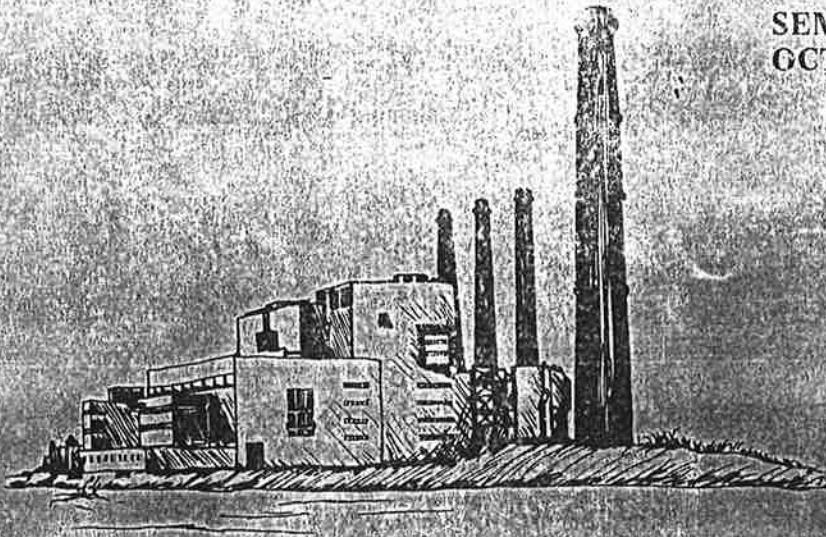


C. ANDERSON

SEMI-ANNUAL REPORT NO. 1A
OCTOBER 1974 THROUGH MARCH 1975



*INVESTIGATIONS OF THE EFFECTS OF
ELECTRICAL POWER GENERATION ON
MARINE RESOURCES IN SALEM HARBOR*

Charles O. Anderson, Jr., David J. Brown
Barry A. Ketschke and Elaine M. Elliott

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Department of Natural Resources
The Commonwealth of Massachusetts



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TABLE OF CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
2.0 PHYSICAL INVESTIGATIONS	2
2.1 Temperature	2
3.0 CHEMICAL INVESTIGATIONS	9
3.1 Water Quality	9
3.2 Heavy Metals	17
4.0 BIOLOGICAL INVESTIGATIONS	19
4.1 Primary Production	19
4.2 Adenosine Triphosphate (ATP)	31
4.3 Finfish	31
4.4 Impingement Investigations	35
4.5 Ichthyoplankton	50
5.0 APPENDIX I	57
6.0 LITERATURE CITED	62

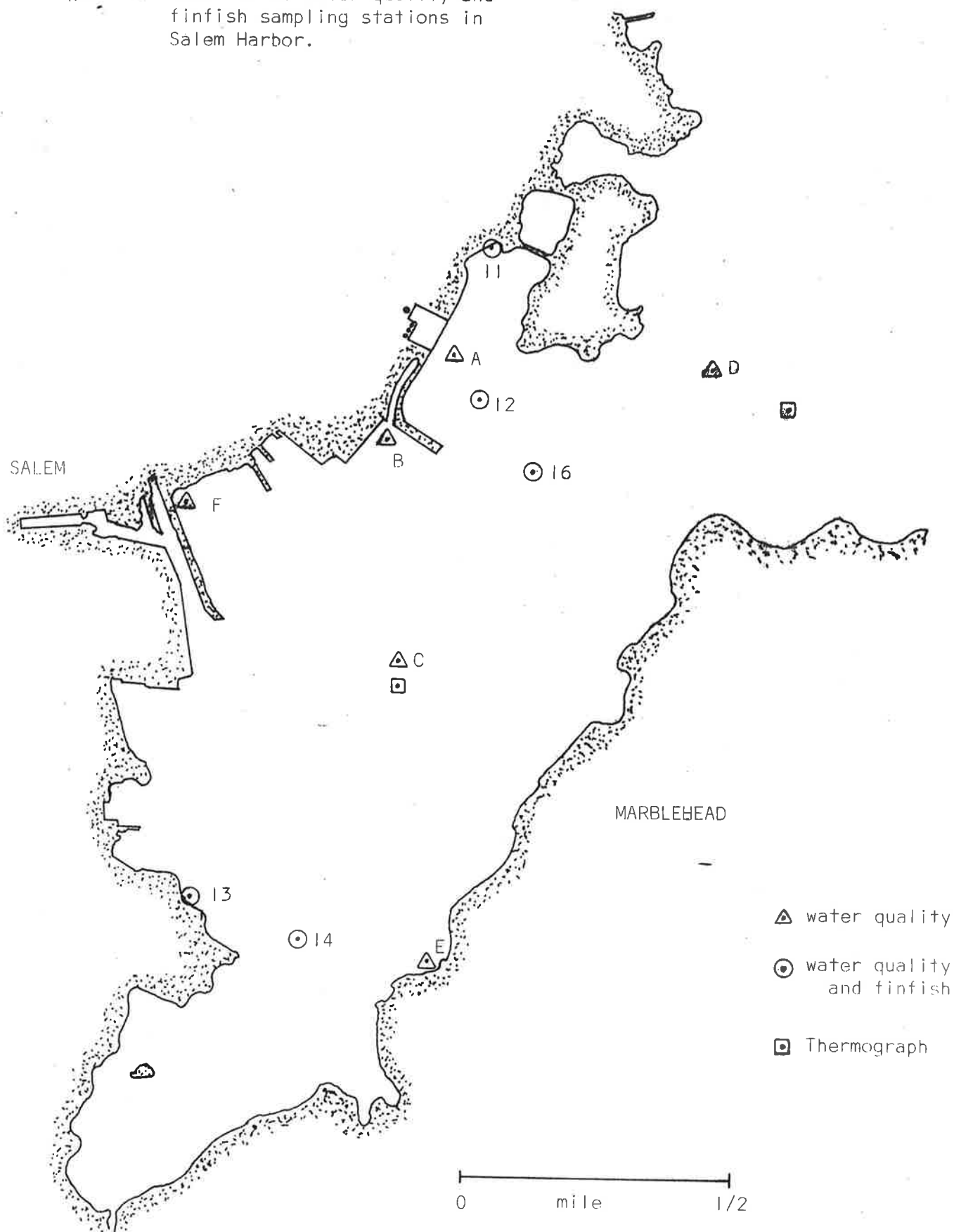
1.0 INTRODUCTION

The following is the first semi-annual report of research performed by the Massachusetts Division of Marine Fisheries under Contract DMF-2-72 - Amendment No. 2. This report contains data for the final quarter (October through December 1974) of the initial contract work plus the first three months (January through March 1975) of the new study. The initial study was essentially a broad ecological survey of Salem Harbor with specific emphasis placed on determining the effects of the addition of a fourth generating unit at the Salem Harbor Electric Station. The new research program includes an intensive ichthyoplankton study and the gathering of baseline data for a proposed fifth unit at the Salem Station.

Routine physical, chemical and biological sampling was performed and the data collected are presented. Changes in the sampling program which pertain to the new contract agreement are explained in each specific section of the text. Ichthyoplankton sampling commenced in March, 1975.

In accordance with the terms of the new contract, the positions of Research Vessel Mate and Fisheries Manager were terminated on December 31, 1974.

Figure 1. Location of water quality and finfish sampling stations in Salem Harbor.



2.0 PHYSICAL INVESTIGATIONS

2.1 Temperature

Average surface water temperature, calculated from 168 readings at eleven stations (11, 12, 13, 14, 16 and A - F) (Figure 1), decreased to 9.3°C. A comparison of weighted average quarterly temperatures is given below:

	<u>Oct. - Dec.</u>	<u>Jan. - Mar.</u>
1972	10.0°C	4.9°C
1973	9.1°C	4.1°C
1974	10.7°C	4.1°C
1975		4.8°C

Mean daily water temperatures, calculated from hourly thermograph readings, are presented for stations A - D in Figure 2. An additional thermograph was installed on November 6 at station D approximately one foot above the bottom (21 ft mlw). Average daily harbor temperature (stations A, C and D) decreased throughout the fall quarter (October - December) at a rate of 0.11°C per day. Daily harbor temperature remained fairly uniform (3 - 7°C) throughout the winter quarter (January - March). Similar temperature patterns were noted for the same periods in 1972, 1973 and 1974. ΔT varied with generation and circulating water volume but never exceeded 12.0°C.

A thermal plume study was conducted on February 28 to map the horizontal and vertical distribution of the heated discharge. Surface thermal patterns (Figure 3) generally conform to previous findings (Quarterly

Figure 2. Continued

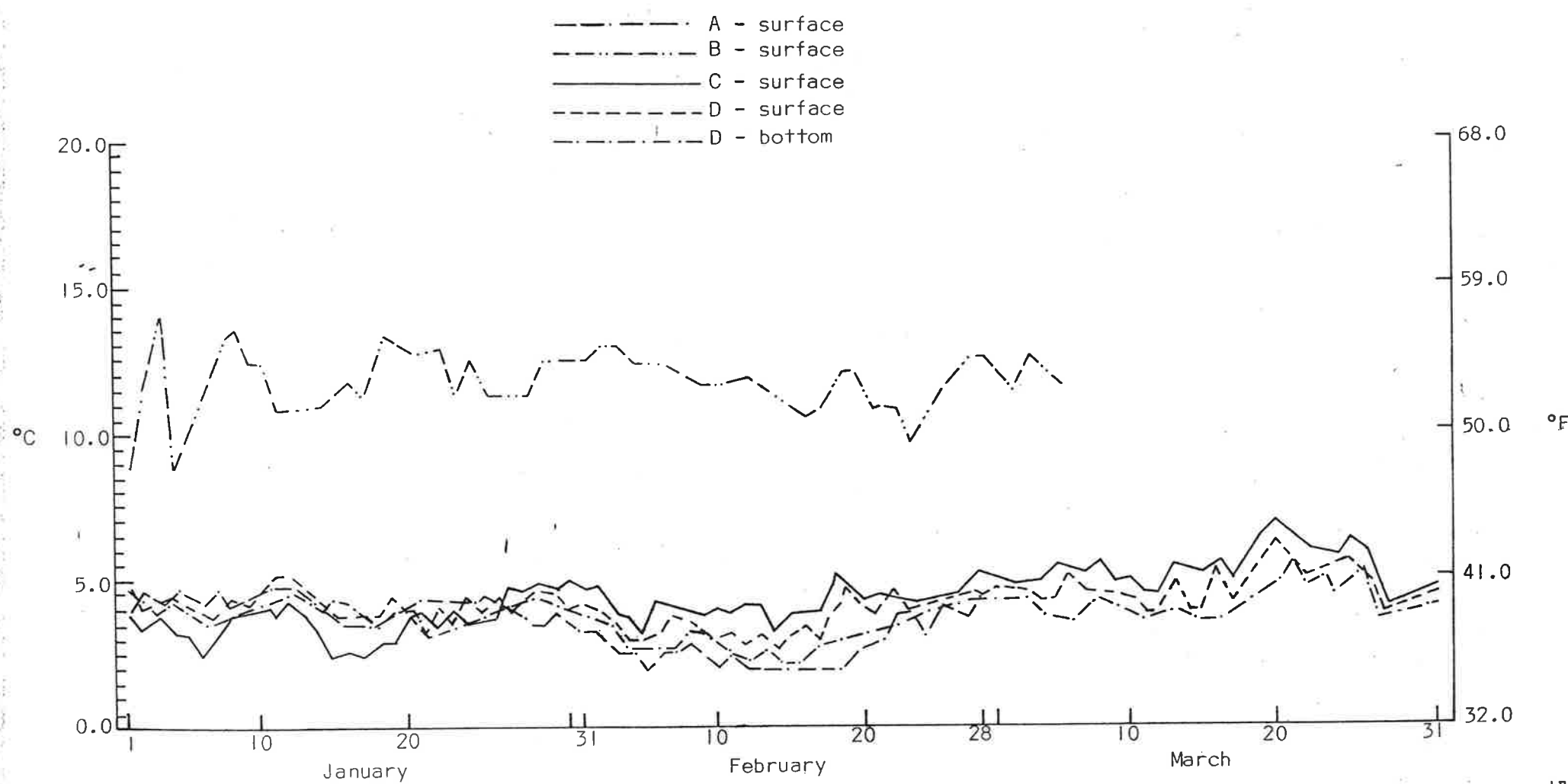


Figure 2. Mean water temperatures recorded at Stations A - D in Salem Harbor, October 1974 through March 1975.

