

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

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1.0 INTRODUCTION

The following is the third semi-annual report of research performed by the Massachusetts Division of Marine Fisheries under Contract DMF-2-72 - Amendment No. 2 with the New England Power Company. This report contains temperature, water quality, sluiceway monitoring, chlorophyll, ^{14}C and ATP data collected during the period October 1975 through March 1976. At the request of the Power Company, all ichthyoplankton data through February, 1976 will be interpreted and presented in a separate report.

Since the last reporting period, Elizabeth Kouloheras has joined the project staff as Assistant Marine Fisheries Biologist and Karen Pearson resigned her position as Laboratory Technician.

2.0 TEMPERATURE INVESTIGATIONS

Average surface water temperatures, taken concurrently with weekly water quality samples at stations A - D (Figure 1), decreased to 8.2°C. A comparison of average quarterly surface temperatures for these stations is given below.

	October - December	January - March
1972	10.0°C	4.9°C
1973	9.1°C	4.1°C
1974	10.7°C	4.1°C
1975	12.2°C	4.8°C
1976		4.5°C

Mean daily water temperatures at stations A - D, calculated from hourly thermograph readings are presented in Figure 2. Significant gaps in the data were caused by mechanical malfunctions of the thermographs located at the surface at station C and at the surface and bottom at station D. The thermistors maintained by the Power Company at stations A and B yielded fairly consistent data, with few missing data points. Generally, temperatures in the harbor (stations A, C and D) decreased steadily through December and remained relatively low through mid-February when they started to increase gradually.

The ΔT , which varied with generation and circulating water volume, ranged from 3.8 to 11.9°C and averaged 7.7°C for the period October through March. For the fall quarter (October - December) the mean ΔT was 8.2°C with a range of 4.1 - 11.9°C. In the winter quarter (January - March), ΔT averaged 7.2°C and ranged from 3.8 - 11.9°C.

Figure 1. Location of water quality, thermograph and adenosine triphosphate sampling stations in Salem Harbor.

