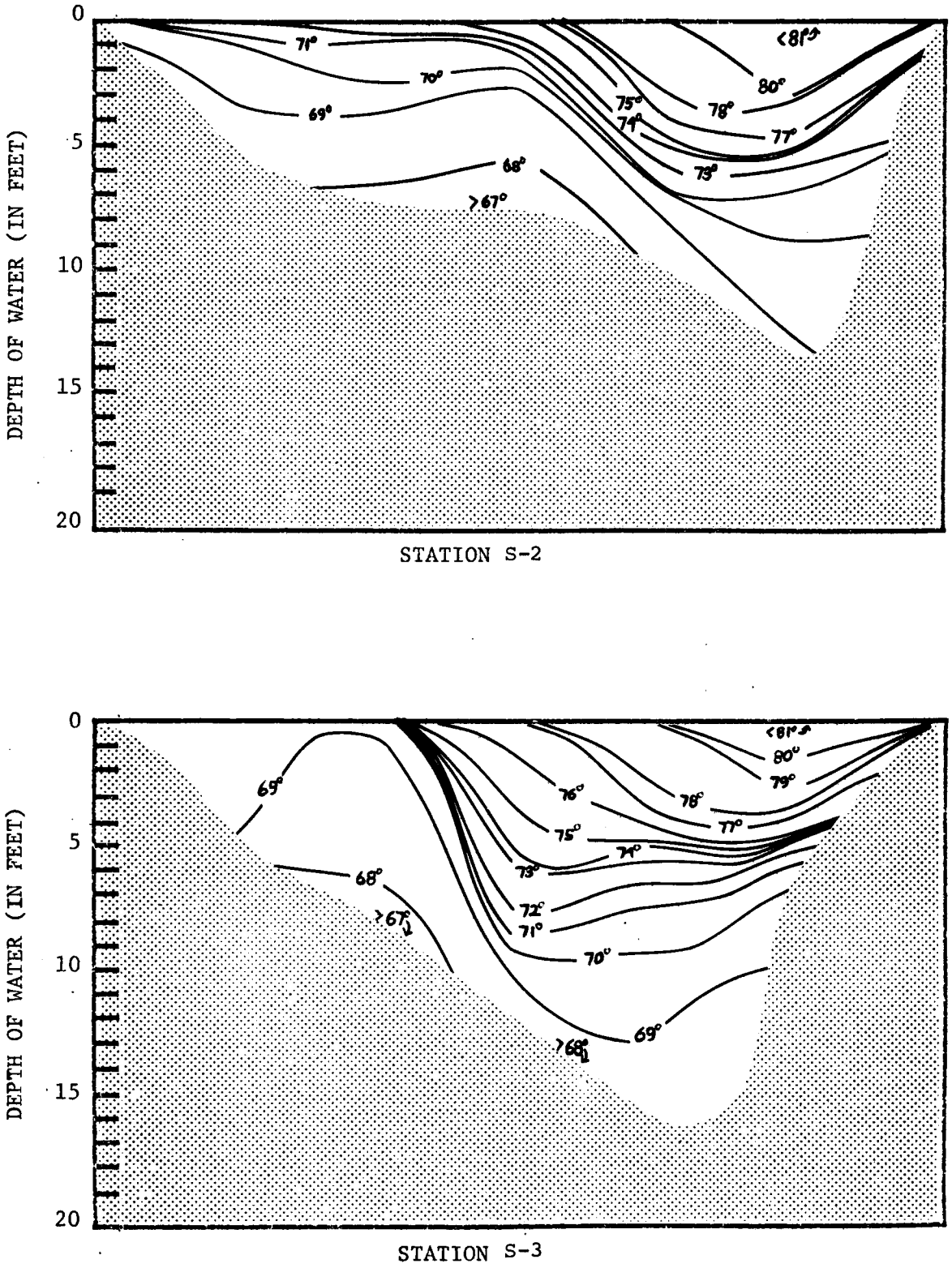
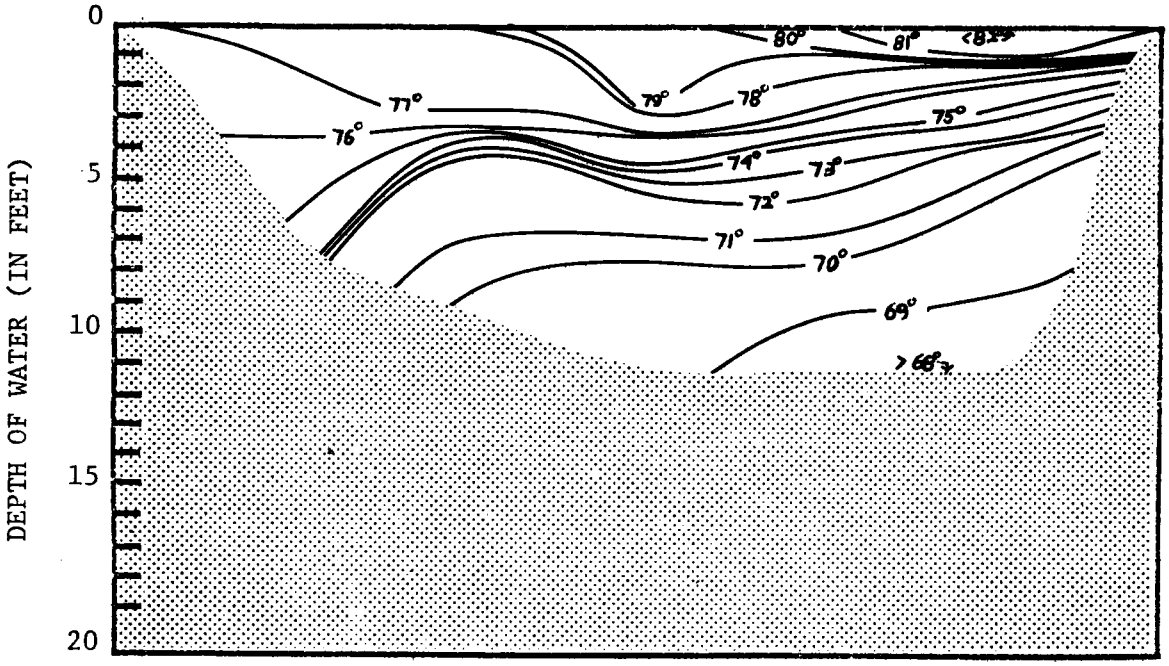
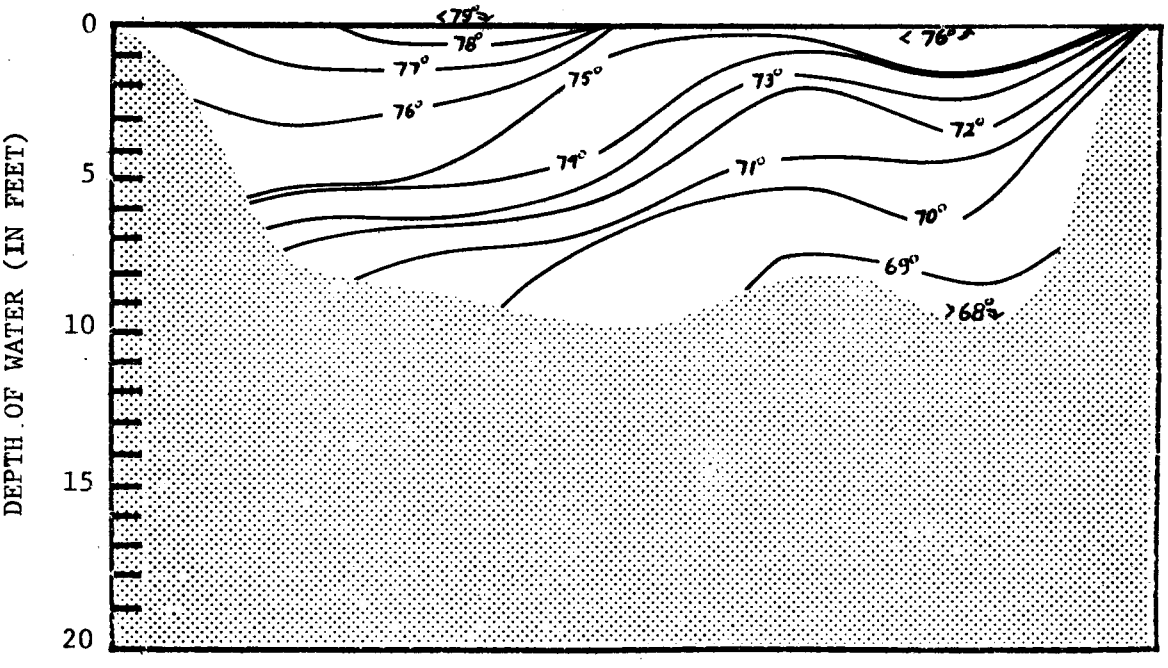


Figure A-4. Temperature Profile - June 8, 1971.



STATION S-4



STATION S-5

Figure A-5. Temperature Profile - June 8, 1971.

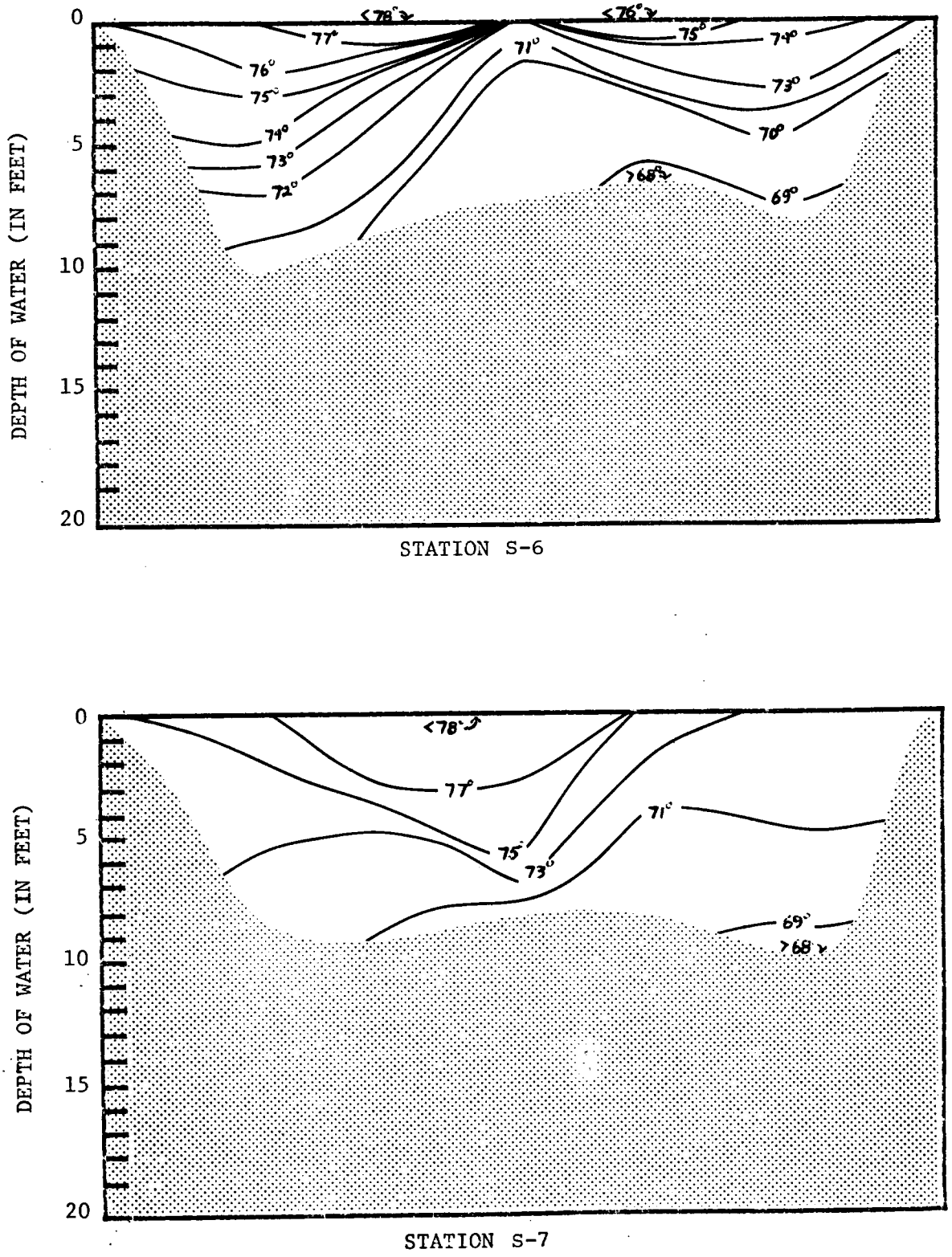


Figure A-6 Temperature Profile - June 8, 1971.