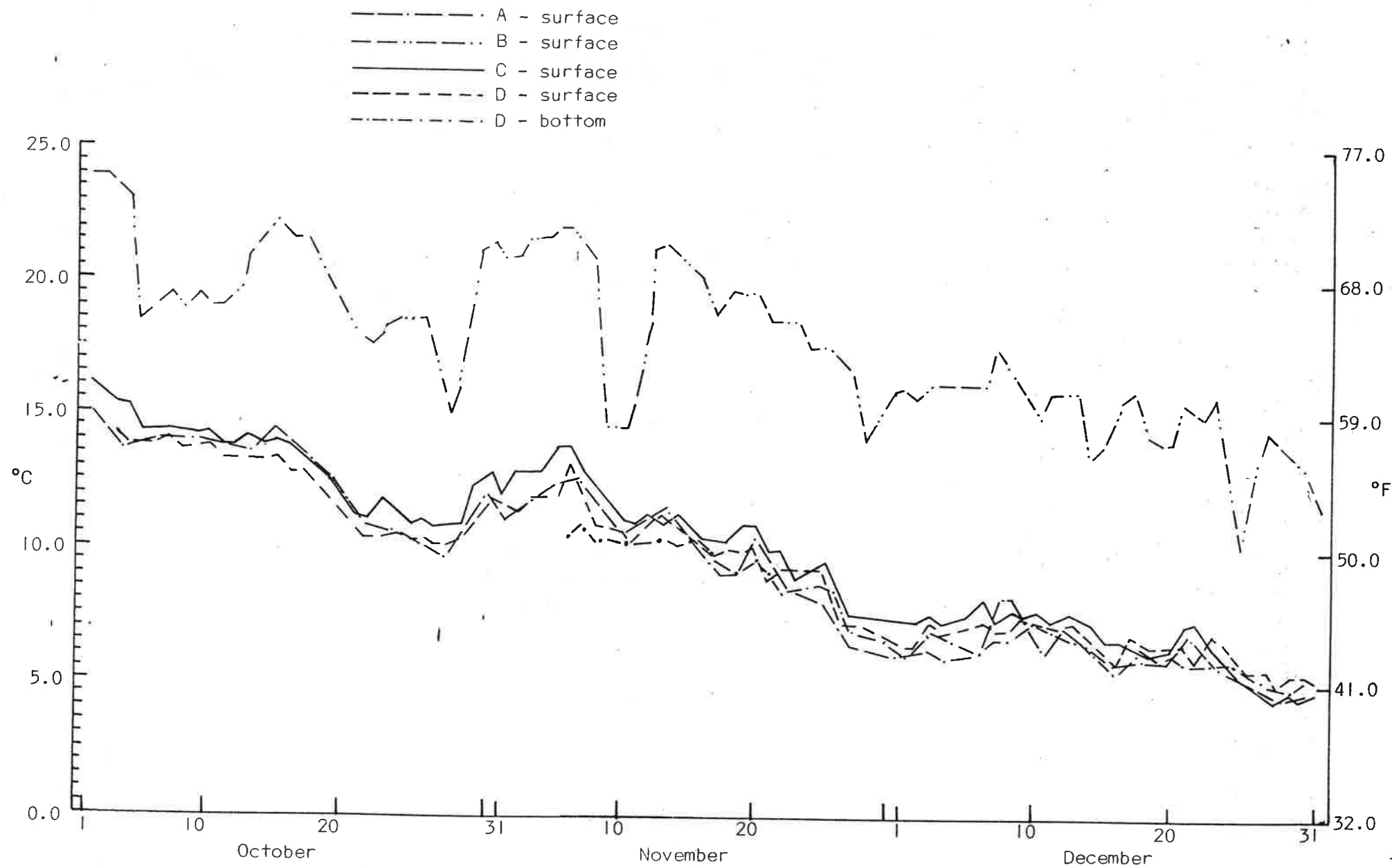


Figure 3. Continued

Intake Temp 3.9°C
Discharge Temp 13.4°C
Generation 737 MW
Circulating Water Volume 441,000 gpm
Wind Direction S
Wind Velocity 11 mph

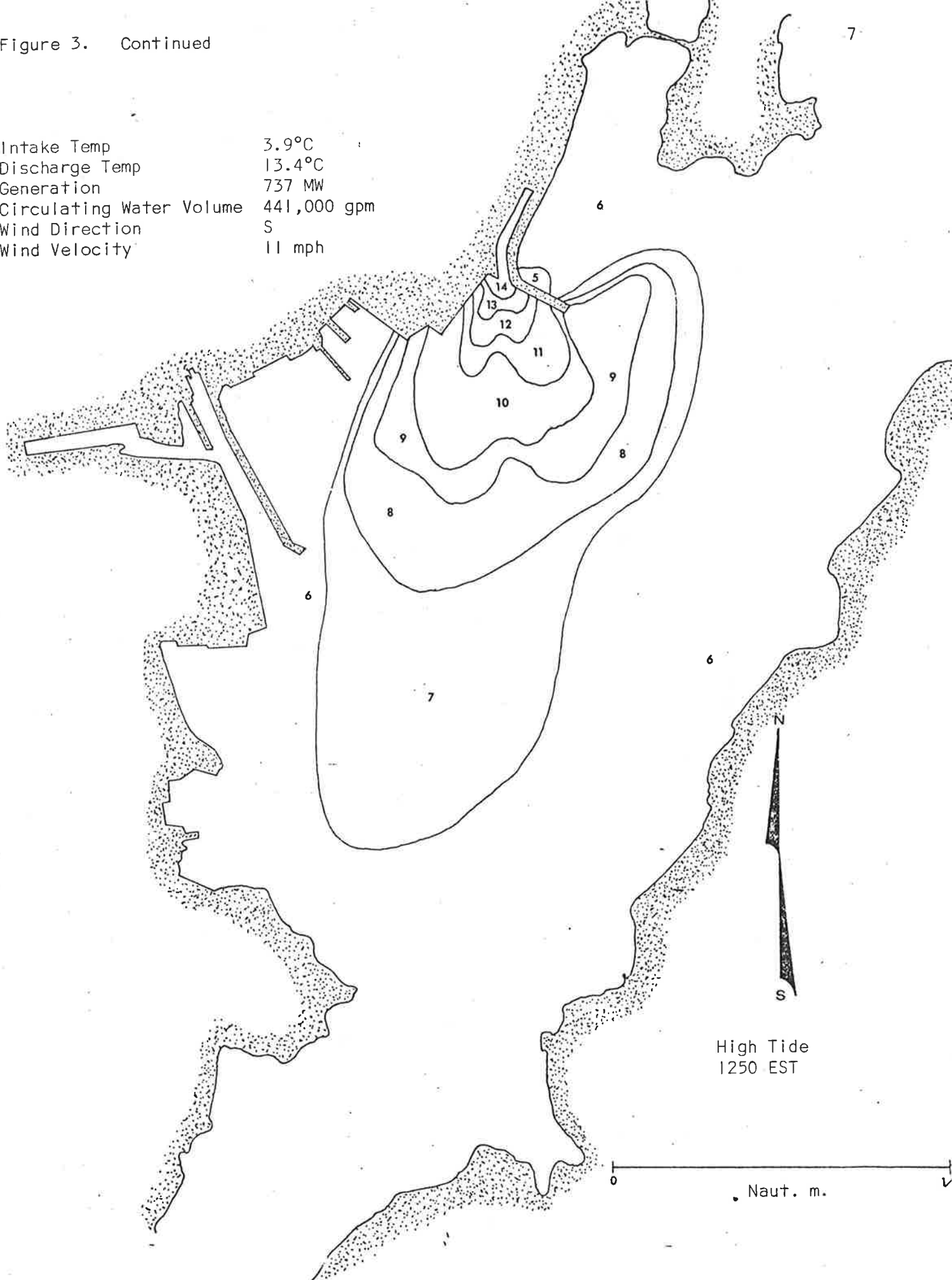
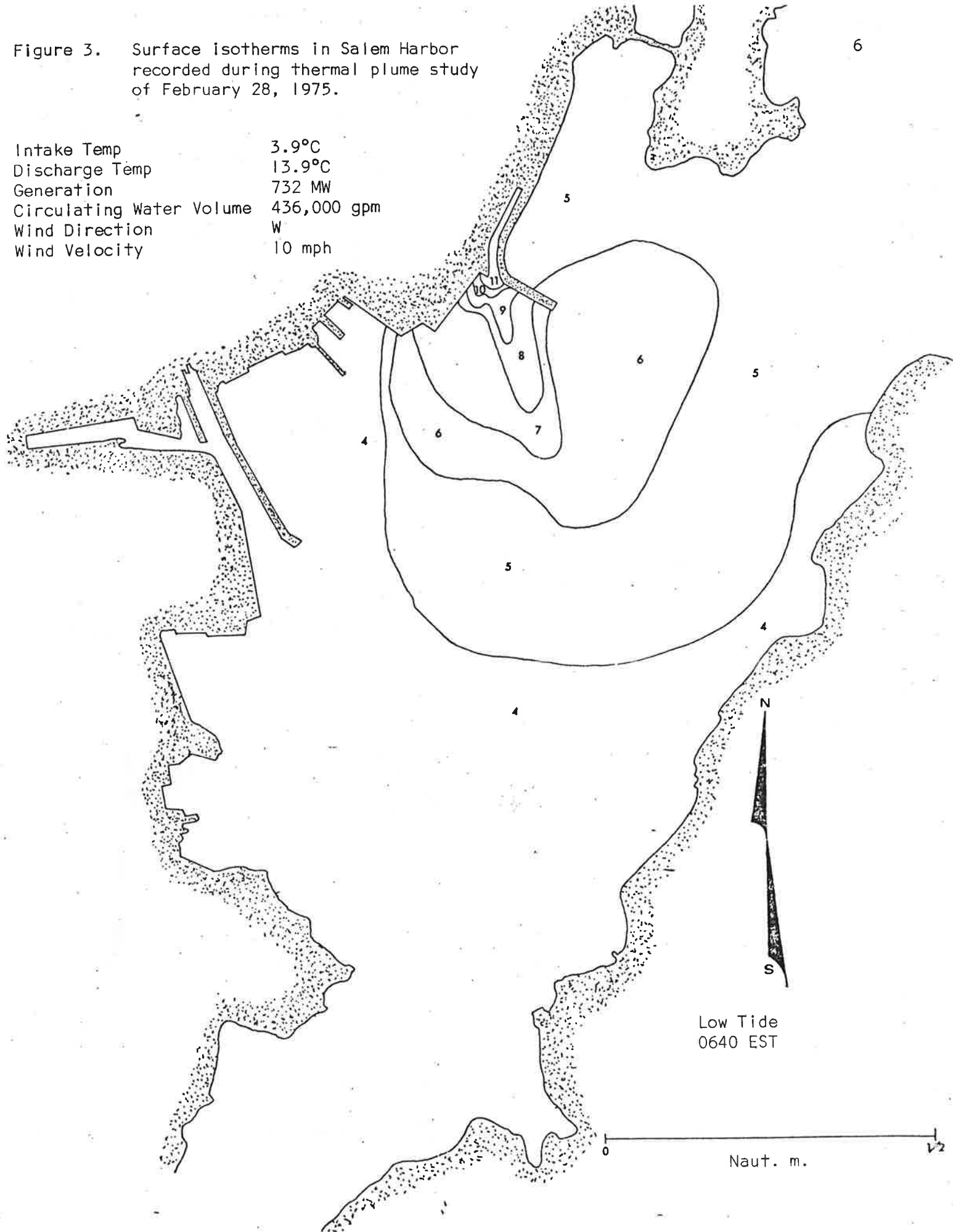


Figure 3. Surface isotherms in Salem Harbor recorded during thermal plume study of February 28, 1975.

Intake Temp	3.9°C
Discharge Temp	13.9°C
Generation	732 MW
Circulating Water Volume	436,000 gpm
Wind Direction	W
Wind Velocity	10 mph



3.0 CHEMICAL INVESTIGATIONS

3.1 Water Quality

In accordance with the new contract, the number of water quality stations, six regular and six supplemental, was reduced to four, A, B, C and D, as of January 1, 1975 (Figure 1).

Due to the questionable accuracy of measuring pH with a Hach 17-N pH kit, as of October 9, 1974, samples were returned to the laboratory where pH was determined with an Instrumentation Laboratory 245 pH meter. Difficulties in nutrient analysis were resolved when nitrite-N and nitrate-N determinations were performed according to methods described by Strickland and Parsons (1968). The change to these methods started on November 6 for nitrite-N and November 14 for nitrate-N. Because salinity in the study area has varied only slightly, as of January 3, 1975, salinity determinations have been made with an American Optical 10419 T.C. Salinity Refractometer rather than by conversion from chlorinity as determined by the Modified Knudsen method.

Ranges for the various water quality parameters taken during the reporting period (October 1974 - March 1975) were as follows: temperature, 1.5 - 25.0°C; salinity, 27.4 - 33.5 ‰; pH, 7.5 - 8.4; dissolved oxygen, 7.0 - 14.5 ppm; biochemical oxygen demand, 0.8 - 8.3 ppm; nitrite-N, <0.1 - 1.1 µg-atoms/L; nitrate-N, 0.0 - 13.8 µg-atoms/L; and phosphate-P, 0.3 - 1.7 µg-atoms/L.

Water quality parameters were within the acceptable tolerance ranges of fish and invertebrates indigenous to Salem Harbor (Table 1).

Reports 8, 10 and 12). The surface thermal patterns, charted at high and low tide, were indicative of the changing flow of the tide. The maximum vertical penetration of heated water at the point of discharge was 6 feet.

Table 1. Water quality data for Salem Harbor, October, 1974 through March, 1975.