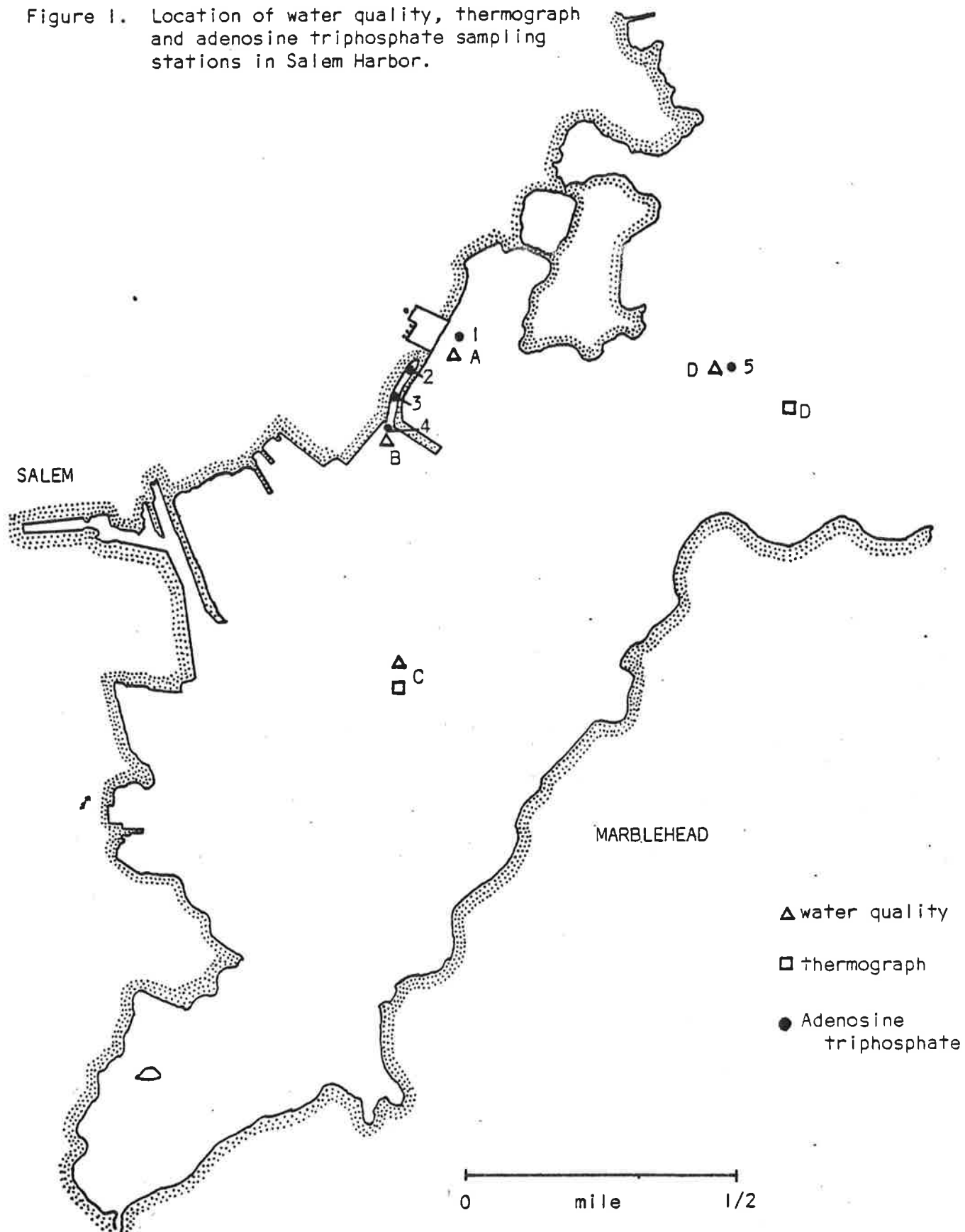


Figure 2. Mean water temperatures recorded at Stations A - D in Salem Harbor, October 1975 through March 1976.-