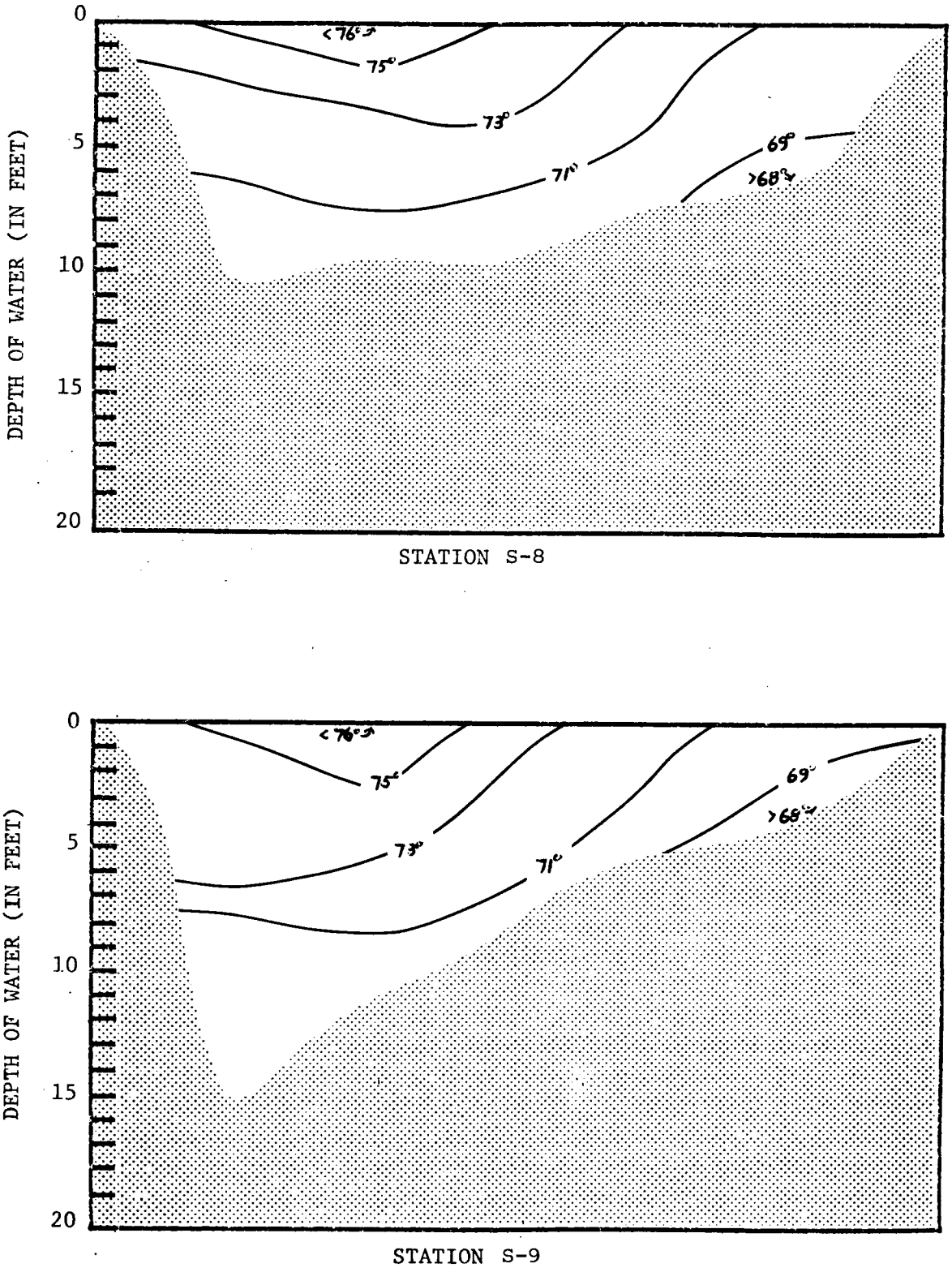
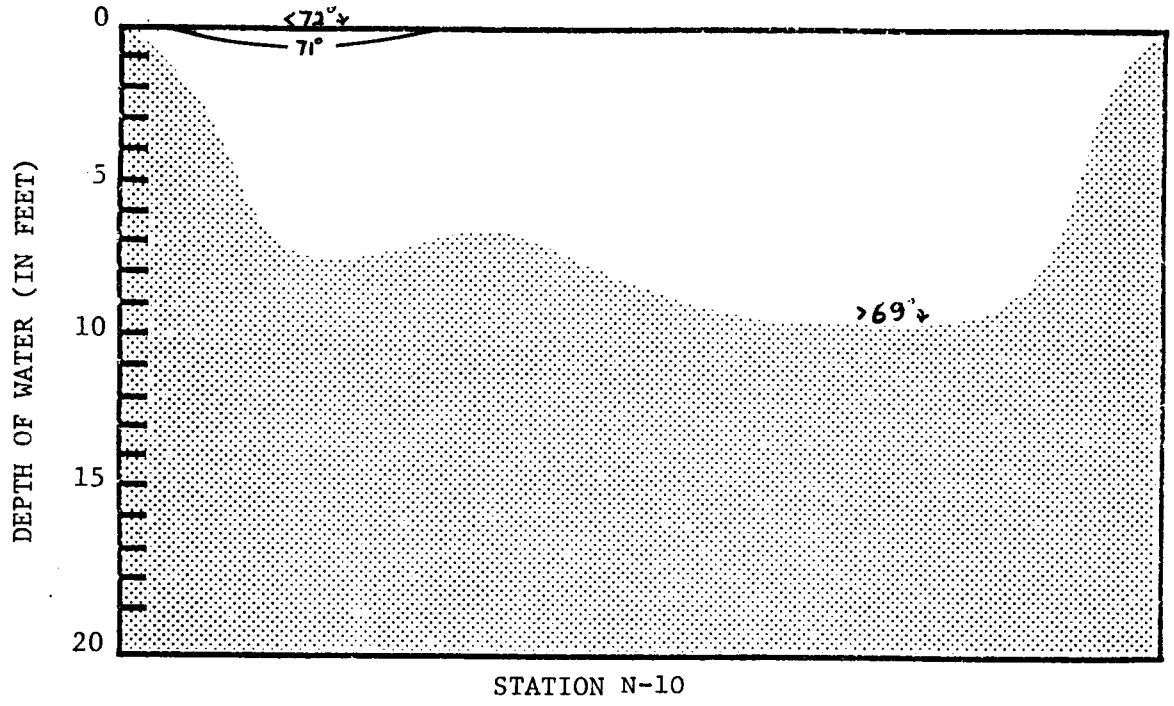


Figure A-7. Temperature Profile - June 8, 1971.



(Re-measurement of ambient temperatures)

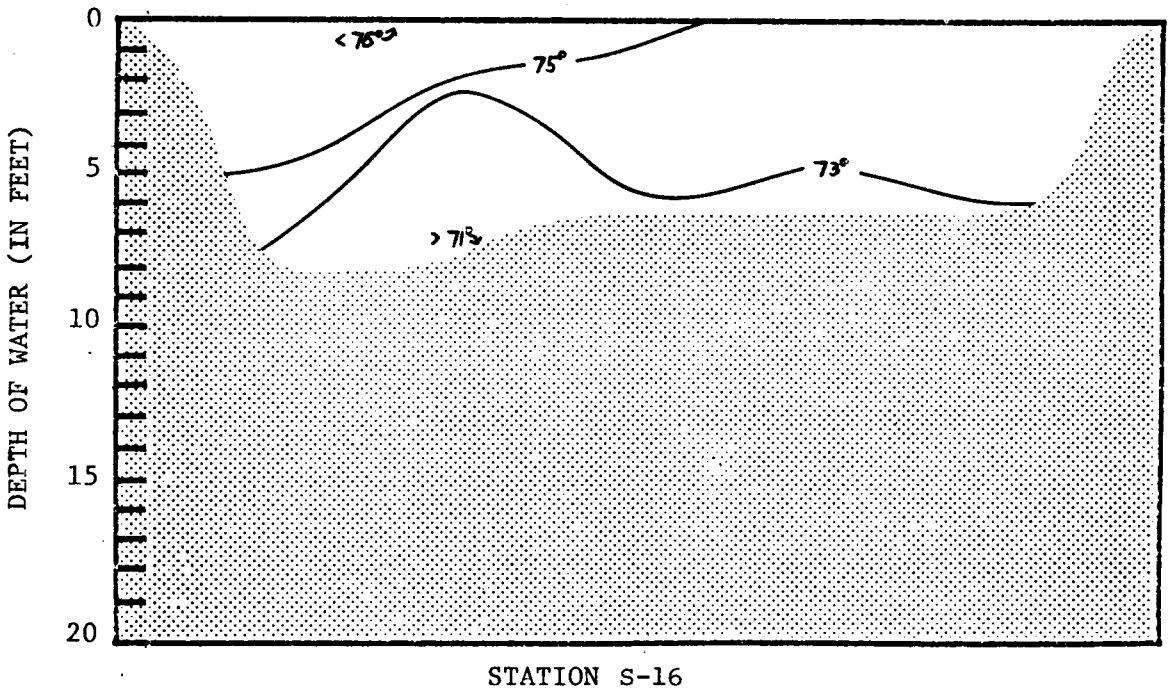


Figure A-8. Temperature Profile - June 8, 1971.

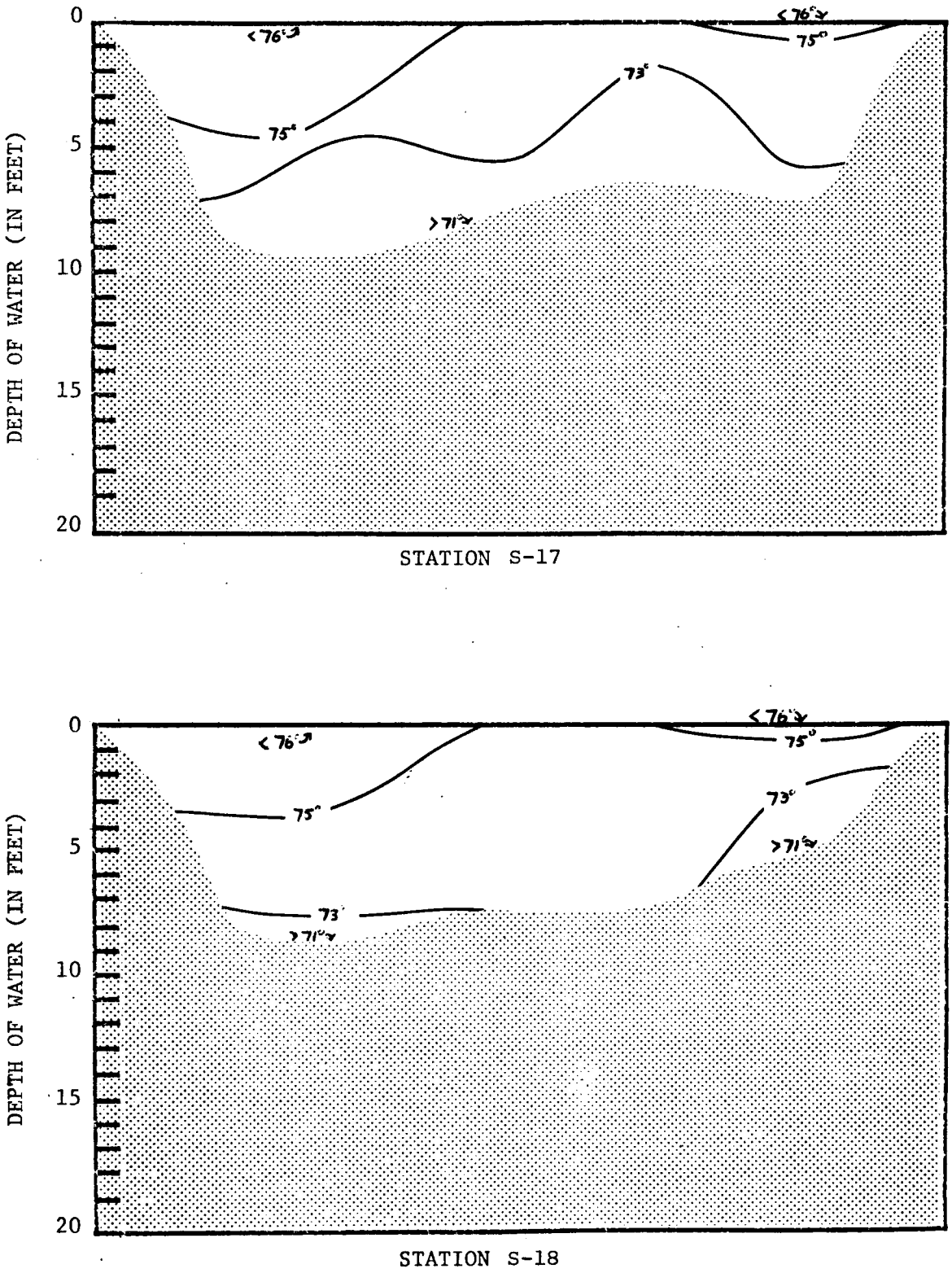
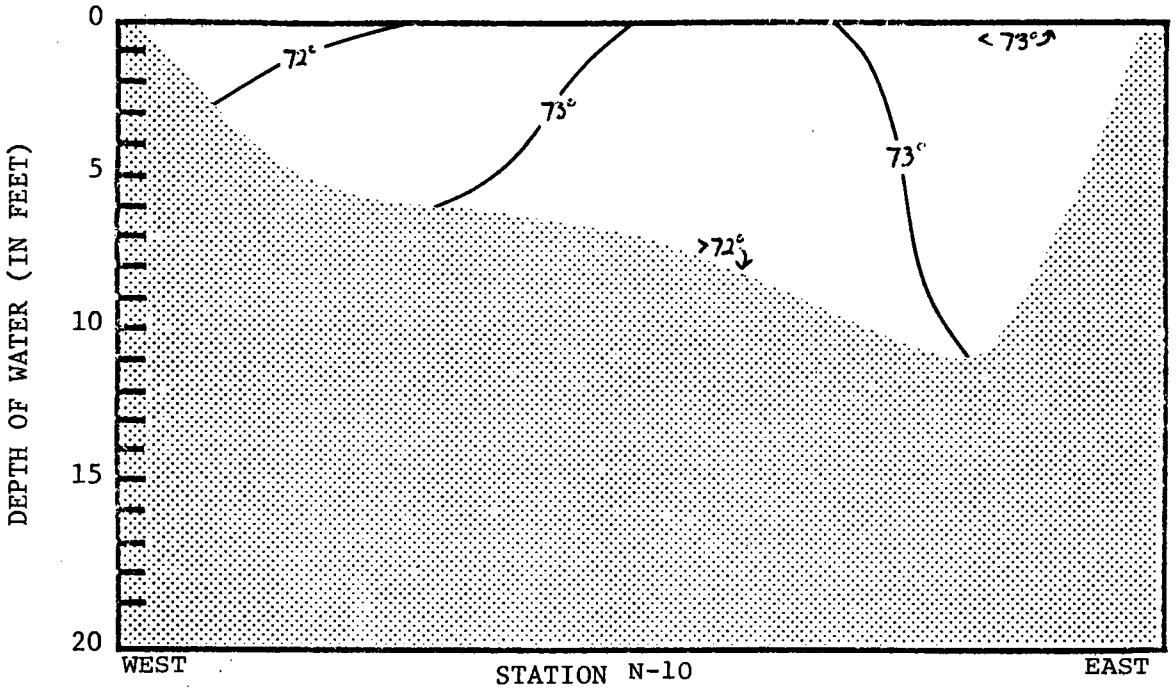


Figure A-9. Temperature Profile - June 8, 1971.