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER		SALINITY (0/00)	pH	O2 (ppm)	BOD (ppm)	NO2-N	NO3-N µg-atoms/L	PO4-P
Station A														
10/1	001901	1210	high +1 1/2	30	S	11.5	14.5	30.8	8.0	9.1				0.5
10/9	001916	0805	high +3 1/2	0	S	7.0	13.5	30.9	7.9*	8.8	2.3			0.8
10/17	001927	1125	low +5 1/2	10	S	12.5	13.0	30.7	7.8	8.0	1.2			1.3
10/23	001944	0920	high +4 1/2	60	S	13.0	10.0	32.0	7.7	8.9	1.9			0.8
10/29	001947	1130	high +2	0	S	18.5	10.0	31.4	7.7	10.1	2.6			0.3
11/6	001969	1150	low +2	100	S	10.5	14.0	31.6	7.6	8.6	3.0	0.3		0.8
11/14	001972	1130	high + 1/2	10	S	11.0	12.0	31.2	**	8.5	2.0	0.6	2.1	0.8
11/22	001985	0920	high +4 1/2	100	S	0.0	9.0	31.6	7.9	8.4	2.1	0.6	4.5	1.0
11/26	001993	1000	high +2	100	S	-1.0	8.0	31.8	8.0	8.8	1.7	0.5	7.4	1.3
12/5	001999	1135	low +2	20	S	3.0	7.0	31.5	8.0	9.8	0.9	0.5	7.8	0.7
12/9	002011	0940	high +2 1/2	100	S	13.0	10.0	31.6	8.0	8.9		0.7	7.3	0.8
12/19	002019	1300	low +4	100	S	4.5	6.5	31.2	8.0	10.0	1.9	0.7	8.2	0.9
12/27	002032	1200	high +3	100	S	1.0	5.0	31.5	8.0	9.3	1.1	0.9	10.3	1.0
1/3	002035	1330	low +4 1/2	100	S	3.0	4.0	30.0	8.0	10.3	2.7	0.3	10.0	1.1
1/8	002039	1110	high +3 1/2	0	S	3.0	4.5	31.0	8.0	10.3	2.4	0.7	10.2	1.2
1/13	002051	0920	low +4	100	S	4.0	5.0	30.0	8.0	10.0	3.2	0.4	9.8	1.1
1/22	002055	1230	low	30	S	10.0	4.0	32.0	8.1	10.9	0.8	0.1	10.3	1.0
1/28	002061	1000	low +5	0	S	3.0	3.0	32.0	8.1	10.8	1.4	0.2	11.1	1.0
2/3	002065	1120	low + 1/2	0	S	-1.5	3.0	31.0	8.1	11.3	1.3	0.1	10.7	0.8
2/11	002072	1135	high	100	S	-1.5	3.0	33.5	8.1	11.5	1.1	0.4	11.1	1.1
2/19	002078	0955	high +5 1/2	80	S	4.0	4.0	33.0	8.1	11.3	0.9	0.4	9.3	1.0
2/28	002085	0730	low +1	0	S	-1.0	5.5	32.0	8.2	12.9	2.3	0.4	6.5	0.7
3/4	002086	1030	low	10	S		2.0	31.0	8.2	13.8	3.2	0.7	5.4	0.6
3/10	002095	0805	low +4 1/2	100	S	-2.0	3.0	31.5	8.2	14.5	7.3	0.3	2.5	0.4
3/19	002101	1005	low + 1/2	100	S	11.0	7.0	32.0	8.3	12.8	4.0	0.1	0.3	0.4
3/26	002111	0805	low +4	100	S	5.5	6.0	32.0	8.3	11.7	3.0	0.1	1.0	0.4

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C		SALINITY (0/00)	pH	O ₂ (ppm)	BOD (ppm)	NO ₂ -N μg-atoms/L	NO ₃ -N μg-atoms/L	PO ₄ -P
						Station B								
10/1	001902	1255	high +2	10	S	14.0	20.5	31.0	8.0	8.5				0.8
10/9	001921	0835	high +4	10	S	8.0	18.5	31.5	7.9*	8.3	2.9			0.8
10/17	001926	1155	high	100	S	11.0	19.0	30.7	7.8	7.7	1.0			1.6
10/23	001943	0915	high +4 1/2	50	S	10.0	18.5	31.8	7.7	8.2	1.5			0.8
10/29	001948	1200	high +2 1/2	20	S	15.0	16.5	31.4	7.7	9.3	1.8			1.5
11/6	001968	1145	low +2	100	S	10.5	25.0	31.3	7.7	8.0	2.9	0.1		0.9
11/14	001973	1100	high	10	S	11.5	21.5	31.1	**	8.3	2.0	0.4	2.1	0.9
11/22	001986	0945	high +5	100	S	0.0	19.5	31.6	8.0	8.5	1.7	0.9	4.3	1.1
11/26	001998	1020	high +2	100	S	-1.5	17.5	31.6	7.9	8.8	1.0	0.5	6.2	1.2
12/5	002000	1150	low +2 1/2	20	S	3.5	17.0	31.3	7.9	9.4	1.3	0.7	8.1	0.7
12/9	002016	1015	high +3	40	S	10.0	18.0	31.8	7.9	9.2		0.4	7.3	0.9
12/19	002024	1340	low +5	100	S	2.5	16.0	31.1	8.0	9.9	1.9	0.5	8.0	0.8
12/27	002030	1140	high +2 1/2	100	S	2.0	15.0	31.4	8.1	8.9	0.9	0.5	9.2	1.0
1/3	002036	1335	low +4 1/2	100	S	1.0	14.0	31.0	7.9	10.2	2.0	0.2	10.0	1.1
1/8	002042	1100	high +3	0	S	3.0	13.0	30.0	8.0	10.1	2.2	0.5	9.8	1.3
1/13	002048	0940	low +4	100	S	4.0	13.0	30.0	7.9	9.7	2.1	0.5	10.6	1.3
1/22	002054	1250	low + 1/2	20	S	4.5	10.5	32.0	8.0	10.2	1.4	0.2	10.3	1.1
1/28	002064	1020	low +5	0	S	2.0	12.0	32.0	8.0	10.7	1.2	0.1	10.3	1.1
2/3	002066	1125	low + 1/2	0	S	-2.0	8.5	30.0	8.0	10.6	0.9	0.4	10.9	0.9
2/11	002071	1130	high	100	S	-0.5	12.0	33.0	8.0	11.3	0.9	0.3	10.9	1.2
2/19	002081	1010	high +5 1/2	60	S	5.0	11.0	33.0	8.1	11.2	1.1	0.4	8.8	1.1
2/28	002083	0720	low +1	0	S	-1.0	10.0	32.0	8.1	11.8	2.3	0.4	6.9	0.7
3/4	002089	1015	low	0	S	-2.5	8.0	31.0	8.2	12.9	3.2	0.4	5.2	0.6
3/10	002096	0825	low +5	100	S	-1.0	13.0	31.0	8.1	13.7	7.7	0.2	0.2	0.5
3/19	002099	1020	low +1	100	S	9.0	12.5	32.0	8.2	11.3	3.5	0.3	1.6	0.5
3/26	002110	0755	low +4	100	S	5.0	12.5	32.0	8.3	10.5	3.2	0.2	0.8	0.6

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	O ₂ (ppm)	BOD (ppm)	NO ₂ -N ug-atoms/L	NO ₃ -N ug-atoms/L	PO ₄ -P
Station C													
10/1	001903	1230	high +1 1/2	10	S	11.0 17.0	31.1	8.0	9.0				0.7
10/9	001918	0820	high +3 1/2	10	S	7.5 13.5	30.5	8.0*	8.8	2.3			0.6
10/17	001925	1140	high	50	S	10.5 12.5	30.0	7.8	8.0	1.7			1.0
10/23	001940	0900	high +4	70	S	10.0 10.0	31.6	7.8	8.8	2.4			1.0
10/29	001949	1140	high +2	20	S	14.0 10.0	31.4	7.8	9.8	2.4			0.8
11/6	001965	1125	low +2	100	S	11.0 15.0	31.5	7.9	8.7	3.3	0.1		0.9
11/14	001971	1105	high	10	S	10.0 11.0	31.1	**	8.4	1.4	0.4	2.0	0.9
11/22	001987	0930	high +4 1/2	100	S	0.0 9.0	31.9	8.0	8.9	1.7	0.9	3.2	1.1
12/5	002001	1205	low +3	30	S	0.0 9.5	31.3	8.0	9.6	1.1	0.7	8.2	0.7
12/9	002013	0955	high +2 1/2	100	S	8.0 9.0	32.4	8.0	9.6		0.4	7.3	0.6
12/19	002021	1320	low +4 1/2	100	S	2.0 8.0	31.2	8.0	9.8	2.6	1.0	7.5	0.8
12/27	002029	1115	high +2	100	S	3.0 4.5	31.2	8.1	10.2	2.3	0.4	9.2	1.0
1/3	002037	1340	low +4 1/2	100	S	0.0 5.0	30.0	8.0	10.2	1.7	0.2	10.1	1.2
1/8	002041	1055	high +3	0	S	3.5 5.5	30.0	8.1	10.3	1.3	0.5	9.5	1.2
1/13	002049	0930	low +4	100	S	3.0 5.0	30.0	8.0	10.0	1.7	0.2	10.8	1.1
1/22	002053	1240	low	30	S	4.5 4.5	33.0	8.1	10.7	1.2	0.1	10.4	1.0
1/28	002063	1015	low +5	0	S	2.0 6.0	32.0	8.1	10.7	0.8	<0.1	10.6	1.1
2/3	002067	1130	low +1	0	S	-2.0 4.0	31.0	8.1	11.5	1.7	<0.1	10.9	0.8
2/11	002070	1125	high	100	S	-2.0 5.0	33.5	8.1	11.4	1.1	0.3	11.1	1.2
2/19	002080	1005	high +5 1/2	60	S	5.0 5.0	33.0	8.2	11.8	1.4	0.2	7.8	0.9
2/28	002082	0715	low +1	0	S	-1.0 5.5	33.0	8.2	12.4	3.2	0.5	6.8	0.7
3/4	002088	1020	low	0	S	-2.0 4.5	32.0	8.3	13.8	3.7	0.3	2.6	0.5
3/10	002097	0820	low +5	100	S	-2.0 5.0	31.0	8.3	14.2	6.4	0.1	0.2	0.4
3/19	002100	1025	low +1	100	S	3.0 7.5	33.0	8.3	12.2	3.7	<0.1	0.0	0.4
3/26	002109	0750	low +4	100	S	5.0 7.0	32.0	8.3	11.7	2.8	0.1	0.2	0.4

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	O ₂ (ppm)	BOD (ppm)	NO ₂ -N μg-atoms/L	NO ₃ -N μg-atoms/L	PO ₄ -P
Station D													
10/1	001904	1220	high +1 1/2	10	S	12.0 14.5	31.0	8.0	8.9				0.6
10/9	001917	0810	high +3 1/2	10	S	7.0 13.5	31.8	8.0*	9.0	2.0			0.6
10/17	001924	1130	low +5 1/2	20	S	12.5 12.5	30.8	7.8	7.9	1.2			1.4
10/23	001939	0855	high +4	90	S	11.0 10.0	32.0	8.0	9.1	3.3			0.6
10/29	001950	1135	high +2	0	S	16.0 10.0	31.7	7.8	9.9	2.3			0.4
11/6	001964	1120	low +2	100	S	10.0 14.0	31.5	7.8	8.7	3.9	<0.1		0.7
11/14	001974	1055	high	10	S	12.5 10.5	31.1	**	8.3	2.2	0.3	2.1	0.8
11/22	001988	0925	high +4 1/2	100	S	0.0 8.5	32.2	8.0	8.7	1.3	1.0	3.3	0.9
11/26	001994	1010	high +2	100	S	0.0 7.0	31.6	8.0	8.8	1.1	0.5	7.2	1.2
12/5	002002	1210	low +3	30	S	0.0 7.5	31.6	8.0	9.6	0.9	0.6	8.0	0.7
12/9	002012	0950	high +2 1/2	100	S	8.0 8.0	31.6	8.0	9.6		0.5	7.0	0.8
12/19	002020	1310	low +4 1/2	100	S	6.5 5.0	30.7	8.1	10.1	2.6	0.9	7.7	1.0
12/27	002031	1150	high +2 1/2	100	S	2.0 5.0	31.6	8.1	9.2	1.1	0.5	9.2	1.0
1/3	002038	1345	low +5	100	S	-1.0 3.0	32.0	8.0	10.3	1.7	0.2	9.8	1.4
1/8	002040	1105	high +3 1/2	0	S	4.0 4.0	30.0	8.0	10.4	2.0	0.5	9.9	1.3
1/13	002050	0925	low +4	100	S	3.0 4.0	30.0	8.0	10.0	1.3	0.2	11.8	1.1
1/22	002052	1255	low + 1/2	20	S	4.5 4.5	32.0	8.1	10.6	1.0	0.1	10.5	1.0
1/28	002062	1010	low +5	0	S	2.0 4.0	32.0	8.1	10.7	1.2	<0.1	11.2	1.1
2/3	002068	1135	low +1	0	S	-2.0 3.5	31.0	8.1	11.3	1.7	<0.1	10.9	0.8
2/11	002069	1120	high	100	S	-2.0 1.5	33.5	8.1	11.4	1.3	0.3	11.2	1.2
2/19	002079	1000	high +5 1/2	80	S	4.5 6.0	33.0	8.2	10.0	1.4	0.3	8.8	1.0
2/28	002084	0725	low +1	0	S	-1.0 5.0	32.0	8.2	12.9	2.0	0.4	6.1	0.7
3/4	002087	1025	low	10	S	-2.5 4.5	31.0	8.3	13.4	2.5	0.4	4.0	0.6
3/10	002098	0810	low +5	100	S	-1.0 2.0	31.5	8.2	14.6	6.0	0.1	0.4	0.5
3/19	002102	1030	low +1	100	S	8.0 7.0	33.0	8.4	12.7	3.6	<0.1	0.1	0.4
3/26	002108	0745	low +4	100	S	5.0 5.0	32.0	8.3	11.7	3.2	0.1	1.0	0.4