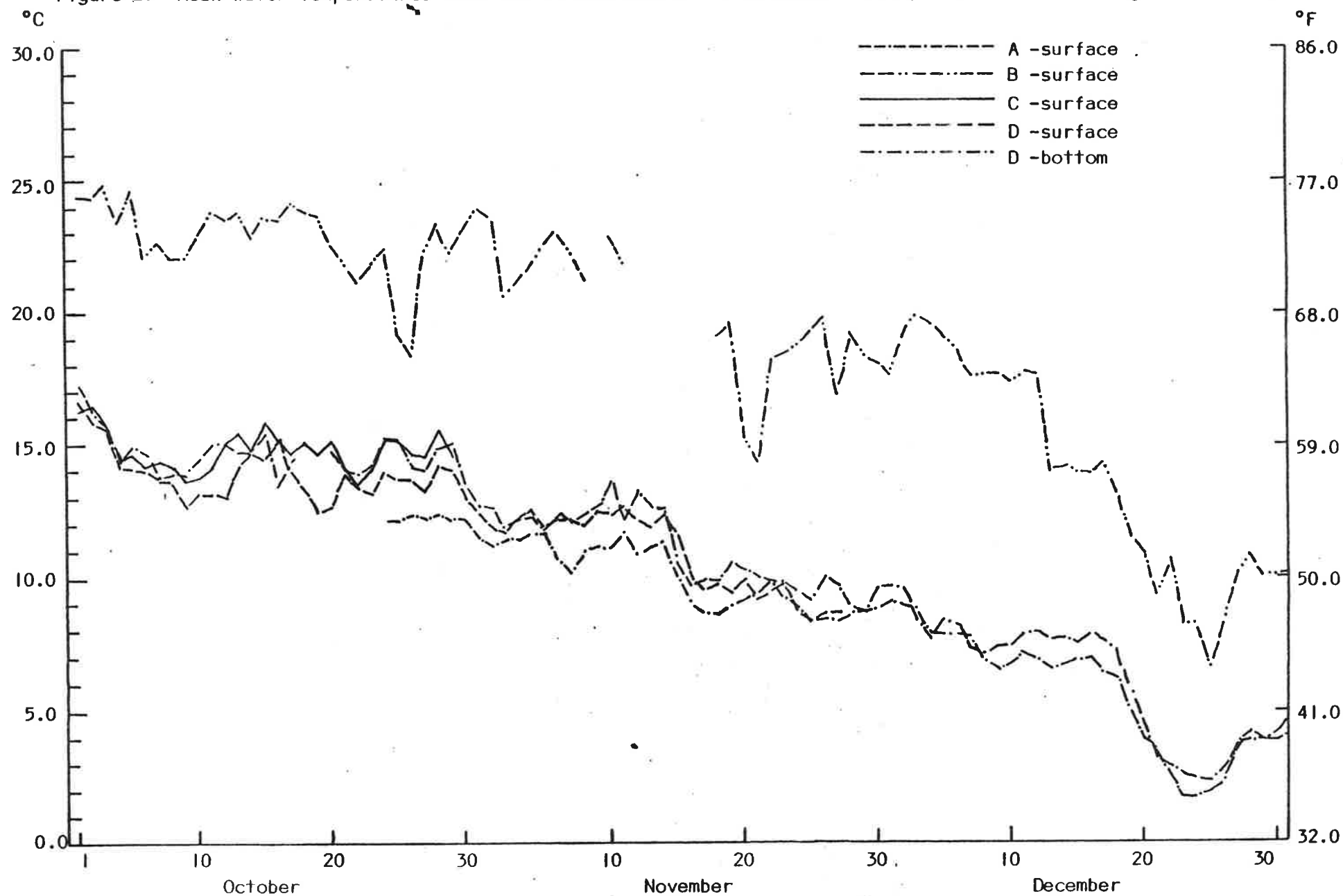
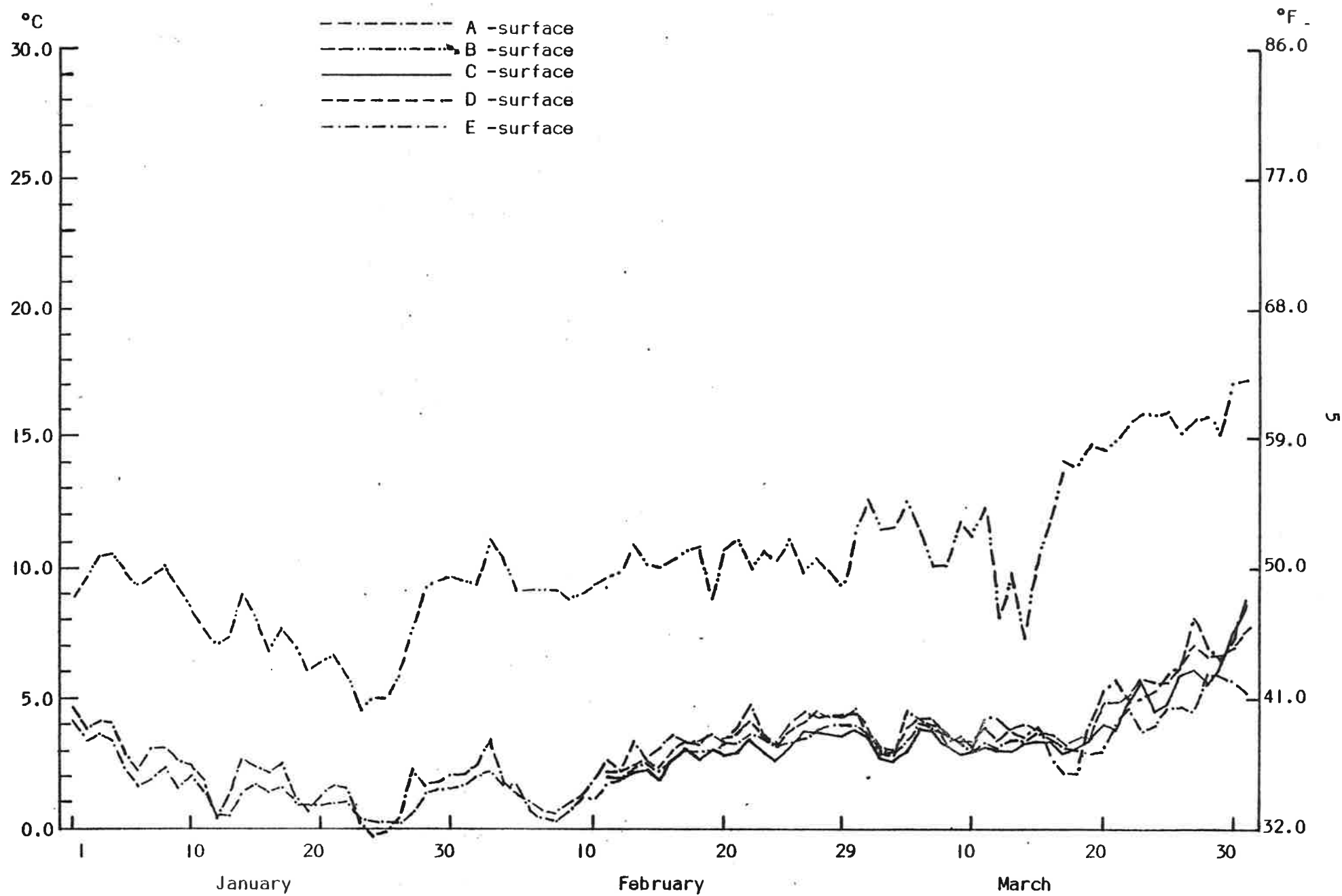