JUNE 28, 1971

SAMPLING CONDITIONS:

Mean Flow:	1,592 cfs
Mean Daily Air Temperature:	66.0° F
Weather:	Clear



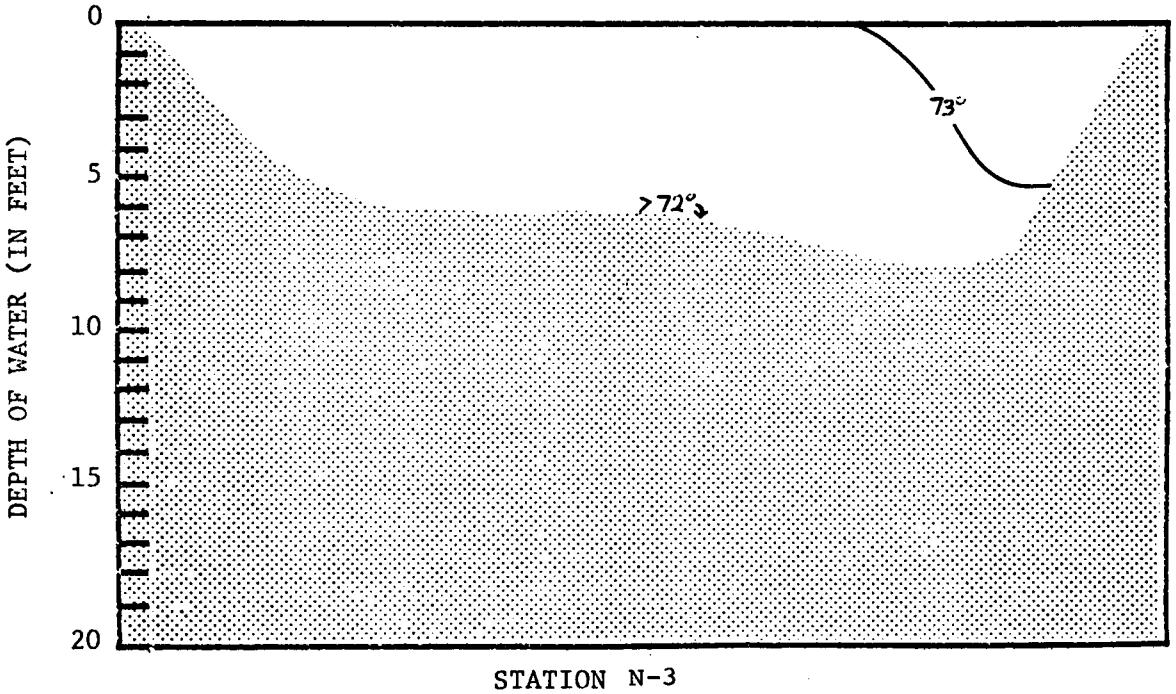


Figure A10. Temperature Profile - June 28, 1971.

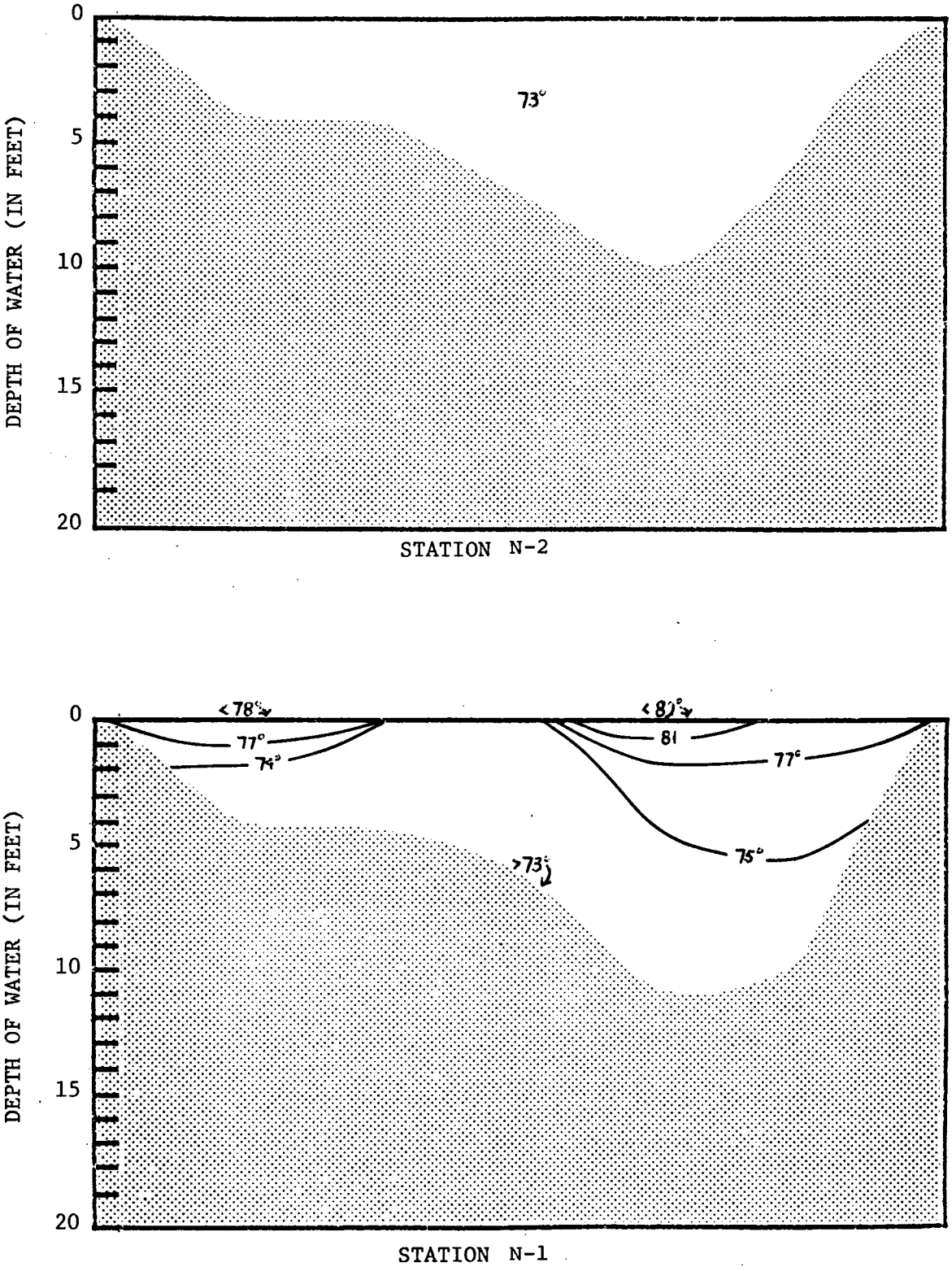


Figure All. Temperature Profile - June 28, 1971.

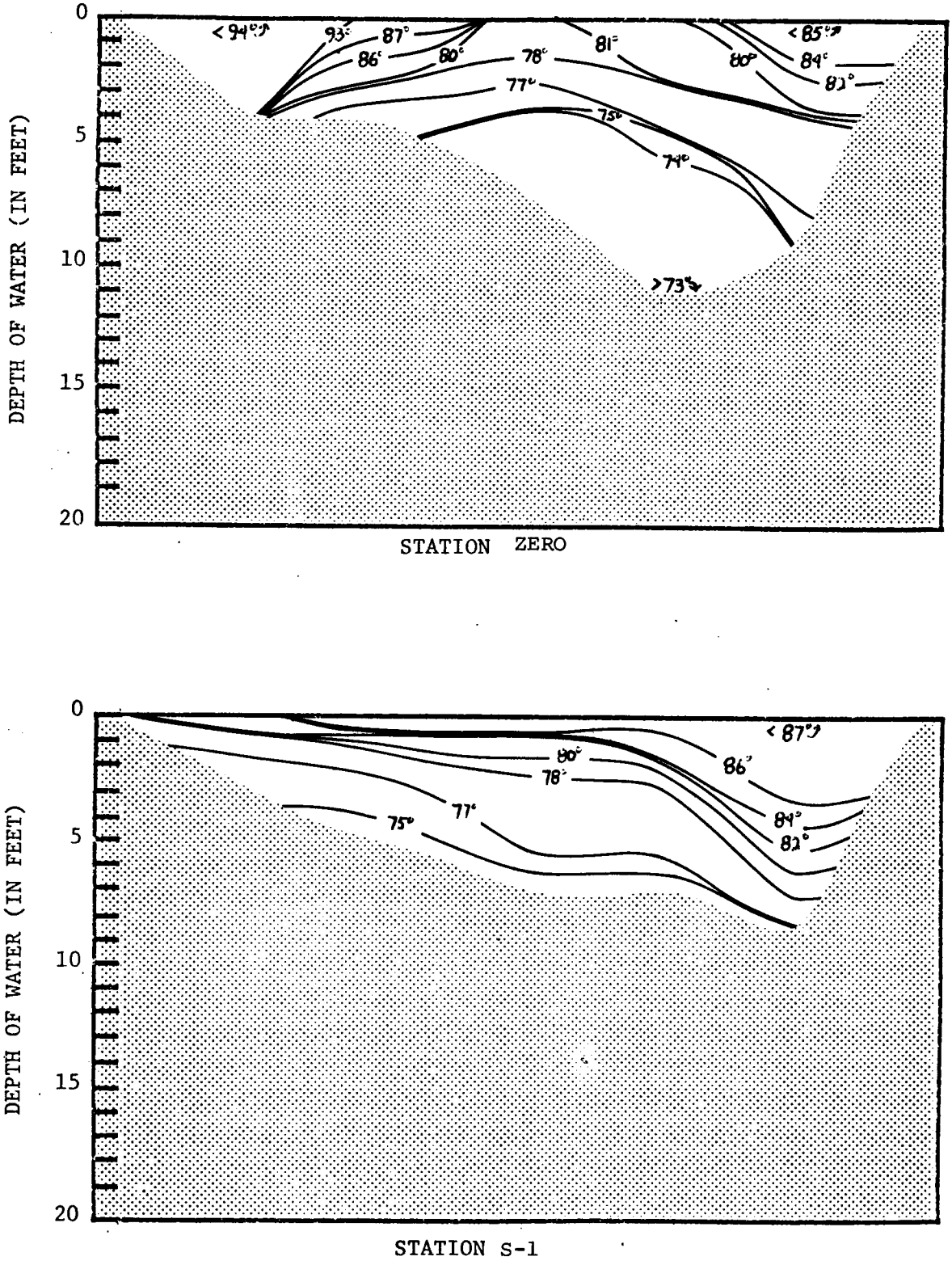
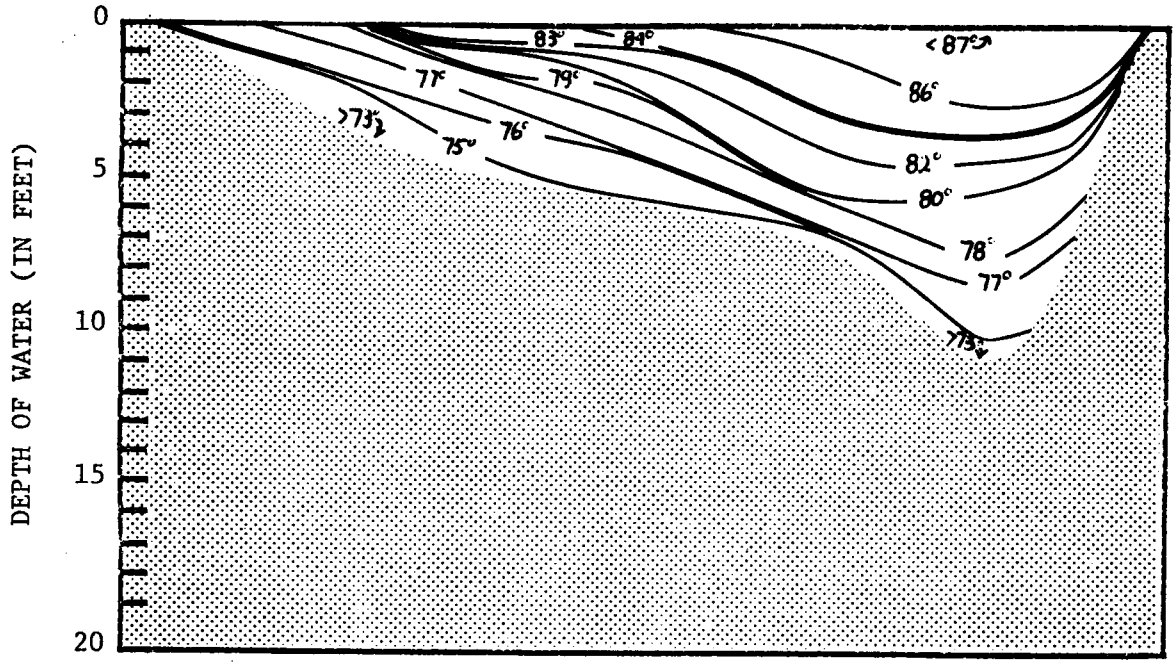
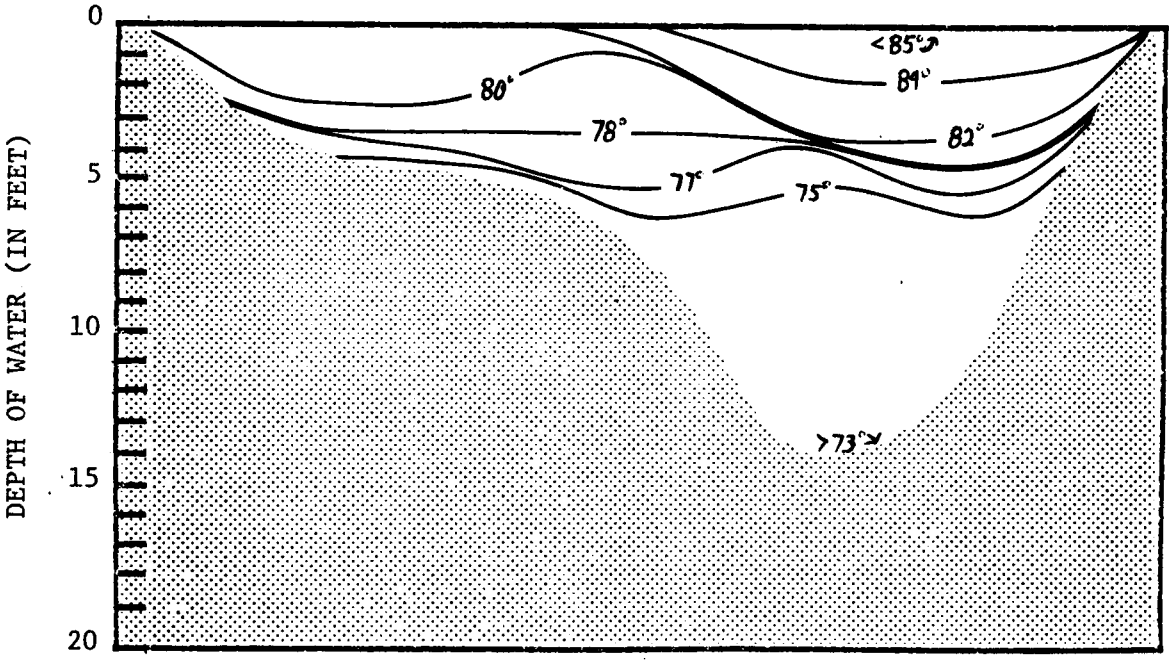