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	O ₂ (ppm)	BOD (ppm)	NO ₂ -N μg-atoms/L	NO ₃ -N μg-atoms/L	PO ₄ -P
Station E													
10/1	001905	1235	high +2	10	S	11.0 16.0	31.0	8.0	9.0				0.7
10/9	001919	0825	high +3 1/2	10	S	8.0 13.5	31.8	8.0*	8.8	2.0			0.6
10/17	001928	1140	high	80	S	10.5 13.0	27.4	7.8	7.8	1.7			1.7
10/23	001941	0905	high +4	70	S	11.5 9.0	31.1	7.9	8.7	1.7			1.0
10/29	001951	1145	high +2	20	S	16.0 10.0	31.6	7.9	10.0	2.5			0.8
11/6	001966	1130	low +2	100	S	11.0 12.5	29.9	7.7	8.0	3.6	0.2		0.6
11/14	001974	1115	high + 1/2	10	S	11.5 11.0	31.1	**	8.1	1.9	0.5	1.7	0.7
11/22	001989	0935	high +4 1/2	100	S	-0.5 8.0	31.2	7.9	9.1	2.2	0.9	3.8	1.0
11/26	001997	1100	high +3	100	S	0.0 7.5	31.6	8.0	9.6	3.3	0.5	6.9	1.3
12/5	002004	1200	low +2 1/2	30	S	2.0 3.0	29.4	8.0	10.9	1.9	0.8	13.8	0.7
12/9	002014	1000	high +3	100	S	8.0 8.0	30.9	8.0	9.6	3.0	0.4	7.2	0.6
12/19	002022	1325	low +4 1/2	100	S	2.5 5.5	30.7	8.0	10.6	2.9	1.0	8.2	0.8
12/27	002033	1125	high +2	100	S	1.0 4.5	31.4	8.1	10.6	2.3	0.5	9.8	1.0
Station F													
10/1	001906	1240	high +2	10	S	11.0 15.0	30.8	8.0	8.5				0.9
10/9	001920	0830	high +4	10	S	8.0 13.5	31.6	8.0*	8.4	2.0			0.6
10/17	001929	1150	high	90	S	11.0 13.5	31.1	7.8	7.8	1.7			1.3
10/23	001942	0910	high +4 1/2	50	S	11.0 10.0	31.8	7.9	8.6	1.5			0.8
10/29	001952	1155	high +2 1/2	20	S	17.0 10.0	32.0	7.8	9.2	2.2			1.0
11/6	001967	1135	low +2	100	S	11.0 16.0	31.8	7.8	8.5	2.9	0.1		0.7
11/14	001975	1125	high + 1/2	10	S	11.0 12.0	31.1	**	8.1	1.6	0.5	1.7	0.8
11/22	001990	0940	high +4 1/2	100	S	0.0 8.0	32.2	8.0	8.9	1.7	0.7	3.1	1.0
11/26	001996	1110	high +3	100	S	0.0 7.0	31.6	8.1	9.2	1.1	0.4	7.6	1.4
12/5	002003	1155	low +2 1/2	30	S	0.0 8.5	31.6	8.0	10.0	1.2	0.5	8.0	0.7
12/9	002015	1010	high +3	100	S	9.0 8.0	31.9	8.0	9.2	2.1	0.4	7.5	0.8
12/19	002023	1335	low +5	100	S	2.0 6.0	31.5	8.0	10.4	1.6	1.1	7.4	0.8
12/27	002034	1135	high +2 1/2	100	S	2.0 5.0	31.8	8.1	9.2	0.8	0.4	9.3	1.1

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	O ₂ (ppm)	BOD (ppm)
<u>Station 5</u>										
10/8	001914	0855	high +5	0	S	9.0 13.0	32.0	8.0	8.9	3.4
10/22	001937	0920	high +5 1/2	0	S	6.0 10.5	32.0	8.0	8.9	4.8
11/11	001962	1015	high +2 1/2	0	S	9.0 10.0	31.0		9.2	4.1
11/25	001991	1000	high +2 1/2	50	S	11.0 9.0	31.0	8.0	8.9	2.7
12/9	002009	1000	high +2	100	S	9.5 7.5	31.0	8.0	9.6	4.1
12/23	002028	1015	high +4 1/2	60	S	4.0 5.0	31.0	8.0	9.5	1.7
<u>Station 11</u>										
10/7	001913	1325	low +4 1/2	50	S	22.0 16.5	30.0	8.0	10.5	2.6
10/21	001935	1220	low +3 1/2	0	S	5.5 11.0	32.0	7.9	12.1	5.5
11/1	001959	0945	low +3 1/2	10	S	19.0 15.0	30.0	7.5	7.0	4.0
11/19	001983	1330	low +5	0	S	12.0 10.0	31.0		10.5	3.0
12/3	002006	1400	high + 1/2	100	S	9.0 7.0	31.0	8.0	9.1	2.6
12/18	002018	1355	high +1 1/2	30	S	5.0 7.0	30.5	8.0	10.2	8.3
<u>Station 12</u>										
10/10	001922	0825	high +2 1/2	0	S	9.0 13.5	32.0	7.9	8.7	2.3
10/24	001945	0820	high +2	0	S	4.5 10.0	32.0	7.7	9.1	2.1
11/4	001960	1330	high	100	S	16.0 11.5	30.5	8.1	10.2	3.0
11/18	001982	1230	low +5		S	9.5 10.0	31.0		8.9	1.9
12/6	002008	1410	low +4 1/2	0	S	7.0 7.5		8.0	9.9	1.5
12/20	002025	1340	low +4	0	S	7.5 7.5	32.0	8.0	10.0	3.9
<u>Station 13</u>										
10/7	001912	1240	low +4	80	S	25.0 15.5	30.0	8.0	9.5	5.9
10/21	001936	1305	low +4	0	S	5.0 9.5	32.0	7.8	9.5	1.8
11/1	001958	1025	low +5	50	S	20.0 13.0	30.5	7.8	9.1	3.7
11/19	001984	1420	high	0	S	11.5 10.0	31.0		8.9	2.0
12/3	002005	1150	low +4 1/2	60	S		31.0	8.0	8.9	4.6
12/18	002017	1435	high + 1/2	40	S	3.0 6.5	31.0	8.0	9.6	2.1

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	O ₂ (ppm)	BOD (ppm)
<u>Station 14</u>										
10/10	001923	0910	high +3	60	S	10.0 14.5	32.0	7.8	8.8	2.7
10/24	001946	0850	high +3	0	S	5.5 10.5	30.5	7.9	9.1	2.6
11/4	001961	1415	high + 1/2	100	S	14.0 12.5	31.0	8.0	10.2	2.9
11/18	001981	1140	low +4		S	8.5 11.0	31.0		8.9	2.2
12/6	002007	1355	low +3 1/2	0	S	4.5 8.0		8.0	10.1	1.8
12/20	002026	1415	low +4 1/2	40	S	3.0 7.5	32.0	8.0	10.2	2.9
<u>Station 16</u>										
10/8	001915	1020	low + 1/2	10	S	10.5 15.0	30.0	8.0	9.0	2.1
10/22	001938	1035	low + 1/2	0	S	8.5 12.0	31.0	8.0	8.6	4.5
11/11	001963	1130	high +3	0	S	13.0 13.0	30.5		8.7	2.2
11/25	001992	1145	high +4	70	S	11.0 14.5	29.5	8.0	8.5	1.8
12/9	002010	1125	high	100	S	9.5 10.0	30.0	8.0	9.4	2.4
12/23	002027	1145	high +5 1/2	50	S	5.5 10.0	31.0	8.0	8.9	8.7

*beginning use of pH meter

**pH meter broken

3.2 Heavy Metals

Copper concentrations in soft shell clams, *Mya arenaria*, and mud (Table 2) were minimal. At no time did copper concentrations in soft shell clams exceed the Food and Drug Administration's alert level of 25 ppm. The ranges for soft shell clams and mud were 5.2 - 9.0 ppm and 6.2 - 22.5 ppm, respectively.

Heavy metal sampling was terminated on December 31, 1974, as per contract agreements. At no time from February 1972 to December 1974 did the copper concentrations in soft shell clams exceed the Food and Drug Administration's alert level of 25 ppm.

Table 2. Copper concentrations (ppm) in soft shell clams, *Mya arenaria*, and mud from Salem Harbor, October - December, 1974.

Date	Station	Soft shell clam	Mud
10/23	11	7.5	18.7
	13	5.2	7.0
11/18	11	9.0	17.6
	13	7.7	6.2
12/19	11	5.3	22.5
	13	6.8	6.4

4.0 BIOLOGICAL INVESTIGATIONS

4.1 Primary Production

Concentrations of chlorophyll α during the sampling period were variable (Table 3). The decline at the end of the previous quarter (Progress Report No. 12) continued to a low on October 17 (Figure 4). There was a slight peak on October 29 which was followed by a general decline to minimal levels during the winter months. A sharp peak was noted at all stations on March 4.

Ranges for chlorophyll α and other accessory pigments for the period were:

Chlorophyll α	0.69 - 17.21 mg/m ³
β	0.00 - 1.04 mg/m ³
γ	0.00 - 6.21 mg/m ³
Carotenoids	0.20 - 7.08 mg/m ³

¹⁴C Carbon assimilation rates also varied during the period (Table 4). Surface assimilation rates declined during the first part of October, 1974 (Figure 4). During the winter months the levels were minimal. There was only a slight increase in surface rates in March, 1975. However, there was no peak during that month as was noted for the chlorophyll concentrations.

Mean assimilation rates for the five relative light intensity levels were separated into two three-month periods (Tables 5 and 6). During the fall months (October - December, 1974) Station B had the lowest mean assimilation rates of all four stations (Figure 5). This had also been noted for the fall months of 1973 (Progress Report No. 9).

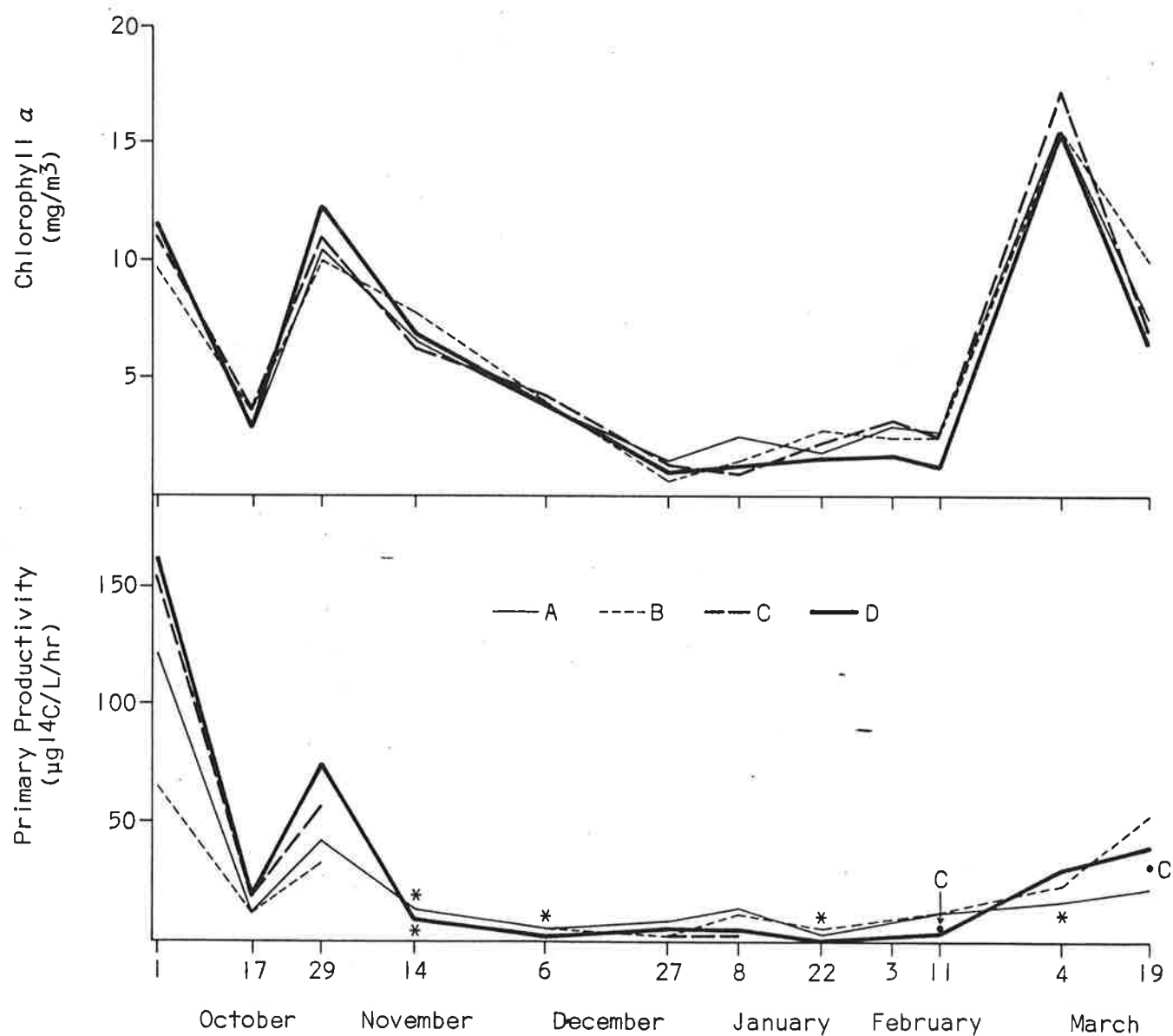
Table 3. Chlorophyll counts (mg/m³) in Salem Harbor, October, 1974 through March, 1975.