Figure 2. Continued



3.0 CHEMICAL INVESTIGATIONS

Weekly water quality monitoring continued at stations A - D (Figure 1). Ranges for the various parameters measured from October 1975 through March 1976 were as follows: water temperature, -1.0 - 24.0°C; salinity, 28.0 - 32.0 0/00; pH, 7.8 - 8.5; dissolved oxygen, 7.7 - 12.7 ppm; biochemical oxygen demand, 1.0 - 6.8 ppm; nitrite-N, <0.1 - 0.6 µg-atoms/l; nitrate-N, <0.1 - 12.1 µg-atoms/l; and phosphate-P, 0.2 - 1.9 µg-atoms/l (Table 1).

Nutrients reached maximum levels midway through the sampling period and then decreased. This also occurred during the same general period in 1974 - 1975 (Semi-Annual Report 1A). Dissolved oxygen concentrations, as expected, increased during the winter months. Salinity and pH remained relatively stable throughout the sampling period.

All water quality measurements met or exceeded the minimal standards necessary to maintain the marine organisms indigenous to Salem Harbor.

Table 1. Water quality data for Salem Harbor, October 1975 through March 1976.

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 µg-atoms/l
Station A													
10/6	002275	0900	low +3 1/2	90	S	17.0 13.5	30.0	8.3	8.9	5.0	<0.1	0.3	0.2
10/16	002279	0740	low +5	40	S	15.0 14.0	30.0	8.2	8.6	*	0.1	0.7	0.4
10/21	002286	0815	low +3	0	S	13.0 13.0	29.0	8.1	8.0	*	0.2	2.8	0.7
10/27	002293	0910	high +5 1/2	10	S	11.0 12.0	29.0	8.2	7.8	*	0.2	1.3	1.0
11/5	002298	0900	low +3	0	S	8.0 11.0	30.0	8.2	8.4	*	0.3	2.4	0.8
11/12	002302	0920	high +3 1/2	10	S	9.0 10.5	31.0	8.2	8.7	*	0.5	4.9	0.9
11/18	002311	0855	low +4 1/2	20	S	12.5 8.0	30.0	8.1	7.9	2.2	0.5	9.1	1.1
11/26	002326	0935	high +5	100	S	4.0 9.5	30.0	8.1	9.1	1.4	0.5	1.3	0.7
12/5	002322	0935	low +3 1/2	100	S	-1.0 7.5	30.0	8.4	9.6	3.0	0.5	5.7	0.9
12/11	002327	0910	high +4	0	S	3.0 7.5	30.0	7.9	9.0	2.9	0.5	8.0	0.9
12/15	002335	0855	high + 1/2	10	S	10.0 7.5	31.0	8.1			0.4	8.3	0.9
12/29	002343	1030	high +2 1/2	0	S	-3.0 3.0	30.0	8.3	10.4	1.3	0.3	10.0	1.2
1/6	002347	1000	low + 1/2	0	S	-6.0 2.0	31.0	8.1	10.9	3.3	0.5	10.3	1.3
1/13	002354	1115	high +2	80	S	-6.5 -1.0	30.0	8.1	11.3	3.3	0.3	10.8	1.3
1/21	002362	0945	low +1 1/2	10	S	-1.5 0.5	30.0	8.1	11.3	*	<0.1	10.6	1.1
1/28	002371	1040	high +2	rain	S	4.0 2.0	31.0	8.1	11.4	*	0.4	12.1	1.8
2/5	002372	1125	low +3	90	S	-7.0 1.0	30.0	8.1	11.7	5.0	0.2	10.0	1.3
2/9	002378	0945	high +4 1/2	10	S	-4.0 0.5	31.0	8.3	11.6	*	0.3	9.6	1.1