Figure A12. Temperature Profile - June 28, 1971.

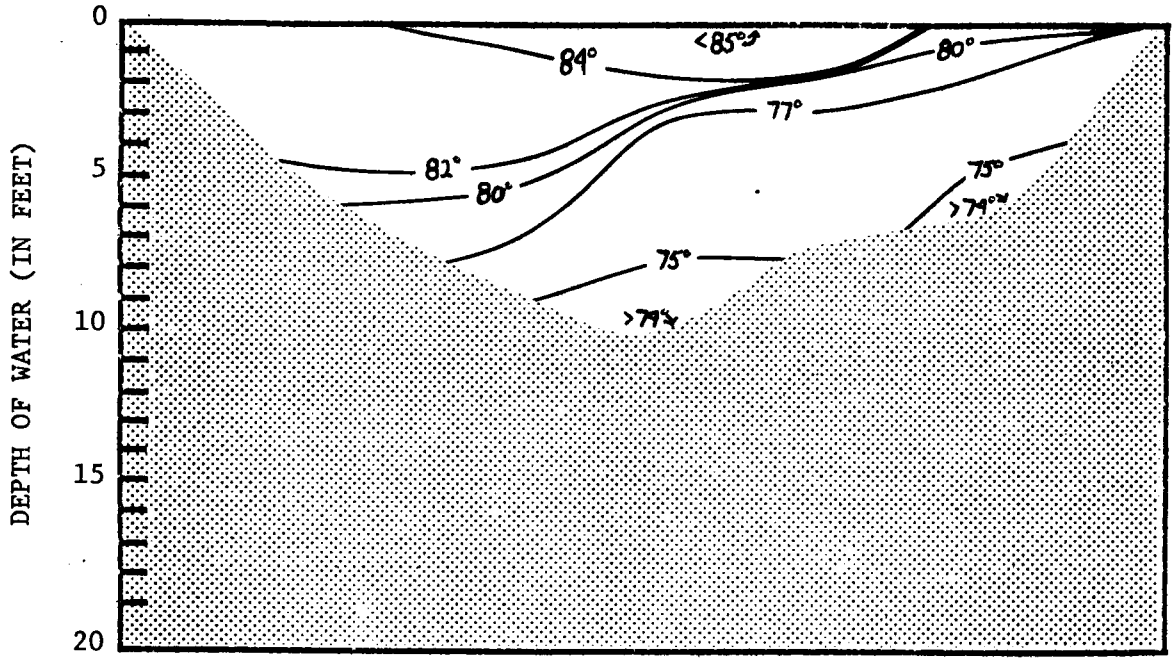


STATION S-2



STATION S-3

Figure A13. Temperature Profile - June 28, 1971.



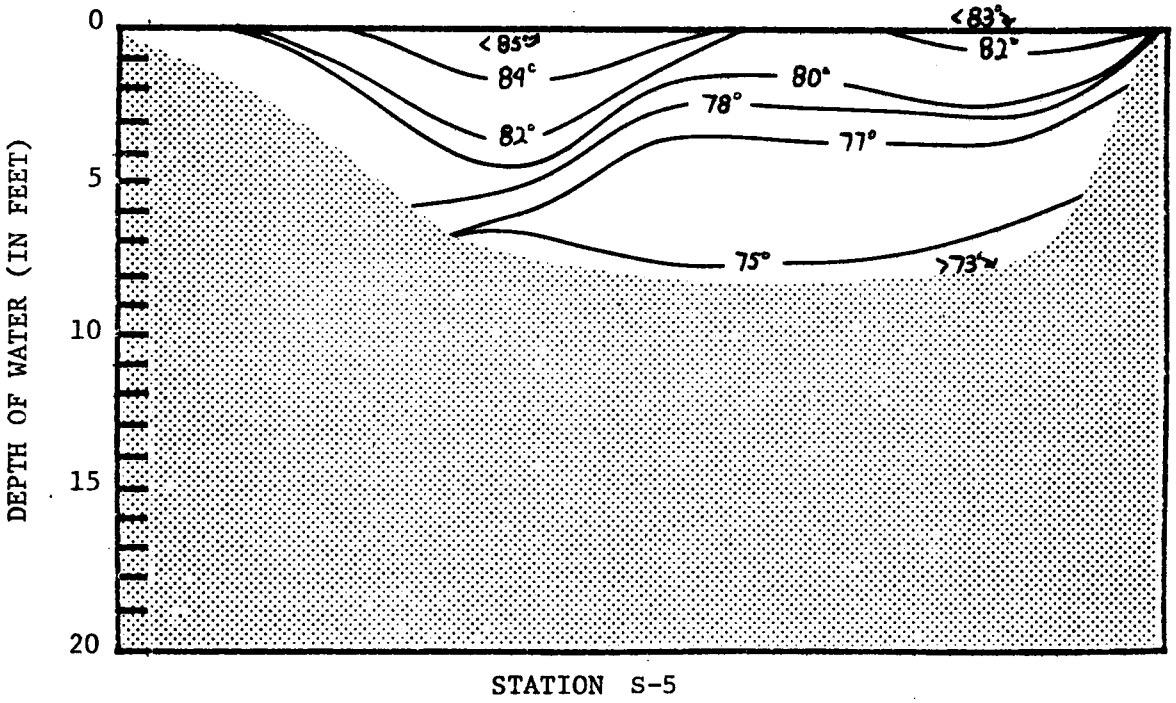
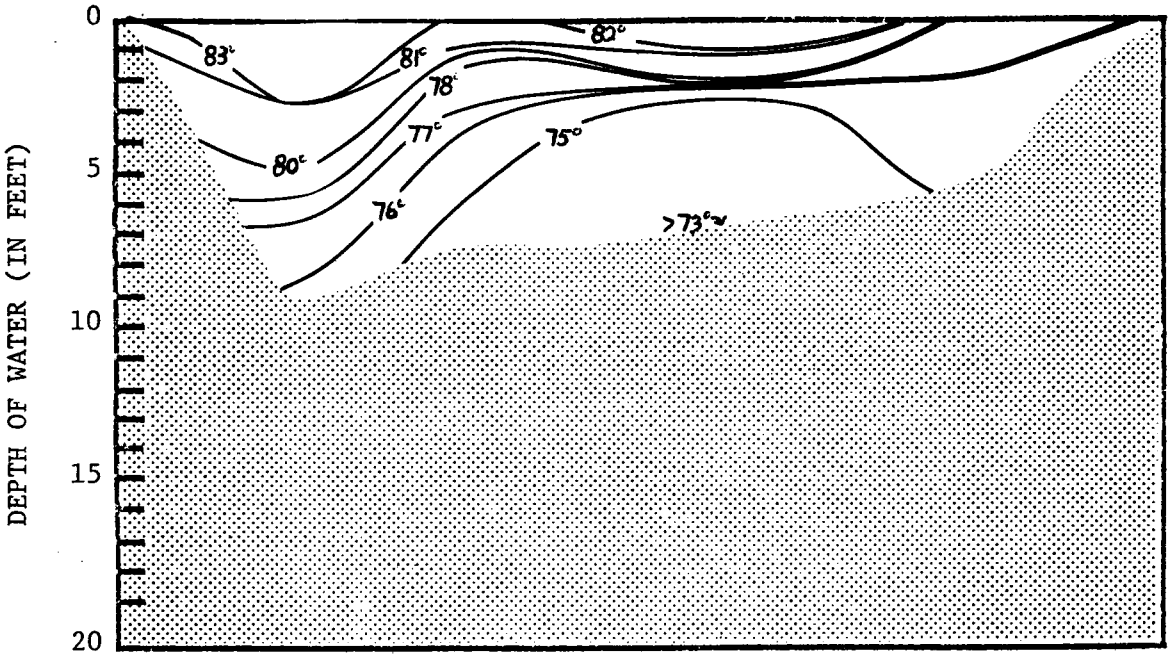


Figure A14. Temperature Profile - June 28, 1971.



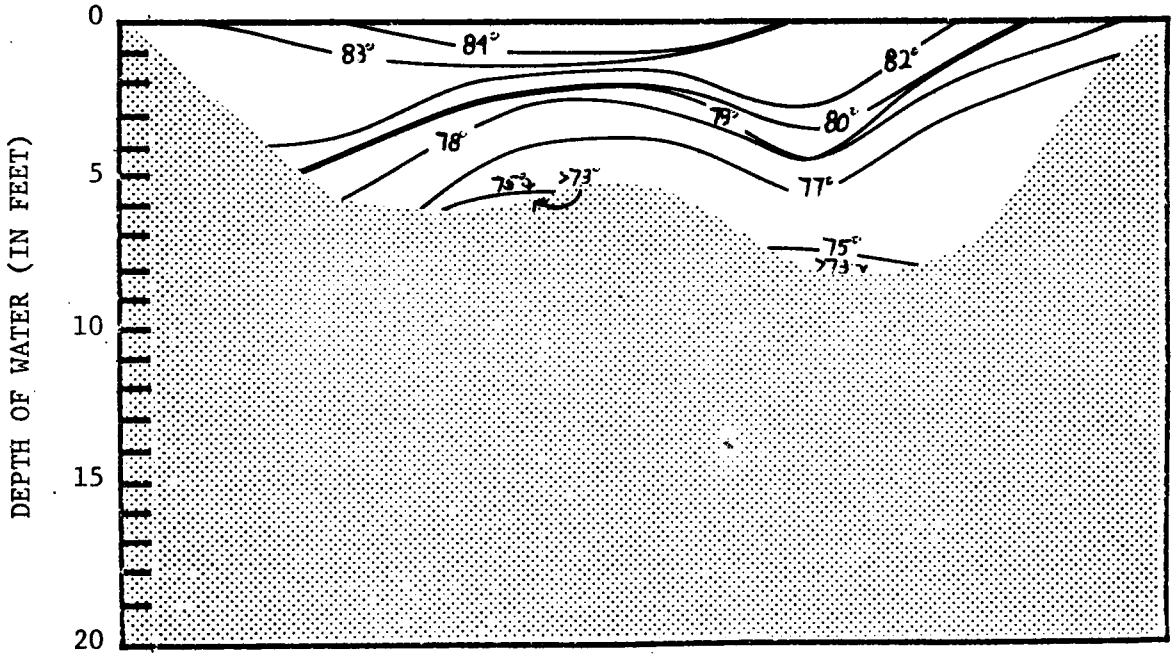
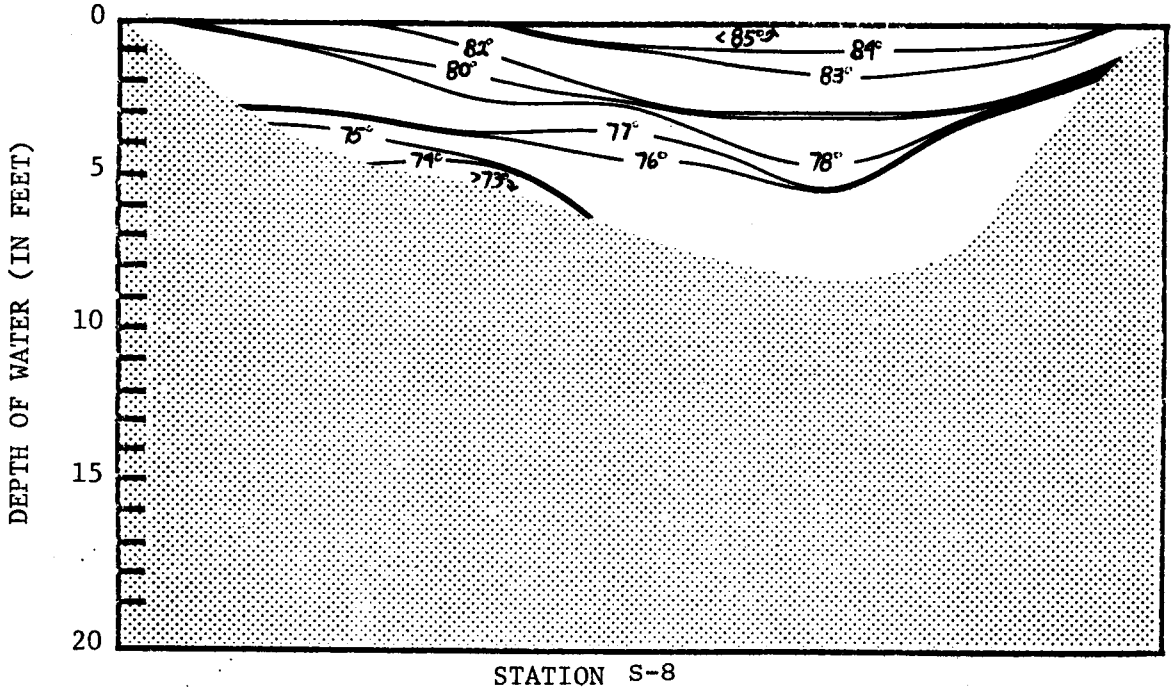


Figure A15. Temperature Profile - June 28, 1971.