Date	Station	Chlorophyll <i>a</i>	Chlorophyll <i>b</i>	Chlorophyll <i>c</i>	Carotenoids
10/1	A	11.57	0.40	4.47	5.96
	B	9.69	0.21	3.45	3.97
	C	11.05	0.28	3.57	4.96
	D	11.53	1.07	5.38	5.51
10/17	A	3.02	0.00	2.49	0.66
	B	3.67	0.31	0.00	1.16
	C	3.67	0.44	0.34	1.16
	D	3.35	0.14	0.55	0.55
10/29	A	10.55	0.47	6.21	3.85
	B	10.01	0.33	5.70	2.98
	C	11.06	0.91	5.48	4.31
	D	12.23	0.48	5.47	5.18
11/14	A	6.65	0.41	2.98	2.75
	B	7.74	0.71	4.00	2.90
	C	6.26	0.00	4.73	2.56
	D	6.89	0.33	2.86	2.60
12/6	A	3.94	0.70	2.19	1.69
	B	3.94	0.73	1.65	1.50
	C	4.22	0.23	1.83	1.69
	D	3.73	0.60	1.91	1.50
12/27	A	1.44	1.04	2.23	0.66
	B	0.69	0.80	1.43	0.76
	C	1.44	1.01	2.77	0.40
	D	0.97	0.30	1.62	0.20
1/8	A	2.51	0.52	1.33	0.84
	B	1.43	0.24	0.31	0.87
	C	0.87	0.20	0.74	0.68
	D	1.29	0.47	0.25	0.68
1/22	A	1.84	0.51	0.80	0.79
	B	2.15	0.27	1.28	0.92
	C	2.53	0.38	0.40	1.22
	D	1.69	0.34	1.31	0.60
2/4	A	3.07	0.07	1.04	1.28
	B	2.52	0.07	0.72	1.11
	C	3.32	0.00	0.80	1.62
	D	1.73	0.05	0.25	0.90

Table 3. Continued

Date	Station	Chlorophyll <i>a</i>	Chlorophyll <i>b</i>	Chlorophyll <i>c</i>	Carotenoids
2/11	A	2.75	0.35	1.03	1.47
	B	2.52	0.47	0.59	1.38
	C	2.52	0.43	1.14	1.15
	D	1.22	0.05	1.11	0.65
3/4	A	15.57	0.60	5.21	7.08
	B	15.49	0.40	4.40	6.78
	C	17.21	0.40	6.20	7.02
	D	15.42	0.01	5.30	6.11
3/19	A	7.41	0.15	2.61	3.34
	B	9.92	0.22	3.53	4.32
	C	6.97	0.13	2.44	3.51
	D	6.59	0.01	2.86	3.42

Figure 4. Chlorophyll α (mg/m^3) and ^{14}C assimilation ($\mu\text{g}^{14}\text{C}/\text{L}/\text{hr}$) taken at the surface for Stations A - D in Salem Harbor, October 1974 through March 1975.



*Sample lost

Table 4. Primary production (^{14}C) in Salem Harbor, October, 1974 through March, 1975.

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature $^{\circ}\text{C}$	$\mu\text{g } ^{14}\text{C/L/hr}$
10/1	A	100	0	14.5	123
		50	3.5	14.0	118
		25	7.5	14.0	100
		10	12	12.5	41
		1	27	10.5	4
	B	100	0	21.5	66
		50	4	21.5	82
		25	8	11.0	47
		10	13.5	11.0	19
		1	27	10.5	4
	C	100	0	16.0	155
		50	4	15.5	110
		25	8	14.5	100
		10	13.5	11.0	16
		1	27	10.0	6
	D	100	0	14.0	162
		50	4	13.5	168
		25	8	12.0	107
		10	13.5	12.0	44
		1	27	10.0	6
10/17	A	100	0	13.0	12
		50	4.5	13.5	12
		25	9	13.0	9
		10	15	13.0	4
		1	27	13.0	1
	B	100	0	20.0	13
		50	4	16.0	11
		25	8	13.0	7
		10	13.5	13.0	4
		1	27	13.0	1
	C	100	0	12.5	19
		50	3.5	12.5	16
		25	6.5	12.5	17
		10	11	12.5	8
		1	21.5	12.5	2
	D	100	0	12.5	19
		50	5	12.5	22
		25	10	12.5	15
		10	16	12.5	8
		1	32.5	12.5	2

Table 4. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g}^{14}\text{C/L/hr}$
12/6	A	100	0	6.5	
		50	3	6.5	6
		25	6	6.5	19
		10	9.5	6.5	5
	B	100	0	14.5	10
		50	3	13.0	5
		25	6	7.5	10
		10	9.5	6.5	4
		1	19	6.5	2
	C	100	0	6.5	3
		50	3	6.5	*
		25	6	6.5	9
		10	9.5	6.5	1
		2	16	6.5	0
	D	100	0	6.0	2
		50	3	6.5	5
		25	6	6.5	5
		10	9.5	6.5	5
		1	19	6.0	12
12/27	A	100	0	5.5	1
		50	6	5.5	9
		25	12	5.5	8
		10	20	5.5	2
		1	35	4.5	2
	B	100	0	13.0	*
		50	5.5	6.5	2
		25	10.5	5.0	4
		10	17.5	4.5	1
		1	35	4.5	2
	C	100	0	4.5	1
		50	6	4.5	3
		25	12	5.0	2
		10	20	5.0	2
		1	38	4.0	2
	D	100	0	4.0	5
		50	5.5	4.0	4
		25	11.5	4.0	4
		10	19	4.0	3
		1	38	4.0	0

Table 4. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g}^{14}\text{C}/\text{L}/\text{hr}$
10/29	A	100	0	10.5	43
		50	4.5	10.5	43
		25	9	10.0	29
		10	15	10.0	18
	B	100	0	14.5	33
		50	4	13.5	38
		25	8	11.5	41
		10	13.5	10.0	22
	C	1	27	10.0	5
		100	0	10.5	58
		50	5	10.5	75
		25	10	10.0	62
	D	10	16	9.5	25
		100	0	10.5	74
		50	4.5	10.5	77
		25	9	10.5	81
		10	15	10.0	28
		1	30	9.5	8
11/14	A	100	0	11.5	14
		50	4	11.0	14
		25	8	11.0	11
		10	13.5	11.0	3
	B	2	23	11.0	*
		100	0	19.0	*
		50	4	16.0	*
		25	8	10.5	10
	C	10	13.5	10.5	2
		1	27	10.0	1
		100	0	11.0	*
		50	4	11.0	22
	D	25	8	11.0	11
		10	13.5	10.0	3
		100	0	10.5	9
		50	4	10.5	12
		25	8	10.5	9
		10	13.5	9.5	5
		1	27	9.5	1

Table 4. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g } ^{14}\text{C/L/hr}$
1/8	A	100	0	4.0	14
		50	5.5	4.0	15
		25	11.5	4.0	15
		10	19	4.0	14
	B	100	0	11.5	12
		50	6.5	5.5	12
		25	13	4.0	11
		10	21.5	4.0	4
	C	2	37	3.5	2
		100	0	5.5	3
		50	5.5	5.0	5
		25	11.5	5.0	5
	D	10	19	4.0	8
		100	0	4.0	5
		50	6.5	3.5	6
		25	13	3.5	9
		10	21.5	3.5	4
1/22	A	100	0	3.5	3
		50	5.5	3.5	7
		25	10.5	3.5	6
	B	100	0	10.5	10
		50	4.5	9.0	9
		25	9	5.0	15
		10	15	3.5	6
	C	1	30	3.5	0
		100	0	3.5	*
		50	5	3.5	9
		25	10	3.5	15
	D	10	16	3.5	9
		100	0	5.0	1
		50	5	5.0	12
		25	10	4.5	10
		10	16	4.0	7
		1	32.5	4.0	1

Table 4. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g}^{14}\text{C/L/hr}$
2/11	A	100	0	3.0	12
		50	7.5	3.0	12
		25	15.5	2.5	9
	B	100	0	9.5	13
		50	7	6.0	8
		25	14	1.5	3
		10	23	1.5	3
		2	39	1.5	0
	C	100	0	3.0	6
		50	7.5	3.0	6
		25	15.5	2.0	6
		10	25	1.5	3
	D	100	0	1.5	3
		50	8.0	1.5	3
		25	16.5	1.5	0
		10	27	1.5	0
3/4	A	100	0	2.0	17
		50	5.5	2.0	30
		25	11.5	2.0	25
		10	19.5	3.0	17
	B	100	0	7.5	24
		50	4	6.0	29
		25	8	4.5	33
		10	13.5	3.5	16
	C	1	27	3.5	7
		100	0	4.0	*
		50	5	3.5	54
		25	10	3.5	51
	D	10	16	3.5	18
		100	0	4.5	31
		50	5.5	4.5	89
		25	10.5	4.0	84
		10	17.5	3.5	40

Table 4. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g}^{14}\text{C/L/hr}$
3/19	A	100	0	7.0	22
		50	4	7.0	*
		25	8	6.5	29
		10	13.5	6.0	18
	B	100	0	11.0	54
		50	3.5	10.0	54
		25	7.5	9.0	44
		10	12	6.0	28
	C	1	24.5	4.5	10
		100	0	6.0	35
		50	3.5	6.0	35
		25	7.5	5.0	69
	D	10	12	5.0	45
		100	0	7.0	41
		50	4.5	6.5	55
		25	9	5.5	67
		10	15	5.0	53
		1	30	4.0	7

*Light bottle lost

Table 5. Mean primary production levels ($\mu\text{g}^{14}\text{C/L/hr}$) in Salem Harbor, October - December, 1974.

Relative light intensity (%)	Station							
	A		B		C		D	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
100	6-123	34	*2-66	24	**3-155	59	5-162	46
50	8-118	36	*4-82	29	2-110	39	4-168	48
25	2-100	26	1-47	18	1-100	32	3-107	37
10	*4-41	15	2-22	8	0-25	9	0-44	16
≤ 2	-	-	1-5	2	*** -	2	1-8	3

*5 samples only
 **4 samples only
 ***2 samples only

Table 6. Mean primary production levels ($\mu\text{g}^{14}\text{C/L/hr}$) in Salem Harbor, January - March, 1975.

Relative light intensity (%)	Station							
	A		B		C		D	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
100	3-22	14	10-54	23	**3-35	15	1-41	16
50	*7-30	16	8-54	22	5-54	22	3-89	33
25	6-29	17	3-44	21	5-69	29	0-84	34
10	**14-18	16	3-28	11	3-45	17	0-53	21
≤ 2	-	-	2-10	4	-	-	***1-7	4

*4 samples only
 **3 samples only
 ***2 samples only

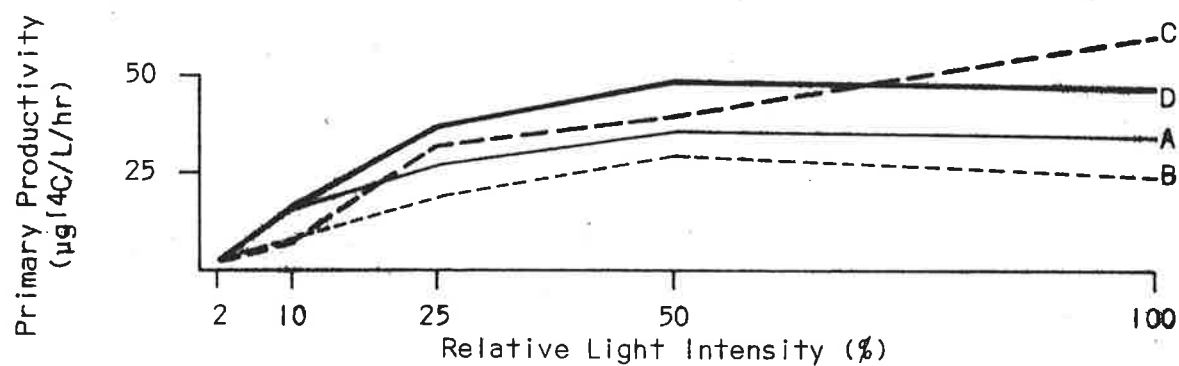


Figure 5. Mean primary production levels ($\mu\text{g } ^{14}\text{C/L/hr}$) at relative light intensity (%) in Salem Harbor, October - December, 1974.