2/19	002389	1045	low +3	50	S	8.0 3.5	30.0	8.2	11.7	4.3	0.2	6.2	0.9
2/25	002393	0850	high +1 1/2	90	S	8.5 3.5	29.0	8.1	11.9	3.3	0.2	2.3	0.7
3/4	002404	1200	low +4 1/2	100	S	2.0 3.0	30.0	8.4	12.3	3.6	0.4	2.3	0.4
3/12	002408	1020	high +3		S	0.0 3.0	32.0	8.4	12.7	3.8	0.2	0.1	0.2
3/19	002409	1100	low +3 1/2	100	S	8.0 5.5	30.0	8.0	12.0	6.8	<0.1	1.6	0.3
3/22	002413	0915	high +5 1/2	10	S	2.0 4.0	30.0	8.3	11.8	4.1	0.1	0.3	0.3
3/29	002426	0845	low +4 1/2	0	S	6.5 6.0	31.0	8.3	11.1	3.8	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	O2 (ppm)	BOD (ppm)	NO2-N µg-atoms/l	NO3-N µg-atoms/l	PO4-P
						Station B							
10/6	002278	0930	low +4	20	S	17.0 16.0	30.0	8.5	8.3	3.7	0.1	0.8	0.4
10/16	002281	0810	low +5 1/2	40	S	19.0 24.0	29.0	8.1	8.2	*	0.1	0.7	0.7
10/21	002289	0850	low +3 1/2	10	S	14.0 23.5	28.0	8.1	7.7	*	0.4	2.0	0.7
10/27	002292	0905	high +5	10	S	10.0 22.0	29.0	8.2	7.9	*	0.3	1.7	0.6
11/5	002301	0940	low +4	0	S	9.0 20.0	30.0	8.2	7.9	*	0.5	2.8	0.8
11/12	002305	0950	high +4		S	10.5 22.0	30.0	8.1	8.4	*	0.6	5.0	1.0
11/18	002312	0900	low +4 1/2	20	S	10.0 17.5	30.0	8.0	7.7	1.5	0.6	9.3	1.2
11/26	002325	0925	high +5	100	S	6.0 17.0	29.0	8.1	8.7	1.8	0.5	1.7	0.8
12/5	002319	1000	low +3 1/2	100	S	-0.5 19.0	30.0	8.5	9.1	2.3	0.4	5.8	0.9
12/11	002330	0925	high +4	0	S	3.0 19.0	30.0	7.8	8.4	1.5	0.4	7.9	0.8
12/15	002338	0910	high + 1/2	10	S	9.5 15.5	31.0	8.1	8.8	2.6	0.4	8.2	0.9
12/29	002346	1100	high +3	0	S	-3.0 12.0	29.0	8.2	9.8	1.4	0.3	10.7	1.4
1/6	002348	1005	low +1	0	S	-7.0 9.0	30.0	8.2	10.2	2.7	0.3	10.3	1.3
1/13	002353	1110	high +2	90	S	-6.5 7.5	29.0	8.1	10.5	3.0	0.3	10.3	1.3
1/21	002361	0940	low +1 1/2	10	S	-2.5 9.5	30.0	8.1	10.3	*	<0.1	10.7	1.2
1/28	002370	1035	high +2	rain	S	5.0 9.0	28.0	8.0	10.6	*	0.4	10.1	1.5
2/5	002375	1140	low +3	80	S	-7.0 10.0	29.0	8.0	10.4	5.3	0.4	10.2	1.4
2/9	002379	0940	high +4 1/2	10	S	-4.0 9.0	30.0	8.3	10.8	*	0.3	10.0	1.2
2/19	002391	1115	low +3 1/2	70	S	7.0 9.0	30.0	8.2	10.5	2.0	0.3	6.0	1.0
2/25	002396	0910	high +1 1/2	80	S	6.5 11.0	28.0	8.1	10.8	2.9	0.3	2.3	0.8
3/4	002403	1155	low +4 1/2	100	S	3.0 13.0	30.0	8.2	10.6	2.5	0.4	1.3	0.6
3/12	002407	1015	high +3	0	S	0.0 8.5	30.0	8.3	12.0	3.8	<0.1	0.3	0.3
3/19	002412	1115	low +3 1/2	100	S	6.0 14.5	31.0	8.1	10.8	3.6	<0.1	1.1	0.4
3/22	002414	0925	high +5 1/2	10	S	-1.5 12.0	30.0	8.1	10.7	3.2	0.2	0.5	0.4
3/29	002429	0910	low +5	0	S	6.0 15.5	31.0	8.1	10.1	4.1	<0.1	0.2	0.5