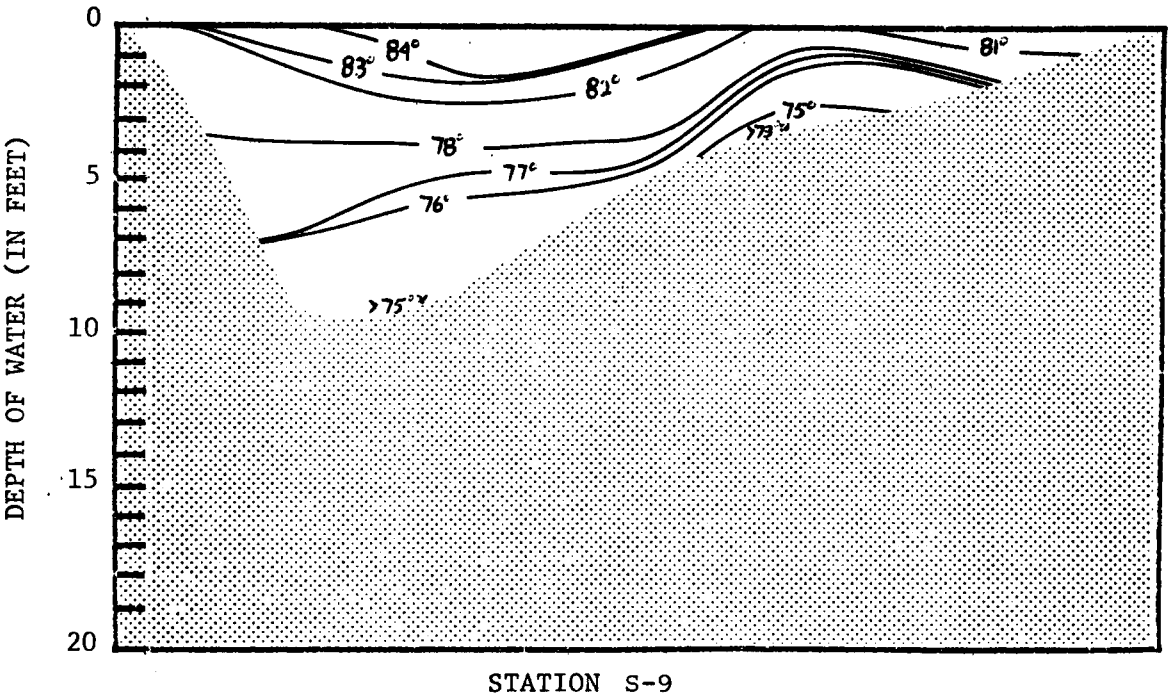
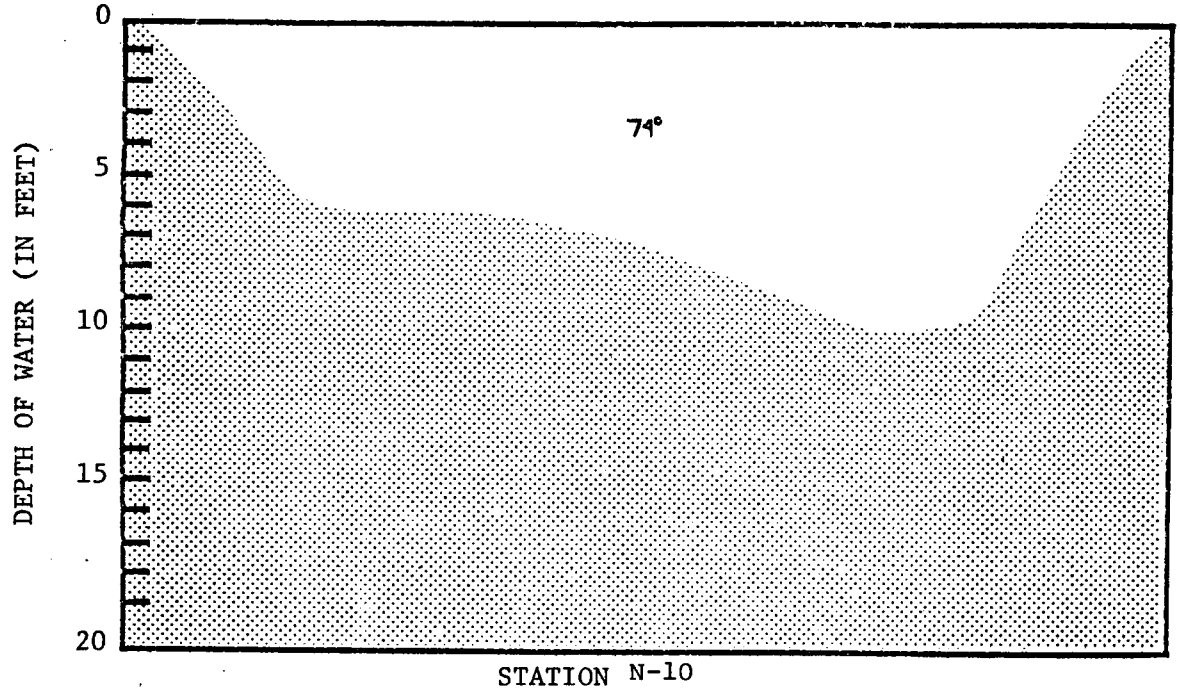


Figure A16 Temperature Profile - June 28, 1971.



(Re-measurement of ambient temperatures)

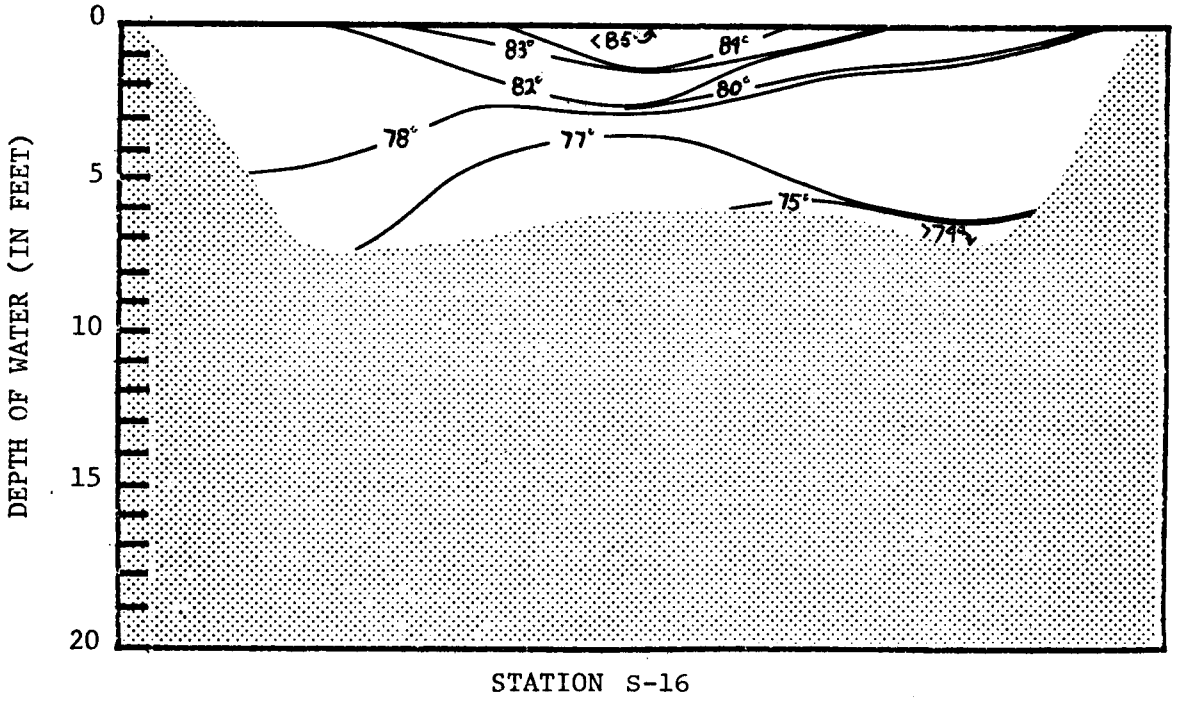
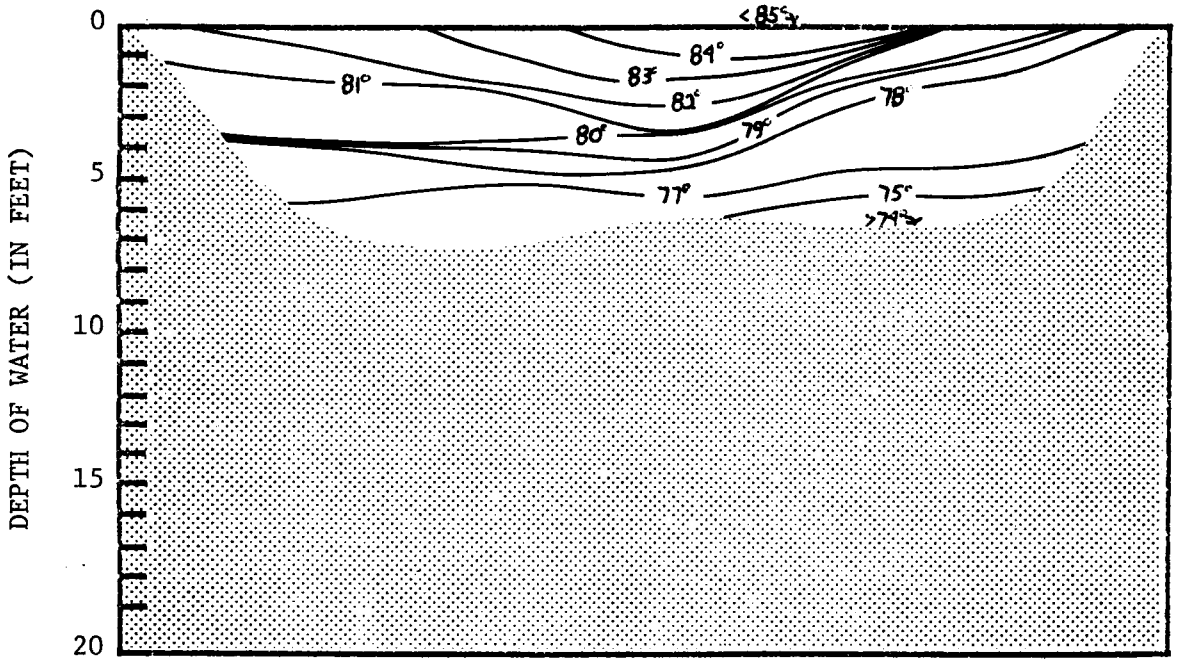
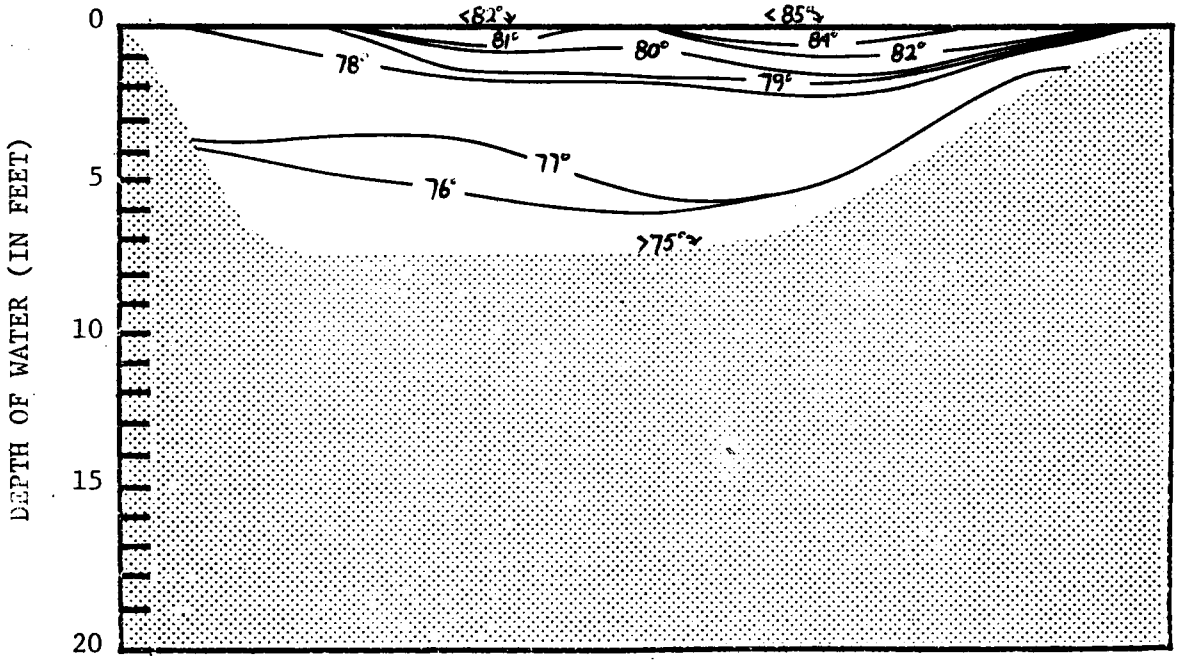


Figure A17. Temperature Profile - June 28, 1971.