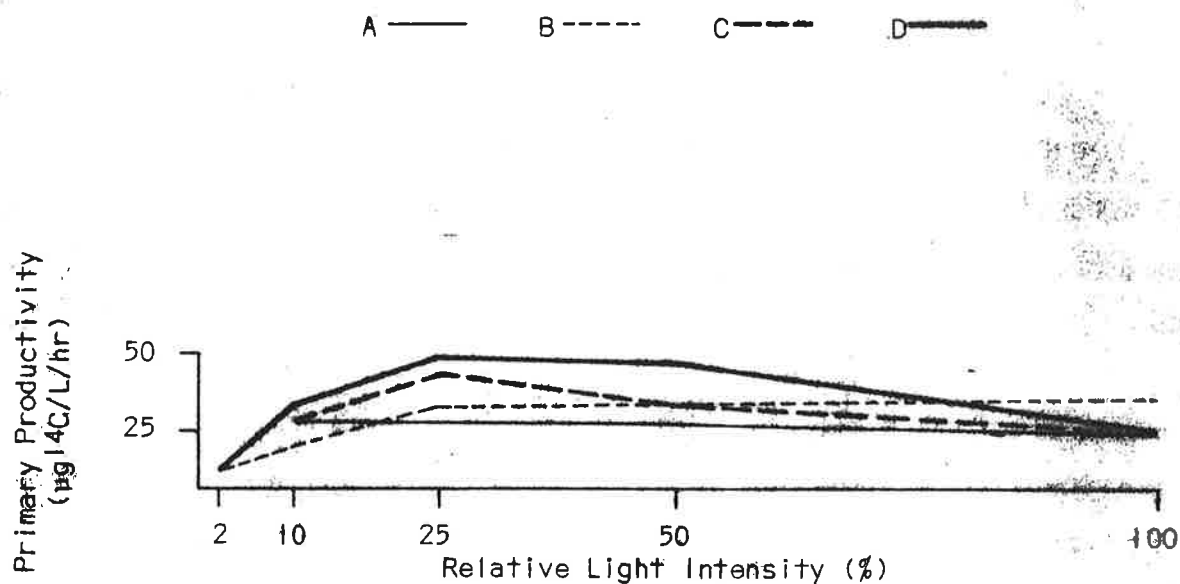


Figure 6. Mean primary production levels ($\mu\text{g } ^{14}\text{C/L/hr}$) at relative light intensity (%) in Salem Harbor, January - March, 1975.

However, during the winter months (January - March, 1975), Station B had the highest mean assimilation rates in the warmer surface water (Figure 6). Again, this had been noted for the same period in 1974 (Progress Report No. 10).

4.2 Adenosine Triphosphate (ATP)

Routine ATP samples were collected from five stations during the sampling period (Figure 7). A new numbering system was employed as of January 1, 1975. The new and old numbering systems are presented below.

<u>Station Number</u> <u>Pre-1975</u>	<u>Station Location</u>	<u>Station Number</u> <u>1975</u>
1	Intake	1
13	Head of discharge canal	2
3	Mid-point of discharge canal	3
4	Mouth of discharge canal	4
12	Navigation Aid "C-21"	5

Results (Table 7) continued to show no consistent variation between stations indicating no mortality of phytoplankton in the discharge canal. Levels of ATP were similar to levels recorded during the same period in 1973 and 1974. ATP values for February and March are not available due to a delay in delivery of the enzyme necessary for laboratory analysis.

4.3 Finfish

In accordance with the new contract agreement with New England Power Company, all seining and trawling for adult and juvenile finfish was terminated on December 31, 1974.

Finfish sampled by trawls and seine in Salem Harbor totaled 9,954 individuals and represented 27 species (Table 8). Four species comprised 88 percent of this total. They were: Atlantic silverside, *Menidia*

Figure 7. Location of ATP (Adenosine triphosphate) sampling stations in Salem Harbor.

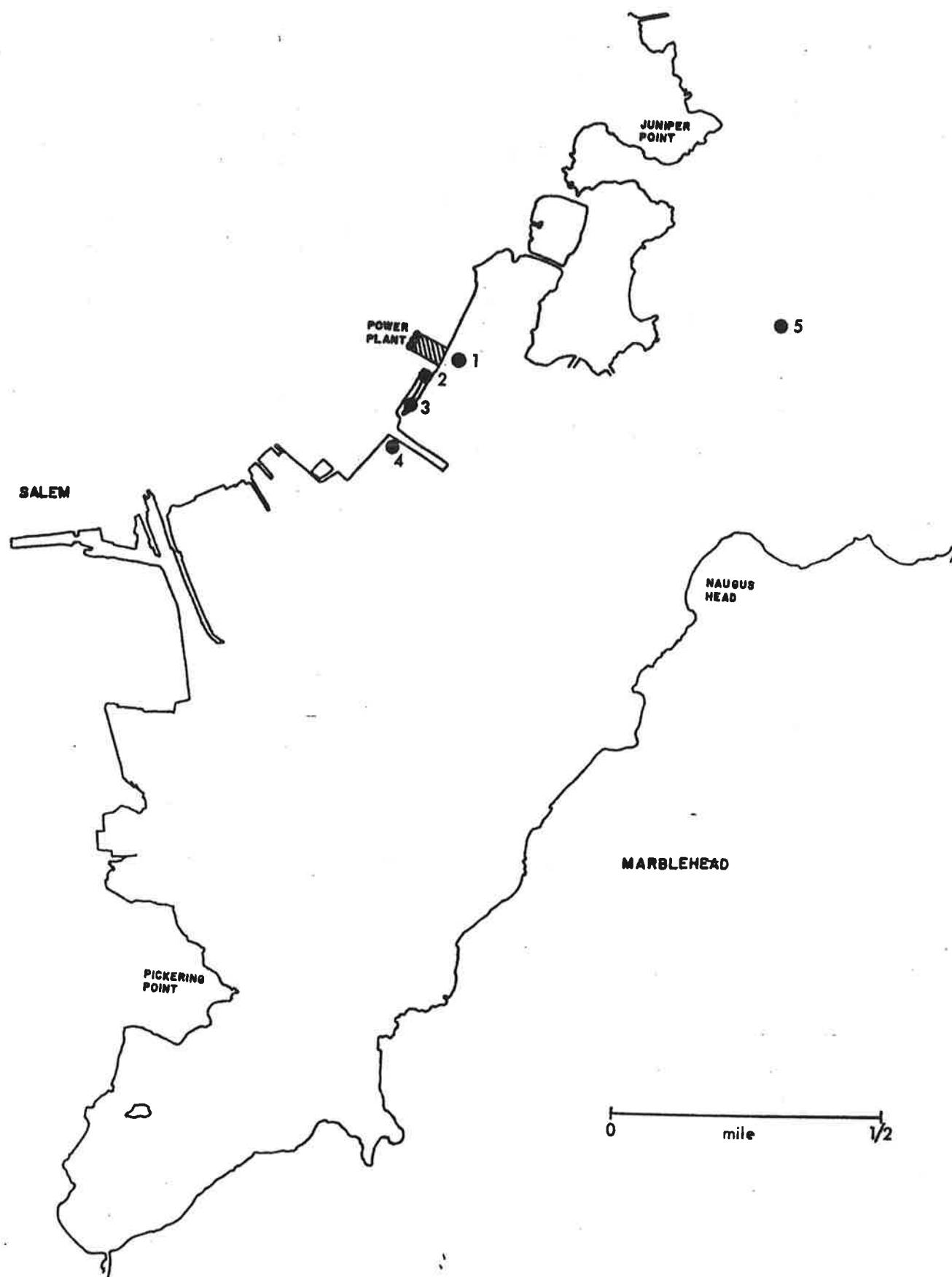


Table 7. Adenosine triphosphate (mgATP/L) levels in Salem Harbor, October 1974 through January 1975,

Station	Date							
	10/1/74	10/17/74	10/29/74	11/14/74	12/5/74	12/27/74	1/8/75	1/22/75
1 (1)	1980	930	810	280	450	340	450	70
2 (13)	385	645	550	340	410	85	410	110
3 (3)	720	300	230	265	480	105	415	95
4 (4)	660	295	-	295	400	155	440	85
5 (12)	1800	855	820	255	320	290	360	125

- Station not accessible

Table 8. Numerical rank of finfish collected in
Salem Harbor, October - December, 1974.

Species	Method of Capture			Totals
	120-ft Seine	30-ft Trawl	49-ft Trawl	
1. Atlantic silverside	2,336	2,092	1	4,429
2. fourspine stickleback	643	1,062		1,705
3. threespine stickleback	95	1,261		1,356
4. winter flounder	172	780	353	1,305
5. blueback herring	385	6		391
6. northern pipefish		281		281
7. rainbow smelt		184	5	189
8. mummichog	67	1		68
9. ninespine stickleback	2	52		54
10. Atlantic cod		17	31	48
11. grubby		32		32
12. Atlantic tomcod		27		27
13. striped killifish	18			18
14. skate*		3	8	11
15. cunner		8		8
16. Atlantic herring	6			6
silver hake		4	2	6
windowpane		2	4	6
17. American eel		3		3
striped searobin		3		3
18. butterfish		2		2
19. Atlantic mackerel		1		1
lumpfish		1		1
ocean pout		1		1
shorthorn sculpin		1		1
white hake		1		1
yellowtail flounder			1	1
Totals	3,724	5,825	405	9,954

*Not separated by species.

menidia (44%); fourspine stickleback, *Apeltes quadracus* (17%); threespine stickleback, *Gasterosteus aculeatus* (14%); and winter flounder, *Pseudopleuronectes americanus* (13%).

Species diversity (total number of different species) remained greatest at the 30-ft shrimp trawl stations (Table 9). The highest value occurred November 4 when 17 different species were taken; however, on successive sampling dates, diversity declined steadily to a low of 6 species on December 20.

At the 30-ft shrimp trawl stations Atlantic silversides, threespine sticklebacks, fourspine sticklebacks and winter flounder were most abundant.

Atlantic silversides and fourspine sticklebacks were the dominant species taken at the 120-ft haul seine stations.

The 49-ft otter trawl accounted for 6 percent of the total catch in Salem Harbor. Winter flounder was the dominant (87%) finfish taken by this gear (Table 8). No sampling was done in October due to the heavy concentration of lobster pots in the trawl area. Winter flounder and Atlantic cod (*Gadus morhua*) were the most abundant species taken outside Salem Harbor (Table 10).

Table 11 lists the total numbers, size ranges, and mean total lengths for the more abundant finfish species taken at each station in Salem Harbor.

4.4 Impingement Investigations

Random Sampling

Random sampling at Units 3 and 4 sluiceways continues to yield minimal numbers of finfish (Table 12). Of the combined total of 256 individuals taken at Units 3 and 4 sluiceways, 79% were represented by three species--

Table 9. Number of finfish species taken, by method of capture, in Salem Harbor, October - December, 1974.

Date	120-ft Seine	30-ft Trawl	49-ft Trawl
10/7	4	*	*
10/10	*	15	*
10/21	4	*	*
10/24	*	13	*
11/1	5	*	*
11/4	*	17	*
11/11	*	*	5
11/18	*	10	*
11/19	6	*	*
11/25	*	*	4
12/3	8	*	*
12/6	*	9	*
12/9	*	*	6
12/18	2	*	*
12/20	*	6	*
12/23	*	*	1

*Method not employed on this date

Table 10. Numerical rank of finfish collected outside Salem Harbor with the 49-ft trawl, October - December, 1974.

Species	Totals
1. winter flounder	260
2. Atlantic cod	136
3. windowpane	39
4. yellowtail flounder	29
5. silver hake	20
6. skate*	11
7. rainbow smelt	4
8. goosefish	3
9. butterfish	1
Totals	503

*Not separated by species.

Table 11. Total numbers, mean lengths, and size ranges for the more abundant finfish species collected, by method of capture, in Salem Harbor, October - December, 1974.

Species	Total Collected	Size Range (mm)	Mean Length (mm)
120-FT. HAUL SEINE			
<i>Station 11</i>			
Atlantic silverside	1,132	65-154	102
<i>Station 13</i>			
Atlantic silverside	1,204	50-159	94
fourspine stickleback	635	30-64	41
blueback herring	362	55-129	93
30-FT. SHRIMP TRAWL			
<i>Station 12</i>			
Atlantic silverside	1,469	65-154	99
winter flounder	382	45-449	138
threespine stickleback	318	30-74	45
<i>Station 14</i>			
fourspine stickleback	986	20-64	41
threespine stickleback	943	25-79	46
Atlantic silverside	623	60-154	97
winter flounder	398	50-394	170
northern pipefish	262	95-199	149
49-FT. OTTER TRAWL			
<i>Station 16</i>			
winter flounder	353	195-534	311

Table 12. Total numbers and mean total lengths (mm) of finfish taken in Units 3 and 4 sluiceways, October, 1974 through March, 1975.