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	NO ₃ -N	PO ₄ -P
												μg-atoms/l	
Station C													
10/6	002277	0915	low +4	40	S	17.0 14.0	30.0	8.3	9.1	3.1	<0.1	0.8	0.3
10/16		0800	low +5 1/2	40	S	14.0 15.0	30.0	8.2	8.3	*	<0.1	0.5	0.4
10/21	002288	0840	low +3	10	S	14.0 14.0	29.0	8.3	8.1	*	0.2	1.9	0.7
10/27	002291	0900	high +5	10	S	11.5 12.0	29.0	8.3	8.5	*	0.2	1.5	0.5
11/5	002300	0930	low +3 1/2	0	S	13.0 10.5	30.0	8.3	8.4	*	0.3	2.7	0.8
11/12	002304	0940	high +3 1/2	25	S	9.0 12.0	31.0	8.1	8.6	*	0.5	4.7	0.9
11/18	002313	0905	low +4 1/2	30	S	8.5 10.0	30.0	8.1	7.9	1.0	0.5	9.1	1.1
11/26	002324	0920	high +5	100	S	4.0 10.5	30.0	8.2	8.8	1.2	0.5	1.5	0.8
12/5	002320	0955	low +3 1/2	100	S	-1.0 11.0	30.0	8.4	9.4	2.3	0.5	5.6	0.9
12/11	002329	0920	high +4	0	S	3.0 8.5	30.0	8.0	8.9	3.0	0.5	7.6	0.9
12/15	002337	0905	high + 1/2	10	S	8.5 7.0	31.0	8.2	9.3	2.7	0.4	8.2	0.9
12/29	002345	1055	high +3	0	S	-3.0 3.0	29.0	8.3	10.5	1.3	0.3	11.3	1.3
1/6	002349	1015	low +1	0	S	-6.0 3.0	30.0	8.3	10.6	2.5	0.3	10.0	1.2
1/13	002352	1105	high +2		S	-6.5 -1.0	30.0	8.3	11.7	2.5	0.3	10.2	1.2
1/21	002360	0935	low +1 1/2	10	S	-3.0 2.5	30.0	8.3	11.1	*	<0.1	10.5	1.4
1/28	002369	1030	high +2	rain	S	4.0 3.0	29.0	8.1	11.2	*	0.3	11.6	1.7
2/5	002374	1135	low +3	80	S	-8.0 0.0	30.0	8.1	11.7	2.9	0.3	9.9	1.2
2/9	002377	0930	high +4	0	S	-3.0 0.5	30.0	8.3	11.8	*	0.3	9.5	1.1
2/19	002392	1100	low +3	60	S	7.0 3.5	29.0	8.4	11.4	3.5	0.2	6.1	0.8
2/25	002395	0905	high +1 1/2	90	S	8.0 3.5	28.0	8.3	12.5	3.2	<0.1	0.6	0.4
3/4	002402	1145	low +4 1/2	100	S	3.5 3.0	30.0	8.4	12.1	3.5	0.4	1.0	0.4
3/12	002406	1000	high +2 1/2	0	S	0.0 3.0	30.0	8.4	12.4	3.6	0.2	0.5	0.2
3/19	002411	1110	low +3 1/2	100	S	4.0 3.5	32.0	8.1	12.1	4.0	0.2	1.0	0.2
3/22	002415	0930	high +5 1/2	10	S	-1.0 4.0	30.0	8.2	11.6	3.6	0.1	0.2	0.2
3/29	002428	0900	low +5	0	S	4.0 6.0	31.0	8.2	10.9	4.3	<0.1	<0.1	0.3