STATION S-17



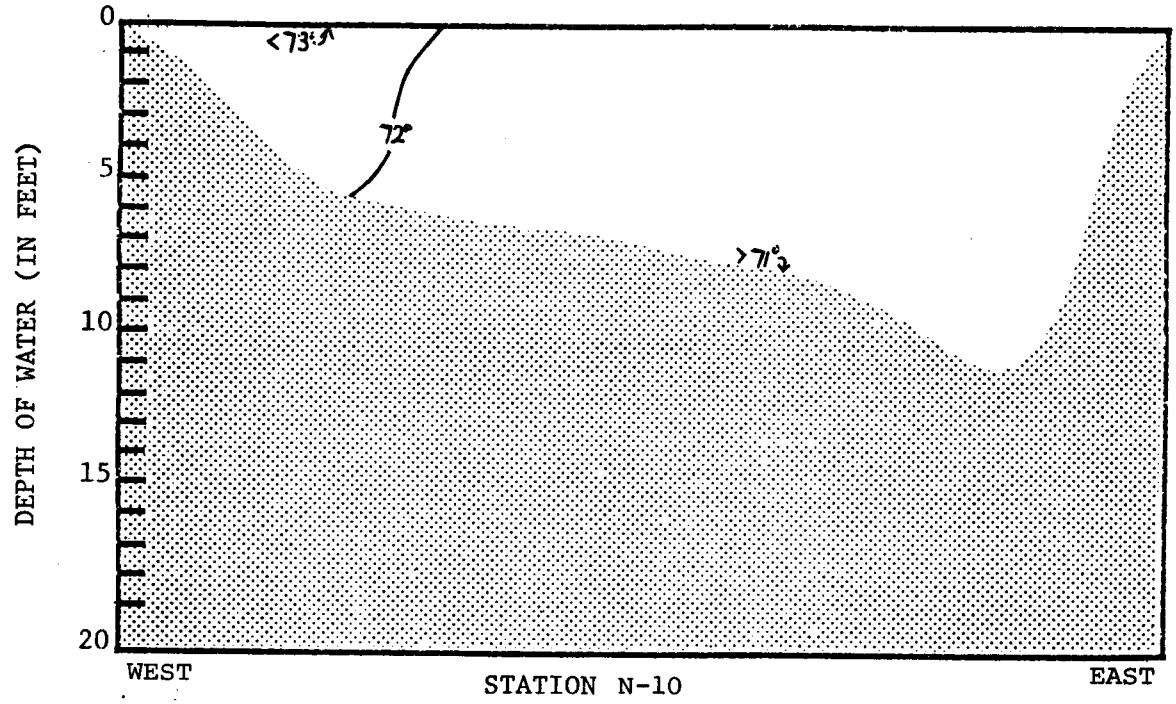
STATION S-18

Figure A18. Temperature Profile - June 28, 1971.

AUGUST 6, 1971

SAMPLING CONDITIONS:

Mean Flow:	2,465 cfs
Mean Daily Air Temperature:	67.0° F
Weather:	Cloudy



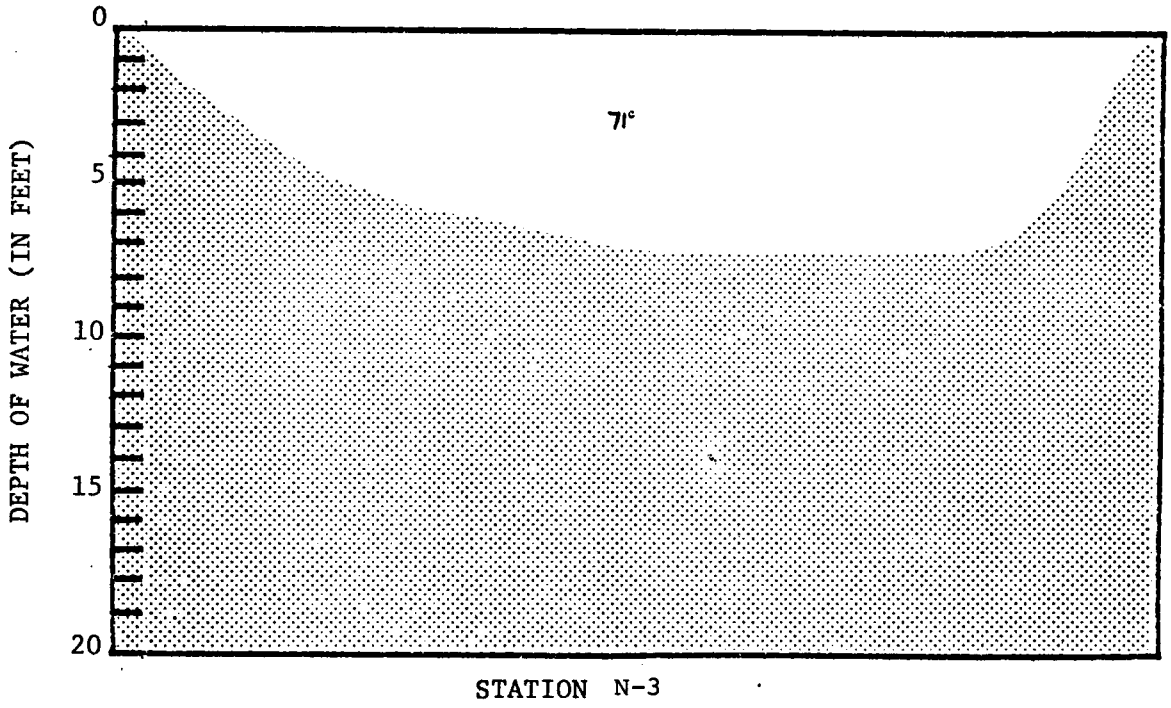
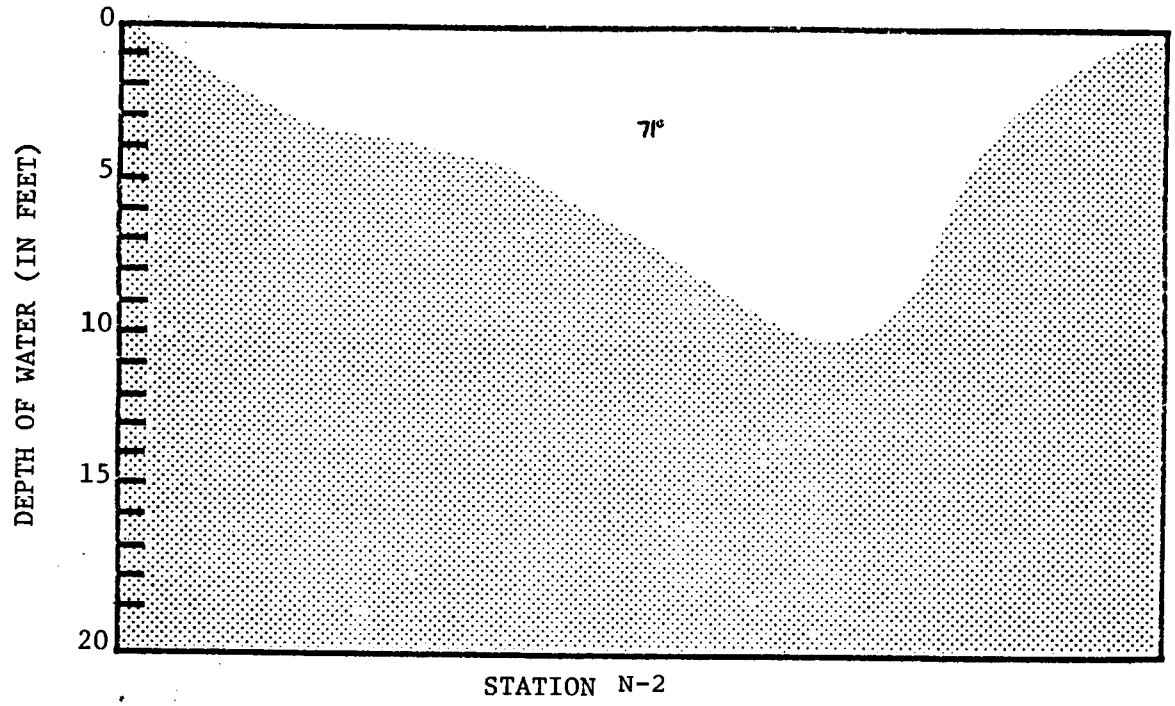


Figure A19. Temperature Profile - August 6, 1971.



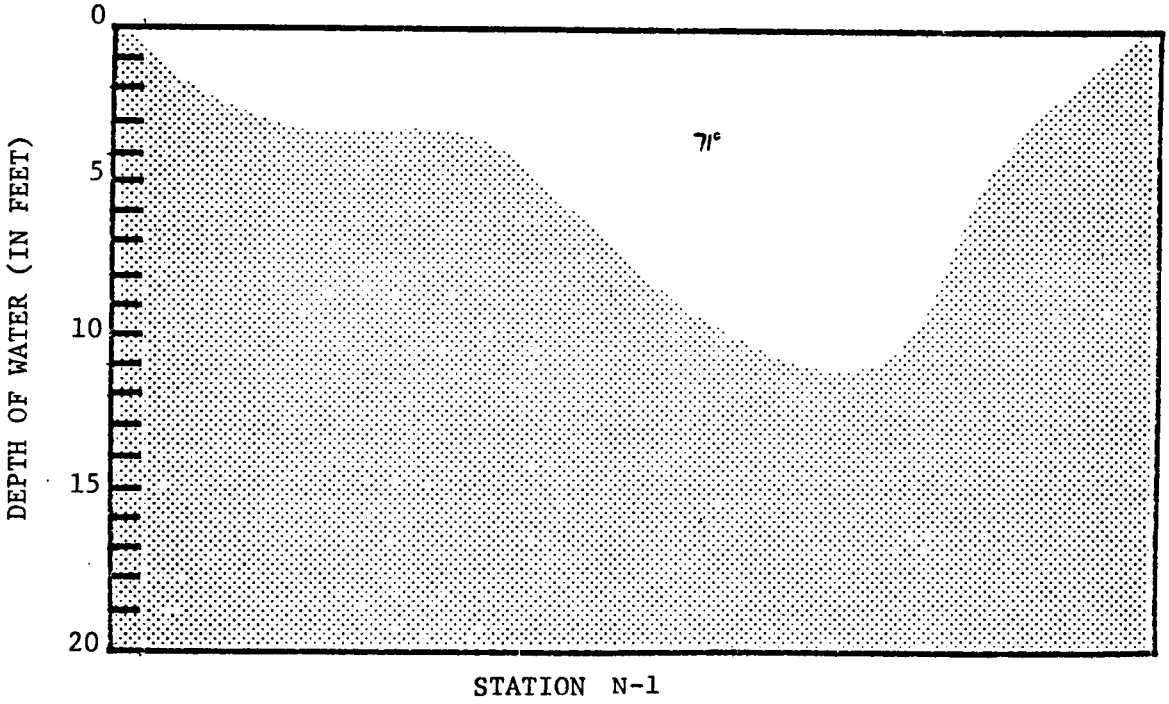
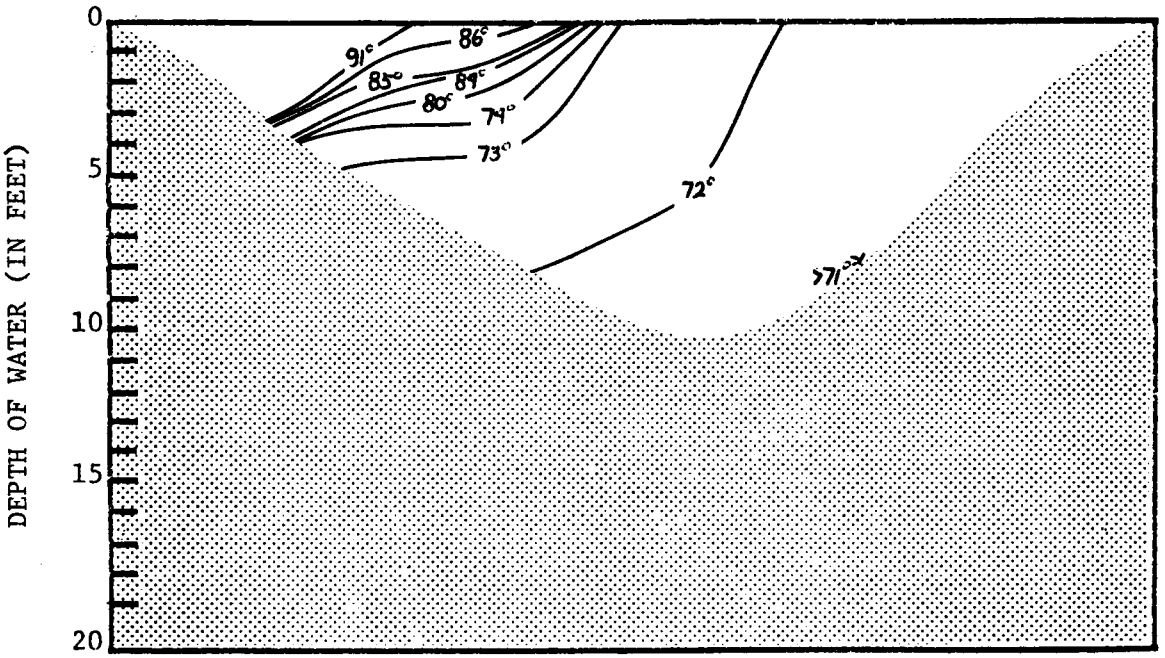


Figure A20. Temperature Profile - August 6, 1971.