	(EST)	10/1	10/3	10/9	10/24	10/25	10/25	10/25	10/29	10/30	11/4	11/5	11/6	
		1000	1000	1200	1200	0600	1000	1200	0600	1500	0900	1100	1100	
		1200	1200	1400	1400	0800	1200	1400	0800	1700	1100	1300	1300	
Species	Tidal Stage (Hrs)	H	L+5	L+2	L+1	H	H+4	L	L+4	L	L+2	L+3	L+2	Totals*
<u>Unit 3</u>														
blueback herring	5 (83)†		9 (68)											14 (14)
winter flounder						1 (242)			1 (87)					2
pearlside							1 (52)							1 (1)
bluefish								1 (252)	1 (257)					2 (1)
Atlantic tomcod									1					1 (1)
<u>Unit 4</u>														
			**	**		**	**	**	**					

Table 12. Continued

Species	(EST) Tidal Stage (Hrs)	11/13	11/15	11/15	11/18	11/18	11/25	12/2	12/9	12/11	12/11	12/16	12/17	Totals*
		1500 1700	0900 1100	1300 1500	1300 1500	1500 1700	1500 1700	1100 1300	1300 1500	0900 1100	1100 1300	1100 1300	1500 1700	
		L	L+5	H+2	H	H+2	L+2	L+5	L	H+1	H+3	L+5	H+3	
<u>Unit 3</u>														
red hake		1 (197)												1 (1)
Atlantic silverside					1			3 (97)						4 (4)
blueback herring						1 (62)								1 (1)
shorthorn sculpin								1 (107)				1 (117)		2
rainbow smelt								1 (77)				3 (145)	28 (181)	32 (31)
northern pipefish								1 (137)						1
winter flounder												1 (117)		1
Atlantic tomcod													3 (165)	3 (1)

Table 12. Continued

Species	(EST) Tidal Stage (Hrs)	11/13	11/15	11/15	11/18	11/18	11/25	12/2	12/9	12/11	12/11	12/16	12/17	Totals*
		1500	0900	1300	1300	1500	1500	1100	1300	0900	1100	1100	1500	
		1700	1100	1500	1500	1700	1700	1300	1500	1100	1300	1300	1700	
		L	L+5	H+2	H	H+2	L+2	L+5	L	H+1	H+3	L+5	H+3	
blueback herring		5 (56)	2 (52)	4 (51)	3 (55)	Unit 4 4 (88)			1 (72)					19 (19)
Atlantic silverside		3 (105)						6 (99)	1 (102)				88 (103)	98 (97)
northern searobin		1 (82)			1 (87)									2 (2)
rainbow smelt		1 (152)						7 (106)					4 (96)	12 (12)
northern pipefish				1 (142)				1 (152)						2 (1)
winter flounder				1 (47)										1
grubby					3 (94)									3
windowpane					3 (54)									3
cunner						1 (120)								1 (1)
threespine stickleback								7 (54)			1 (52)		6 (51)	14 (10)
mummichog										1				1 (1)

Table 12. Continued

Species	(EST) Tidal Stage (Hrs)	12/24	1/2	1/2	1/7	1/7	1/7	1/13	1/23	1/27	1/30	2/6	2/10	Totals*
		0900 1100	1300 1500	1500 1700	0700 0900	1100 1300	1500 1700	1300 1500	1100 1300	1500 1700	0900 1100	1100 1300	1500 1700	
		H+3	H	H+2	H+1	H+5	L+3	H+2	H+5	H+5	L+3	H+5	H+5	
rainbow smelt			1 (217)			<u>Unit 3</u> 1 (95)								2
winter flounder			1 (122)											1
Atlantic silverside						3 (115)					1 (107)	2 (102)	2 (82)	8 (6)
Atlantic silverside				1 (102)		<u>Unit 4</u>			**		6 (100)	1 (92)		8 (8)
winter flounder												3 (82)		3
threespine stickleback												4 (51)		4

Table 12. Continued

Species	(EST) Tidal Stage (Hrs)	2/20	2/20	2/24	2/28	2/28	3/6	3/10	3/10	3/13	3/14	3/17	3/21	3/24	Totals*
		0900	1500	1200	0800	1200	0600	1000	1200	1200	0600	0800	1300	1200	
		1100	1700	1400	1000	1400	0800	1200	1400	1400	0800	1000	1500	1400	
		H+5	L+4	H+4	L+2	H	H+1	H+1	H+3	H+1	L+1	L+1	L+3	H+5	
<u>Unit 3</u>															
Atlantic silverside					1 (97)										1
winter flounder						1 (387)	1 (82)								2
rainbow smelt							1 (67)							1 (82)	2 (1)
lumpfish									1 (292)						1 (1)
northern pipefish														2 (154)	2
<u>Unit 4</u>															
Atlantic silverside		1 (102)				**							**	**	1 (1)

*Number of dead fish shown in parenthesis

†Mean total length in mm

**Unit shut down

Atlantic silversides (47%), rainbow smelt (19%), and blueback herring (13%). A total of 17 species were taken. During 98 hours of investigations at the Unit 3 sluiceway, 84 finfish (11 species) were taken. Unit 4 yielded 172 finfish (11 species) during 78 hours of sampling. The catch rates for Units 3 and 4 were 0.9 fish/hr and 2.2 fish/hr.

Mortality rates at Units 3 and 4 sluiceways were 75% and 88%.

On October 25, 1974 a pearlside, *Maurolicus pennanti*, was taken in the Unit 3 sluiceway. This species had not previously been taken during the study. Bigelow and Schroeder (1953) state that *M. pennanti* ranges widely in the open Atlantic, but has not often been recorded on the American side of the Atlantic. Thus the capture of this species is considered as a rare occurrence.

24-hr Investigations

Continuous 24-hr investigations performed on November 7 - 8, January 28 - 29, and March 19 - 20 yielded 6, 24, and 8 finfish, respectively, at the Unit 3 sluiceway and 231, 94, and 5 finfish at the Unit 4 sluiceway (Tables 13, 14 and 15). In all, 16 species were taken. Two species (blueback herring and Atlantic silversides) accounted for 80% of all finfish captured. A rank of finfish abundance for the combined three 24-hr investigations is presented in Table 16.

Ninety-four percent of the finfish impinged on the Unit 4 traveling screens during November were juvenile blueback herring. Atlantic silverside was the dominant species impinged in January (60%).

Mortality at the Unit 3 sluiceway was 29%. Unit 4 sluiceway mortality was 77%. The latter mortality was attributed to the great number of blueback herring since this species is not tolerant to physical stress.

Table 13. Total numbers and mean total lengths (mm) of finfish taken in Units 3 and 4 sluiceways during a continuous 24-hr investigation, November 7 - 8, 1974.

Species	Time (EST)	November 7 (0800 EST) - November 8 (0800 EST)				Totals*
		1200	1800	2000	2200	
		1400	2000	2200	2400	
		<u>Unit 3</u>				
northern searobin			1 (97)†			1
blueback herring			2 (60)	1 (72)	1 (77)	4 (2)
bluefish					1 (247)	1
		<u>Unit 4</u>				
blueback herring		1 (77)	80 (75)	7 (81)	128 (75)	216 (216)
silver hake			1 (192)		1 (177)	2 (2)
northern searobin			1 (77)			1 (1)
cunner			1 (67)	1 (77)	4 (74)	6 (6)
Atlantic silverside				1 (102)	1 (107)	2 (2)
winter flounder					3 (99)	3 (3)
rainbow smelt					1 (87)	1 (1)

*Number of dead fish shown in parenthesis

†Mean total length in mm.

Table 14. Total numbers and mean total lengths (mm) of finfish taken in Units 3 and 4 sluiceways during a continuous 24-hr investigation, January 28 - 29, 1975.

Species	Time (EST)	January 28 (1600 EST) - January 29 (1600 EST)												Totals*
		1600 1800	1800 2000	2000 2200	2200 2400	2400 0200	0200 0400	0400 0600	0600 0800	0800 1000	1000 1200	1200 1400	1400 1600	
		Unit 3												
American eel		1 (532)†												1
Atlantic cod		1 (112)												1
windowpane			1 (142)											1
blueback herring			2 (84)											2 (1)
Atlantic silverside			4 (104)	1 (92)				1 (102)	1 (-)			1 (122)		8 (8)
rainbow smelt			1 (112)					1 (127)						2 (1)
grubby				2 (102)		1 (107)	1 (102)							4
winter flounder				1 (192)	3 (132)							1 (102)		5

Table 14. Continued

Species	Time (EST)	January 28 (1600 EST) - January 29 (1600 EST)												Totals*
		1600 1800	1800 2000	2000 2200	2200 2400	2400 0200	0200 0400	0400 0600	0600 0800	0800 1000	1000 1200	1200 1400	1400 1600	
Atlantic silverside		33 (94)	7 (89)	3 (97)	3 (94)	<u>Unit 4</u> 2 (100)	2 (107)		2 (104)		2 (94)	2 (97)		56 (14)
threespine stickleback		13 (48)	8 (53)		2 (57)			1 (57)						24 (2)
blueback herring		1 (107)	2 (84)											3 (3)
rainbow smelt		1 (77)	1 (72)			1 (172)								3 (3)
winter flounder			1 (97)		1 (77)				1 (67)					3
windowpane				1 (162)			1 (92)							2
striped killifish						1 (82)								1
fourspine stickleback								1 (47)	1 (42)					2

*Number of dead fish shown in parenthesis.

†Mean total length in mm.

Table 15. Total numbers and mean total lengths (mm) of finfish taken in Units 3 and 4 sluiceways during a continuous 24-hr investigation, March 19 - 20, 1975.

Species	Time (EST)	March 19 (0500 EST) - March 20 (0500 EST)								Totals*
		0500	0700	0900	1100	1700	2300	0100	0300	
		0700	0900	1100	1300	1900	0100	0300	0500	
<u>Unit 3</u>										
rainbow smelt†		5 (94)†				1 (152)				6
northern pipefish								2 (152)		2
<u>Unit 4</u>										
blueback herring			1 (102)	1 (112)						2
Atlantic silverside					1 (107)					1 (1)
northern pipefish							1 (172)		1 (157)	2

*Number of dead fish shown in parenthesis

†Mean total length in mm

Table 16. Rank of finfish taken during continuous 24-hr investigations in Units 3 and 4 sluiceways in November, January and March, 1974 - 1975.

Species	Unit 3	Unit 4	Totals
1. blueback herring	6	221	227
2. Atlantic silverside	8	59	67
3. threespine stickleback		24	24
4. rainbow smelt	8	4	12
5. winter flounder	5	6	11
6. cunner		6	6
7. grubby	4		4
northern pipefish	2	2	4
8. windowpane	1	2	3
9. fourspine stickleback		2	2
northern searobin	1	1	2
silver hake		2	2
10. American eel	1		1
Atlantic cod	1		1
bluefish	1		1
striped killifish		1	1
Totals	38	330	368

4.5 Ichthyoplankton

After several unavoidable delays, ichthyoplankton sampling began on a bi-weekly basis on March 5, 1975. Five minute oblique (bottom to surface) tows were made at eleven stations in Beverly - Salem Harbor (Figure 8). Nine of these stations were selected using a 3/4 mile square grid system, with additional stations located in the plant's intake basin and discharge area. Paired 60 cm bongo nets with 505 μ mesh nets were used to collect the samples. Filtered water volume was determined with two General Oceanics Model 2030 digital flow meters. One sample was preserved immediately in a 10% formalin solution, while the other was returned "live" to the laboratory for processing.

Upon return to the laboratory, fish eggs and larvae were removed from the sample for identification, enumeration and preservation in a 5% buffered formalin solution. During the initial phase of the study each sample was re-sorted. As the study progresses and sorting techniques improve, only a small percentage of the samples, selected randomly, will be re-sorted. When possible, eggs with questionable identifications are hatched in the laboratory, as larval identification is more reliable. Questionable larvae were sent to the Narragansett, Rhode Island Laboratory of the National Marine Fisheries Service for verification.

Five species of eggs, including: American plaice, *Hippoglossoides platessoides*; Atlantic cod, *Gadus morhua*; haddock, *Melanogrammus aeglefinus*; winter flounder, *Pseudopleuronectes americanus*; and yellowtail flounder, *Limanda ferruginea*; were positively identified. In addition, one egg was keyed out to be either red hake, *Urophycis chuss*, or fourbeard rockling,

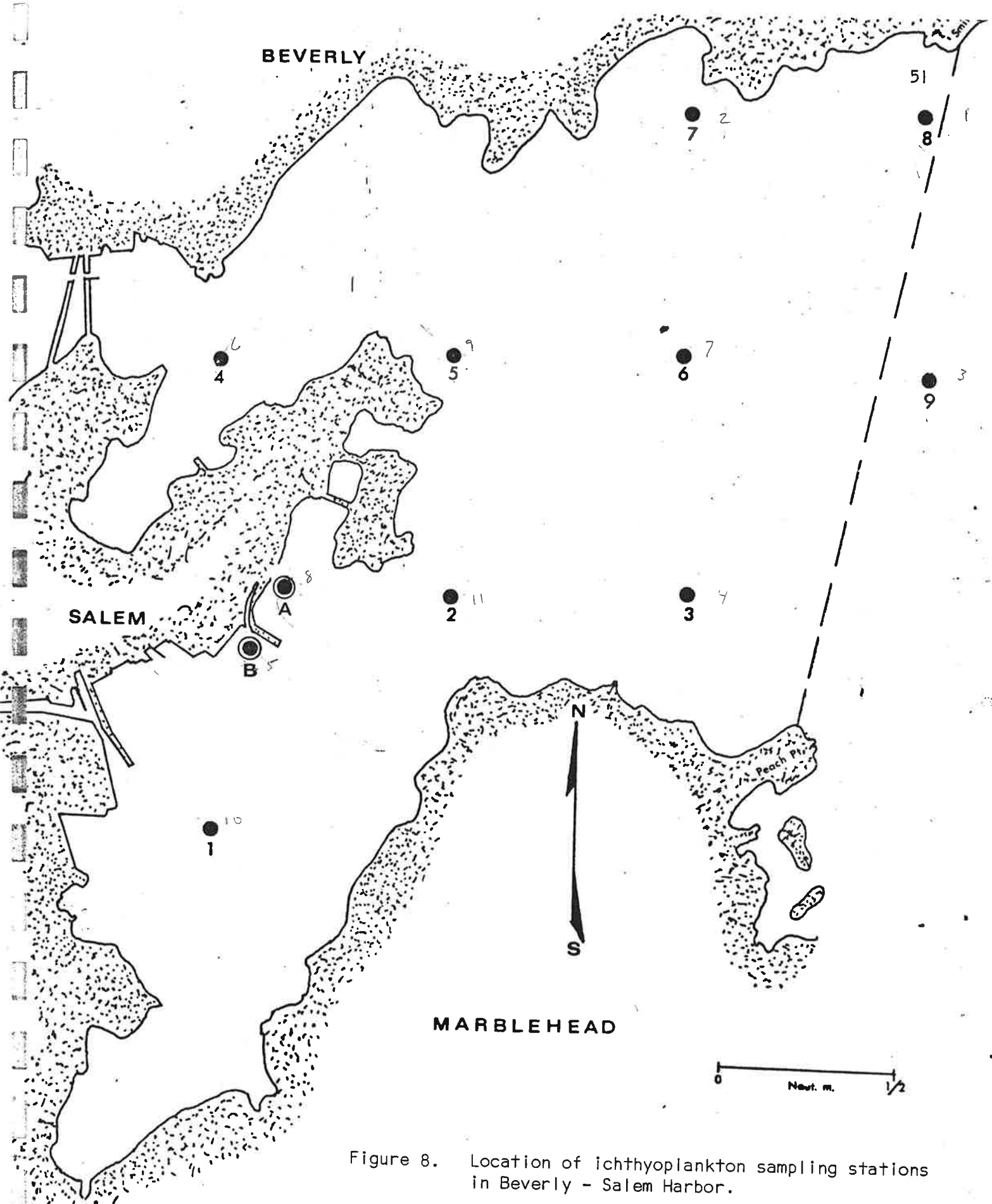


Figure 8. Location of ichthyoplankton sampling stations in Beverly - Salem Harbor.