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 µg-atoms/l
Station D													
10/6	002276	0910	low +4	80	S	17.0 13.0	30.0	8.4	9.4	4.4	<0.1	0.8	0.2
10/16	002280	0750	low +5	40	S	16.0 13.5	30.0	8.3	8.5	*	0.1	0.6	0.4
10/21	002287	0830	low +3	0	S	13.0 13.0	29.0	8.2	8.0	*	0.2	1.8	0.6
10/27	002290	0855	high +5	10	S	13.5 13.0	29.0	8.3	8.3	*	0.2	1.6	0.5
11/5	002299	0920	low +3 1/2	0	S	10.0 10.0	30.0	8.3	8.5	*	0.4	3.1	0.8
11/12	002303	0935	high +3 1/2	50	S	10.5 9.0	31.0	8.2	8.5	*	0.5	4.6	0.9
11/18	002314	0910	low +5	30	S	10.0 8.5	30.0	8.1	8.1	1.2	0.5	9.7	1.1
11/26	002323	0910	high +4 1/2	100	S	4.0 9.0	30.0	8.2	9.3	1.9	0.4	1.6	0.8
12/5	002321	0945	low +3 1/2	100	S	-2.5 7.5	32.0	8.4	9.7	1.9	0.4	5.6	0.9
12/11	002328	0915	high +4	0	S	3.0 7.0	30.0	8.1	9.1	2.9	0.5	8.4	0.8
12/15	002336	0900	high + 1/2	10	S	9.0 7.0	31.0	8.3	9.2	2.3	0.4	8.3	0.9
12/29	002344	1050	high +3	0	S	-4.5 3.0	30.0	8.3	10.4	2.3	0.3	10.0	1.2
1/6	002350	1020	low +1	0	S		30.0	8.3	10.9	1.6	0.3	10.3	1.3
1/13	002351	1100	high +2	90	S	-6.5 -1.0	30.0	8.3	11.3	3.3	0.3	11.0	1.4
1/21	002359	0930	low +1 1/2	10	S	-3.0 0.5	30.0	8.3	11.3	*	<0.1	10.4	1.3
1/28	002368	1025	high +2	rain	S	3.0 2.0	29.0	8.2	11.3	*	0.3	11.9	1.9
2/5	002373	1130	low +3	80	S	-8.0 0.0	30.0	8.2	11.7	3.8	0.3	11.9	1.3
2/9	002376	0925	high +4	10	S	-1.5 0.0	30.0	8.3	11.7	*	0.2	10.6	1.1
2/19	002392	1105	low +3 1/2	70	S	5.5 3.5	30.0	8.4	11.5	3.4	0.3	7.6	0.9
2/25	002394	0900	high +1 1/2	90	S	4.0 3.0	29.0	8.2	11.8	4.4	0.2	4.6	0.7
3/4	002401	1140	low +4 1/2	100	S	2.5 2.0	30.0	8.4	12.4	3.9	0.2	4.3	0.4
3/12	002405	0955	high +2 1/2	0	S	-1.0 2.0	30.0	8.3	12.3	3.3	0.1	0.2	0.2
3/19	002410	1105	low +3 1/2	100	S	4.0 3.5	31.0	8.1	12.1	4.8	0.1	0.7	0.2
3/22	002416	0935	high +5 1/2	10	S	-1.5 4.0	30.0	8.2	11.8	4.7	0.2	0.3	0.3
3/29	002427	0850	low +4 1/2	0	S	5.0 5.0	30.0	8.3	11.1	5.0	<0.1	0.1	0.5