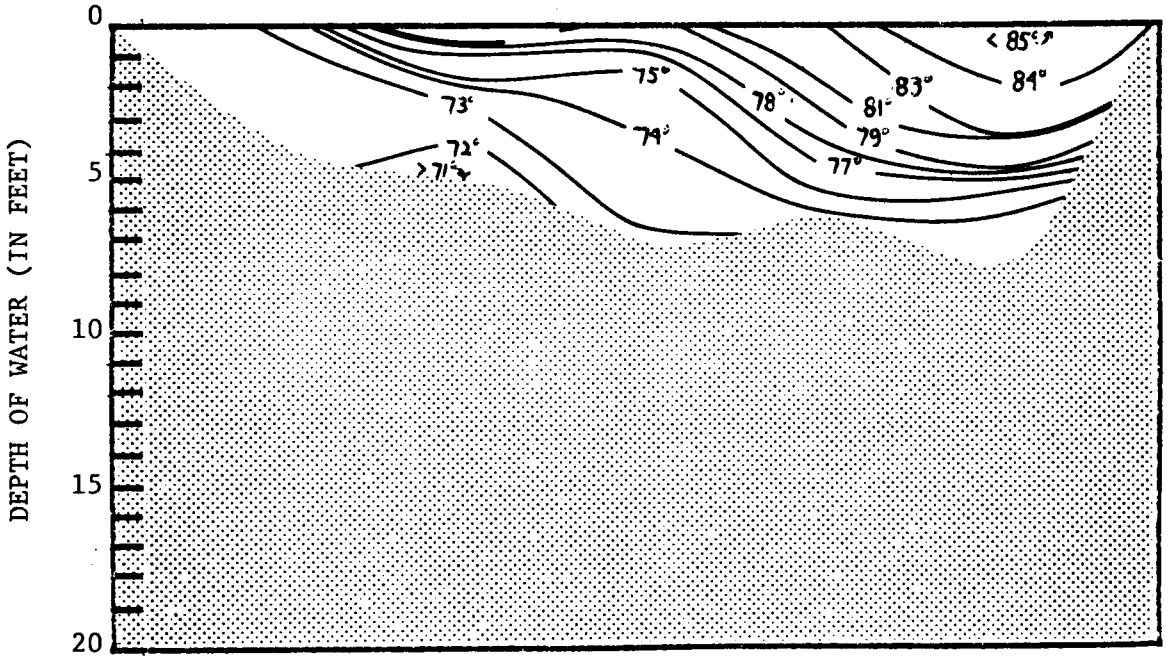
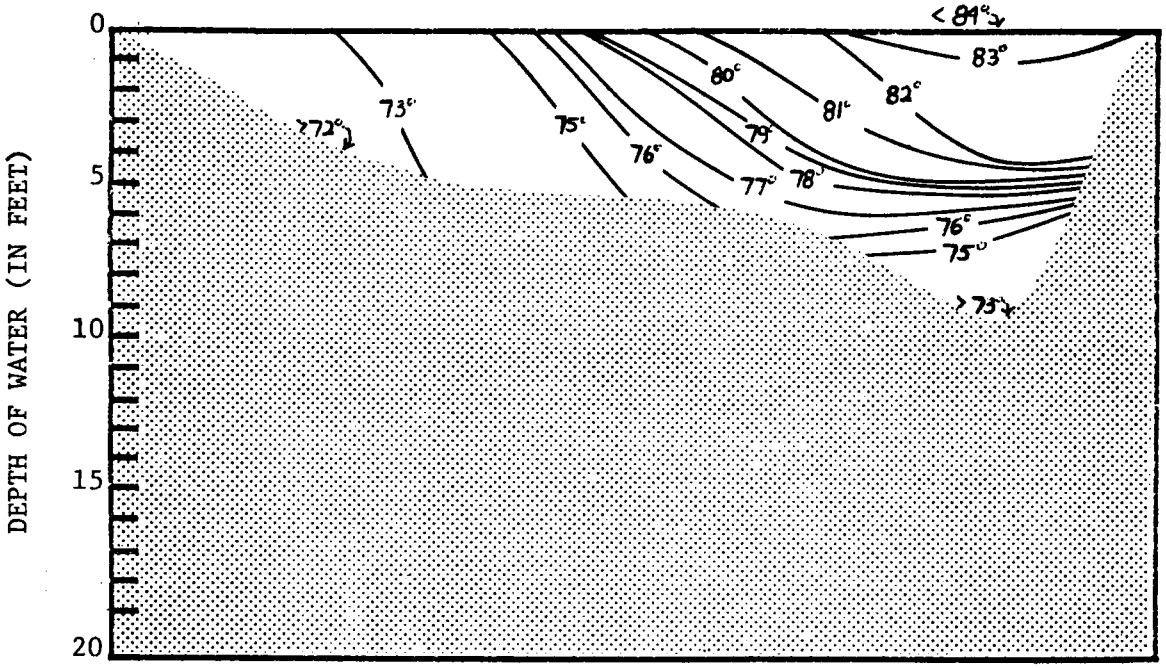
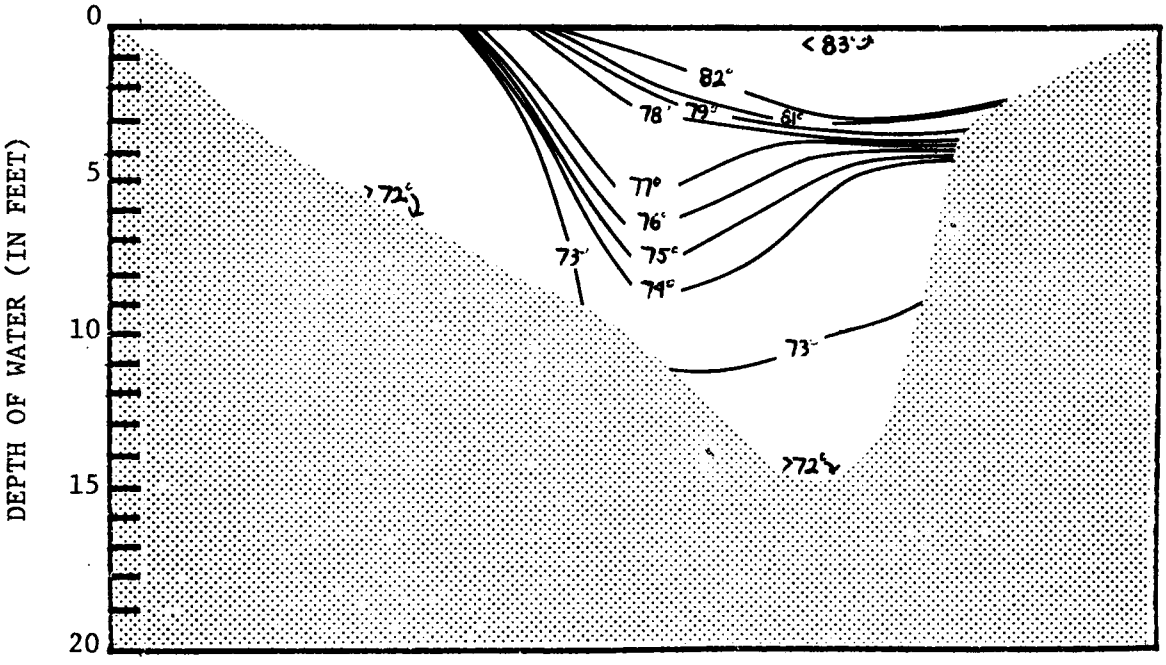


Figure A21. Temperature Profile - August 6, 1971.

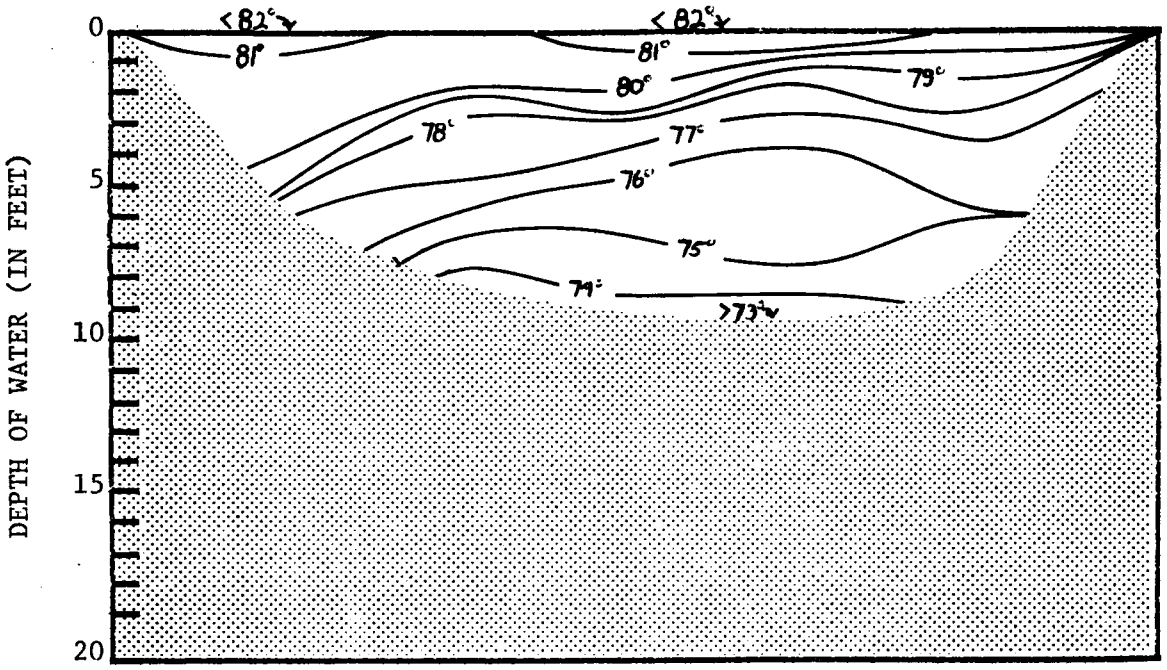


STATION S-2

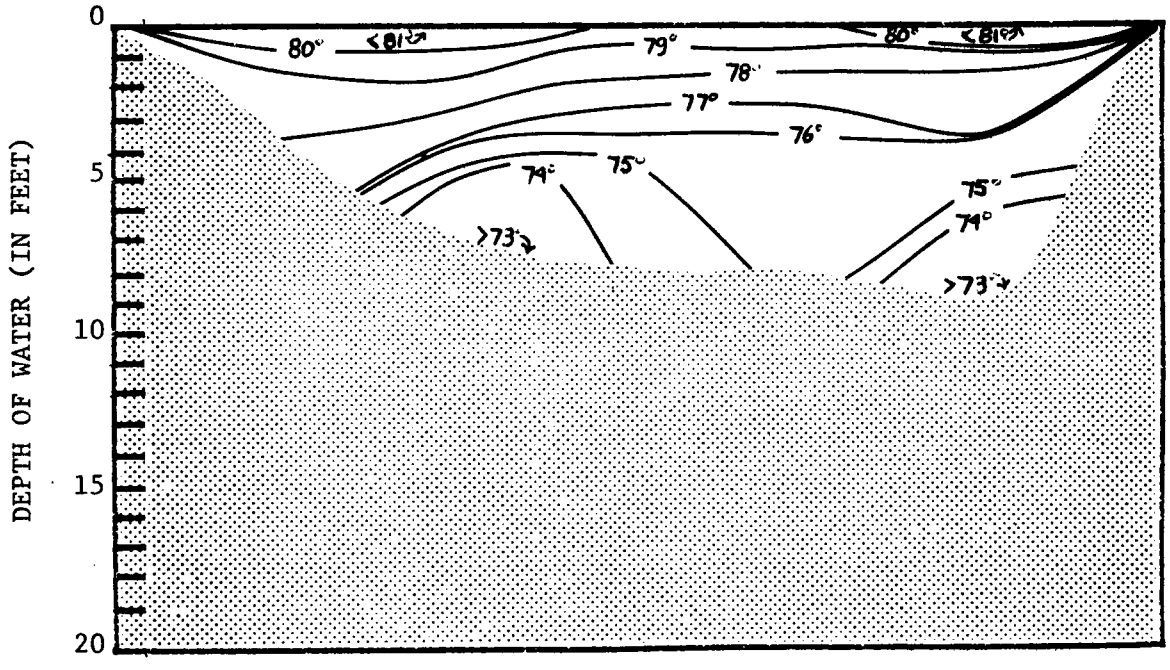


STATION S-3

Figure A22. Temperature Profile - August 6, 1971.

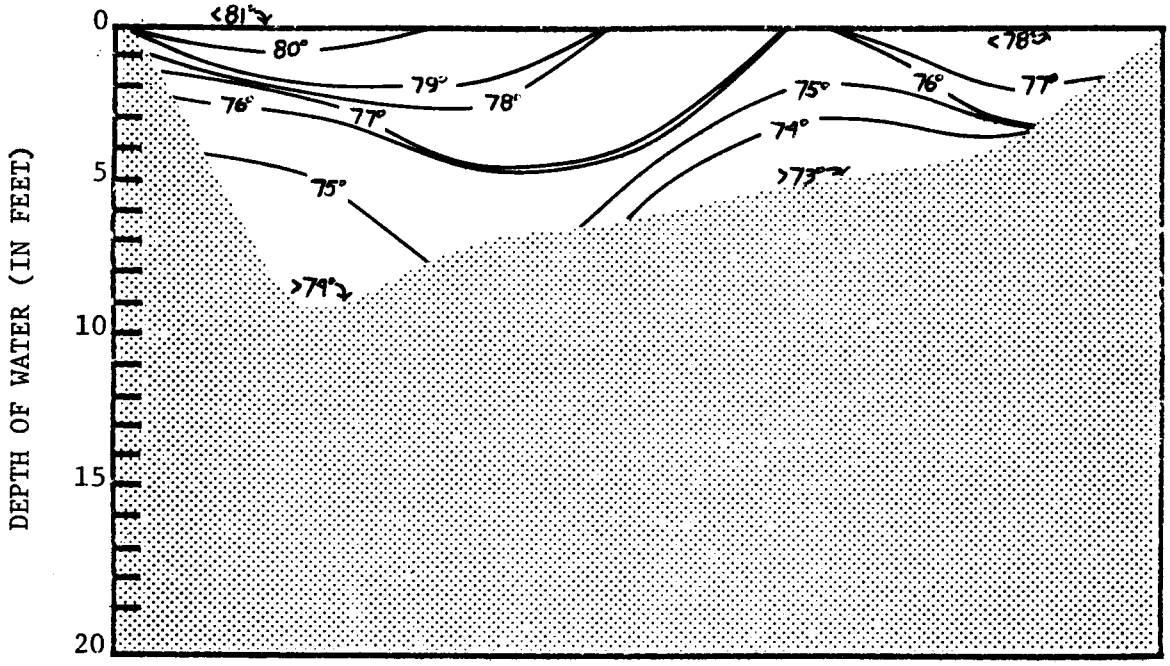


STATION S-4



STATION S-5

Figure A23. Temperature Profile - August 6, 1971.