Enchelyopus cimbrius and several eggs could only be identified to the family Gadidae. Twelve different species of larvae were identified, including sand lance, *Ammodytes* spp.; longhorn sculpin, *Myoxocephalus octodecemspinosus*; rock gunnel, *Pholis gunnellus*; seasnail, *Liparis* spp.; wrymouth, *Cryptacanthodes maculatus*; American eel, *Anguilla rostrata*; Atlantic herring, *Clupea harengus harengus*; pollock, *Pollachius virens*; alligatorfish, *Aspidophoroides monopterygius*; American plaice and Atlantic cod. One group of larvae was identified to family (Gadidae) only. Several eggs and larvae were severely mutilated during capture and are listed as "unidentified fragments."

A detailed listing of all ichthyoplankton sampling results is presented in Table 17. Longhorn sculpin, rock gunnel and sand lance were the most abundant larvae taken. The most abundant eggs were American plaice. Because only two sampling periods are included, further discussion of long term trends and distribution is not possible at this time.

Table 17. Species and numbers of fish eggs and larvae (per 100 cubic meters) taken during sampling in Beverly - Salem Harbor, March, 1975.

Species	March 5		March 6		March 18		Total Eggs Larvae
	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³	Eggs/100m ³	Larvae/100 m ³	
<u>Station 1</u>							
Gadidae				0.9			Total Eggs Larvae 10.9 52.8
<i>Ammodytes</i> spp.				14.9		11.3	
longhorn sculpin				12.1		5.0	
rock gunnel				6.5		1.2	
seasnail				0.9			
yellowtail flounder			0.9				
American plaice					3.8		
Atlantic cod					1.2		
unidentified					5.0		
<u>Station 2</u>							
Gadidae		1.2					Total Eggs Larvae 5.8 85.7
American plaice					5.8		
<i>Ammodytes</i> spp.		8.4				32.4	
longhorn sculpin		2.4				11.6	
rock gunnel		13.2				12.4	
winter flounder					5.8		
seasnail		2.4					
unidentified						1.7	
<u>Station 3</u>							
American plaice		1.7			4.7		Total Eggs Larvae 6.7 177.2
<i>Ammodytes</i> spp.		17.7				30.6	
Atlantic cod					1.2		
Atlantic herring						1.2	
longhorn sculpin		56.5				24.7	
rock gunnel		25.3				8.2	
wrymouth						1.2	
seasnail		7.6					
unidentified	0.8						53
unidentified fragments		2.5					

Table 17. Continued

Species	March 5		March 6		March 18	
	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³
<u>Station 4</u>						
Gadidae				1.4		0.8
<i>Ammodytes</i> spp.				1.4		13.9
longhorn sculpin				19.1		4.9
rock gunnel				6.8		1.6
yellowtail flounder			0.7			
American plaice					7.3	
winter flounder					3.3	
<u>Station 5</u>						
Gadidae		2.2				
American eel		1.1				
American plaice	1.1				1.1	
<i>Ammodytes</i> spp.		8.7				7.8
longhorn sculpin		83.6				17.7
rock gunnel		27.2				17.7
seasnail		3.3				
winter flounder					12.2	
<u>Station 6</u>						
<i>Ammodytes</i> spp.		8.8				23.3
longhorn sculpin		37.6				23.3
rock gunnel		22.1				8.1
seasnail		6.6				
American plaice					2.0	
red hake or fourbeard rockling					1.0	

Total
eggs
11.5
larvae
48.1

Total
eggs
14.4
larvae
11.3

Total
eggs
3.3
larvae
129.8

Table 17. Continued

Species	March 5		March 6		March 18	
	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³
<u>Station 7</u>						
cod - haddock	0.8					
American plaice	3.3				11.9	2.2
<i>Ammodytes</i> spp.		10.0				128.0
longhorn sculpin		45.1				22.8
rock gunnel		10.8				23.9
seasnail		2.5				1.1
wrymouth		1.7				
Atlantic cod					3.2	
Atlantic herring						1.1
haddock					1.1	
<u>Station 8</u>						
cod - haddock	0.9					
Atlantic cod						1.2
American plaice	1.8				9.4	1.2
<i>Ammodytes</i> spp.		21.1				68.2
longhorn sculpin		46.8				7.0
pollock		0.9				1.2
rock gunnel		14.7				1.2
seasnail		12.8				
alligator fish		0.9				
unidentified fragments						4.7
<u>Station 9</u>						
American plaice	0.8				11.3	
<i>Ammodytes</i> spp.		12.9				68.0
Atlantic cod					0.9	0.9
Atlantic herring						0.9
longhorn sculpin		88.6				49.1
pollock		0.9				0.9
rock gunnel		27.5				22.7
seasnail		1.7				1.9

Total
eggs
20.3
larvae
261.1

Total
eggs
12.1
larvae
181.9

Total
eggs
13.0
larvae
276.0
55

Table 17. Continued

Species	March 5		March 6		March 18	
	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³	Eggs/100 m ³	Larvae/100 m ³
<u>Station A</u>						
American plaice					2.3	
<i>Ammodytes</i> spp.			4.4			2.3
longhorn sculpin			2.2			4.6
rock gunnel			1.1			2.3
unidentified fragments			2.2			
<u>Station B</u>						
American plaice					7.6	
<i>Ammodytes</i> spp.			6.9			27.4
Atlantic cod			0.9			
longhorn sculpin			17.3			15.1
rock gunnel			14.7			18.0
winter flounder					0.9	
yellowtail flounder					0.9	
unidentified			0.9		0.9	

Total
eggs
2.3
larvae
19.1

Total
eggs
10.3
larvae
101.2

5.0 APPENDIX I
SAMPLING PROCEDURES

SAMPLING PROCEDURES

CHLORINITY

Field Collection: 300 ml/sample of seawater.

Laboratory Analysis: Modified Knudsen method, from Strickland and Parsons (1968).

SALINITY

Laboratory Analysis: Direct reading from an American Optical 10419 T.C. Salinity Refractometer.

Field Analysis: (sluiceway investigations) Direct reading from a G.M. hydrometer, calibrated from 0 - 45 0/00.

HYDROGEN ION

Field Analysis: Hach Chemical Company test kit, Model 17-N.

Samples collected from May 15 - December 1, 1972 were analyzed with a Hach test kit, Model CA-10. Prior to May 15 a Kontes mini-pH meter was employed.

Laboratory Analysis: (~~As of 10/9/74~~) Determined with ~~an instrumentation~~ ^{a Beckman Model 3500 digital} laboratory 245 pH meter. Adjusted for salinity and temperature according to Strickland and Parsons (~~op. cit.~~).
(1968).

DISSOLVED OXYGEN

Field Collection: 300 ml/sample of seawater fixed with 1 ml manganous sulfate reagent and 1 ml alkaline iodide reagent.

Laboratory Analysis: Titration by Winkler method.

BIOCHEMICAL OXYGEN DEMAND

Field Collection: 300 ml/sample of seawater.

Laboratory Analysis: Titration by Winkler method following 7-day incubation.

COPPER

Field Collection: Soft shell clam - 6/sample, approximately 2" in length. Mud - 1 pint sample taken from same area as soft shell clams. Lobster - 1/sample, approximately 3" in carapace length.

Laboratory Analysis: Utilizing a modified Strickland and Parsons (*op. cit.*) method, the soft portions of clams and 6 grams of lobster gills are digested and analyzed.

NITRATE

Field Collection: 300 ml/sample of seawater.

Laboratory Analysis: Cadmium - copper column reduction of Nitrate to Nitrite and ultraviolet spectrophotometric determination from Strickland and Parsons (*op. cit.*).

NITRITE

Field Collection: 300 ml/sample of seawater.

Laboratory Analysis: Spectrophotometric method from Strickland and Parsons (*op. cit.*).

INORGANIC PHOSPHATES

Field Collection: 300-ml/sample of seawater.

Laboratory Analysis: Modified colorimetric determination from Strickland and Parsons (*op. cit.*).

BENTHIC

Field Collection: Benthic algae and invertebrates and sampled at sites selected at various depth contours. Quadrats are established by attaching a 12-ft. line to the site marker and swinging a circle of 10-ft radius. The first quadrat is located 2 ft from the marker, and subsequent quadrats are located 2 ft and 70° counterclockwise from the former. This procedure is repeated until 5 1/4 m² samples are collected within each circle. Samples are stored and frozen in plastic bags until analyses.

CHLOROPHYLL

Field Collection: Surface seawater is filtered through a 316 micron mesh nytex cloth into a one gallon nalgene bottle and stored in a light-proof box for transport to the laboratory.

Laboratory Analysis: Samples are stored in a cool dark place not exceeding eight hours from collection. Estimation of extracted algae cell pigments is made spectrophotometrically using the SCOR/UNESCO method outlined by Strickland and Parsons (*op. cit.*).

FINFISH

Field Collection: Sets are made at selected sites with gear of the following design:

120 x 8 ft seine, with 1 1/2 in mesh wings and 3/4 in mesh bag (2 sets);

30 x 25 ft trawl with 1 1/2 in mesh wings and 1 in mesh cod end (2 sets);

49 x 38 ft trawl with 5 in mesh wings and 4 in mesh cod end (1 set).

Seines are set parallel to shore with the aid of a skiff and drawn to the shore by lines of approximately 75 ft. Trawl cruises are along a fixed course. Where obstructions occur, cruise lines are altered. Fishing time is five minutes with the 30-ft trawl and 20 minutes with the 49-ft trawl.

Finfish collected are separated by species, enumerated, and measured for total length in millimeters.

ICHTHYOPLANKTON

Field Collection: Oblique (bottom to surface) tow with Ocean Instruments 60 cm paired aluminum bongo frames, equipped with 505 μ mesh nets. Nets are towed for a minimum of 5 minutes at a vessel speed of 2 knots. The nets are returned, while the vessel is underway, at approximately one ft per second. Net depth is determined with an Endeco Type 121 transducer. Vessel speed is determined with an ~~Omni-Contender~~ knotmeter and the vessel's tachometer. Filtered water volume is determined with two General Oceanics Model 2030 digital flow meters.

Laboratory Analysis: Eggs and larvae are removed from each sample, identified, enumerated and preserved for storage in a 5% buffered formalin solution.

SLUICEWAY INVESTIGATIONS

Field Collection: Finfish, invertebrates and marine vegetation are sampled in the intake sluiceways to Units 3 and 4. Traps, constructed of 1/2 in welded steel rod and covered with 1/4 in mesh galvanized screen, are periodically placed in the respective sluiceways for two hour intervals. All organisms are identified, enumerated and measured. Water temperatures and salinities are recorded during each sampling interval.

TEMPERATURE MONITORING

In situ monitoring is conducted with Endeco 109 continuous recording thermographs. Thermographs are installed at prescribed locations and depths by personnel utilizing SCUBA. Temperature data is retrieved at approximately 30-day intervals and delivered to Environmental Devices Corporation for reduction and verification.

ADENOSINE TRIPHOSPHATE

Field Collection: Following removal of zooplankton with an 80 micron mesh net, water is filtered through a 2.4 GF/A millipore filter retained in a Swinex 25 filter holder locked between two 50 ml disposable syringes. After filtration the filter pad is removed, quick frozen on dry ice, and placed in a labeled glass vial for transport to the laboratory. All samples remain frozen until analyzed. Triplicate samples are collected at each sampling site.

Laboratory Analysis: ATP is assayed enzymatically using the luciferin-luciferase ~~inose~~ bioluminescence system outlined by Strehler (1968).
 OSL

14C

Field Collection: At depths determined by a 30 cm secchi disc (100, 50, 25, 12 and 0% relative light intensity), unfiltered water is incubated 2 - 4 hours in 300 ml BOD bottles containing a solution of radioactive carbon. Duplicate samples are collected in light and dark bottles. Immediately following incubation all samples are placed in a light proof container for transport to the laboratory.

Laboratory Analysis: Following filtration of phytoplankton from seawater samples, the uptake of fixed radioactive carbon is determined by the techniques of Strickland and Parsons (*op. cit.*) modified to use liquid scintillation.

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