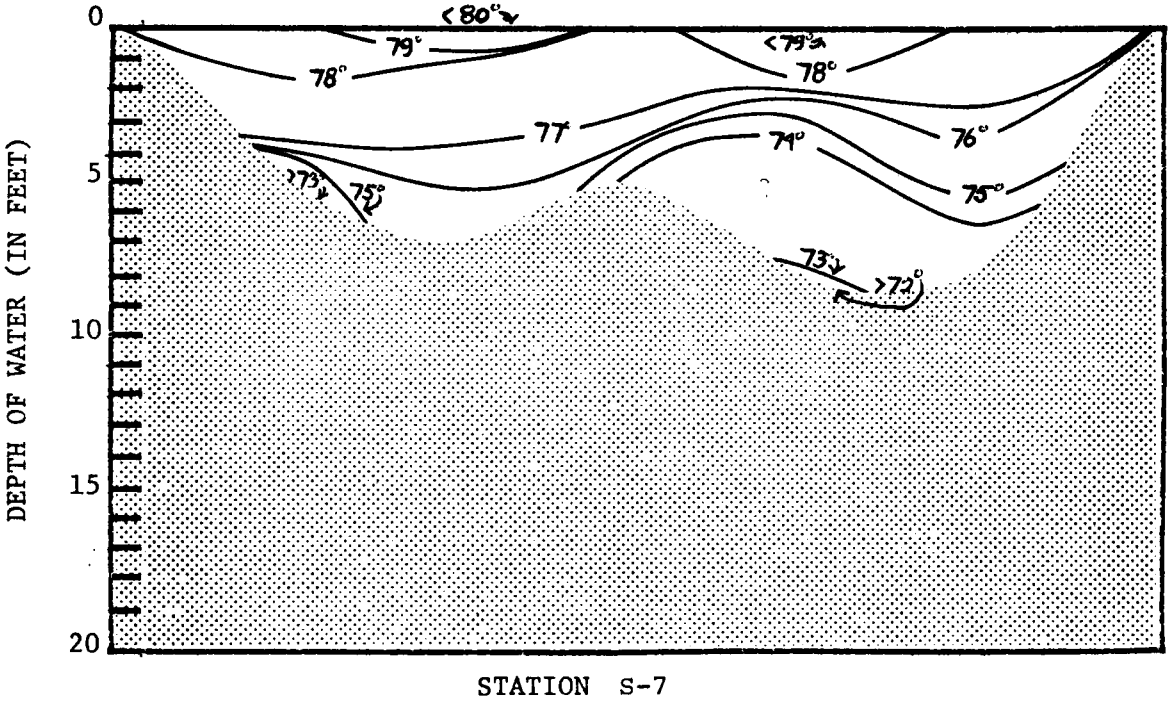


Figure A24. Temperature Profile - August 6, 1971.

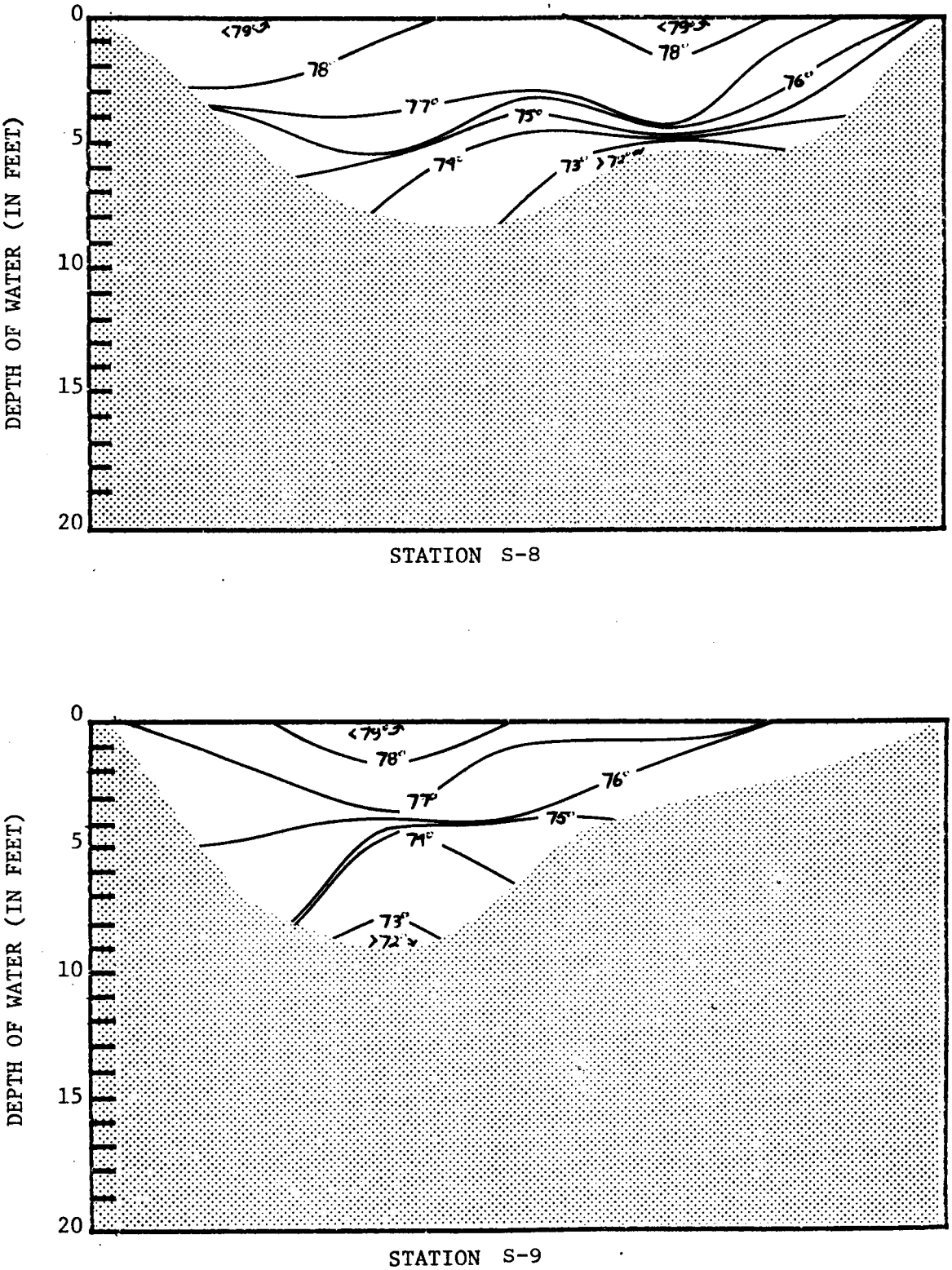
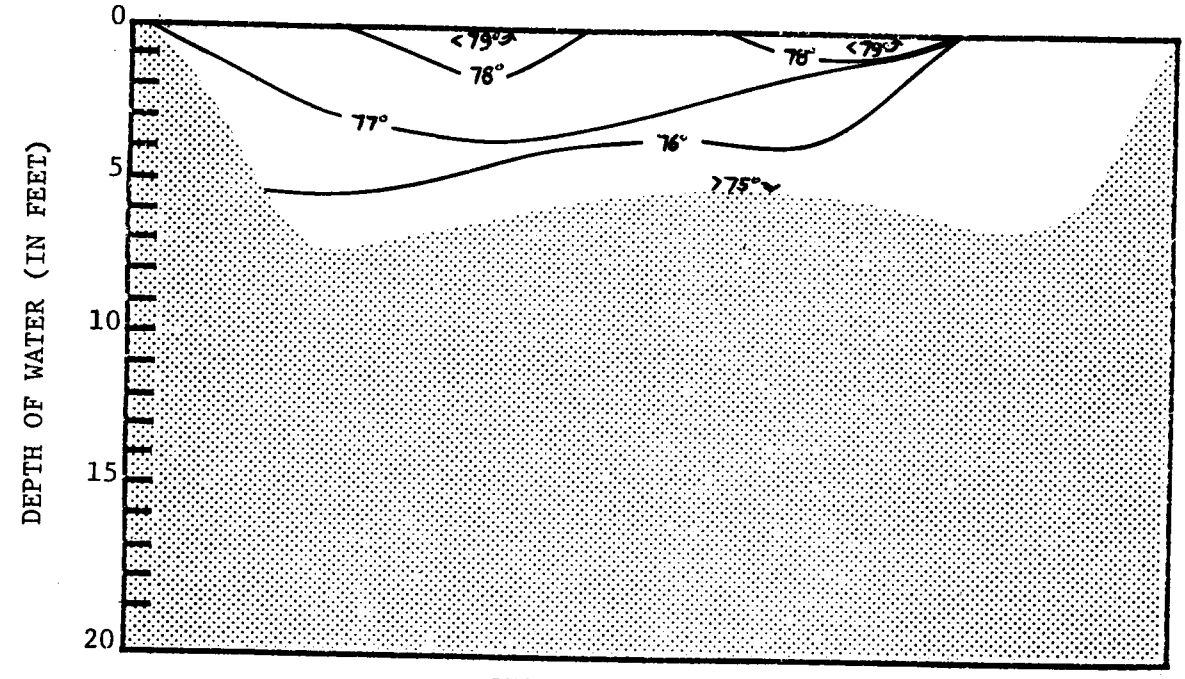
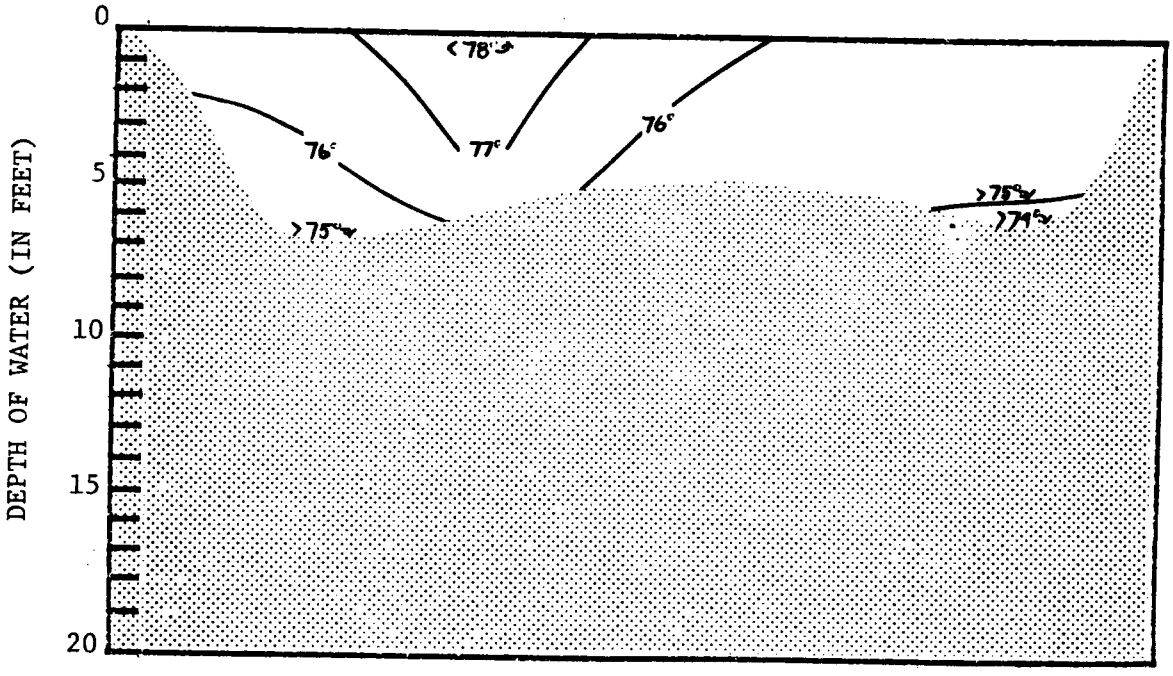


Figure A25. Temperature Profile - August 6, 1971.



STATION S-17



STATION S-18

Figure A27. Temperature Profile - August 6, 1971.

GLOSSARY OF COMMON NAMES

ELECTRO-FISHING SURVEY

SCIENTIFIC NAME	COMMON NAME
Catostomus commersoni	White sucker
Notropis cornutus	Common shiner
Lepomis gibbosus	Pumpkinseed
Perca flavescens	Yellow perch
Roccus americanus	White perch
Notropis umbratilis	Redfin shiner
Ictalurus nebulosus	Brown bullhead
Ictalurus natalis	Yellow bullhead
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Semotilus corporalis	Fallfish
Esox niger	Chain pickerel
Lepomis auritus	Redbreast sunfish
Anguilla rostrata	American eel
Salmo gairdneri	Rainbow trout
Salvelinus fontinalis	Eastern brook trout