*BOD incubator malfunction

4.0 BIOLOGICAL INVESTIGATIONS

4.1 Primary Production

The decline in the concentration of chlorophyll α noted at the end of the summer quarter of 1975 (Semi-Annual Report No. 2A) was succeeded by a slight peak at all stations in early October (Table 2 and Figure 3). This was followed by a general decline to minimal levels during the winter months. Station D, however, leveled off from mid-November to mid-December and then resumed its decline. A sharp peak was noted for all stations on February 25, 1976, with the exception of station A, which peaked on the following sampling date (March 22). Chlorophyll α peaked at approximately the same time last year and was generally of the same magnitude (Semi-Annual Report No. 1A).

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

Chlorophyll α	0.59 - 14.40 mg/m ³
b	0.00 - 1.61 mg/m ³
c	0.00 - 4.87 mg/m ³
Carotenoids	0.18 - 6.52 mg/m ³

During the fall quarter ¹⁴Carbon surface assimilation rates declined at all stations. Generally, minimal levels occurred in the winter months, however, a peak was noted on February 25 (Table 3). The magnitude of the peak at station A was low in comparison to the other stations (Figure 3). With the exception of station A, surface production rates peaked and declined on the same dates as chlorophyll α .

Mean assimilation rates for the fall and winter months were variable (Tables 4 and 5). In the fall, the lowest mean assimilation rates at 100% light intensity occurred at station B, the discharge canal (Figure 4). This had also been noted for the fall months of 1973 and 1974 (Progress Report No. 9 and Semi-Annual Report No. 1A).

During the winter quarter (January - March, 1976) mean assimilation rates generally exhibited the classic phenomenon of reduced uptake at the surface and increased uptake at 50% illumination (Figure 5). At station B the mean production rates at the 100% level increased relative to the fall months (Table 5). Station A had the lowest mean assimilation rates at all light intensities (Figure 5).

4.2 Adenosine Triphosphate (ATP)

Routine ATP samples were collected from five stations during the sampling period (Figure 1). ATP levels fluctuated greatly during the period,

Table 2. Chlorophyll counts (mg/m³) in Salem Harbor,
October 1975 - March 1976.

Date	Station	Chlorophyll <i>a</i>	Chlorophyll <i>b</i>	Chlorophyll <i>c</i>	Carotenoids
10/21	A	8.28	1.45	4.87	3.15
	B	7.00	1.61	3.83	2.70
	C	8.16	1.13	4.57	2.78
	D	7.85	0.92	4.13	2.75
11/12	A	4.90	0.46	2.56	2.05
	B	3.72	0.71	2.47	1.23
	C	3.64	0.55	1.69	1.60
	D	4.27	0.27	0.92	1.81
12/12	A	2.59	0.79	2.61	0.70
	B	2.45	0.53	1.36	0.57
	C	2.49	0.67	2.00	0.45
	D	4.54	0.27	0.91	0.41
1/6	A	1.09	0.21	0.44	0.42
	B	0.84	0.26	0.85	0.18
	C	0.85	0.22	0.00	0.19
	D	0.59	0.03	0.95	0.31
1/21	A	1.36	0.00	0.12	0.27
	B	1.11	0.06	0.43	0.52
	C	0.95	0.16	0.24	0.44
	D	1.12	0.03	0.00	0.91
2/9	A	1.87	0.26	1.50	0.62
	B	1.91	0.81	3.09	0.45
	C	1.89	0.49	2.33	0.46
	D	1.94	0.07	2.63	0.69
2/25	A	5.76	0.00	0.25	2.69
	B	13.98	0.00	2.67	6.22
	C	12.90	0.00	2.88	6.16
	D	14.40	0.00	3.51	6.52
3/22	A	7.18	0.00	1.96	3.50
	B	9.59	0.02	2.50	4.31
	C	9.73	0.08	3.13	4.63
	D	7.46	0.00	2.44	3.78

Figure 3. Chlorophyll a (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 1975 through March 1976.

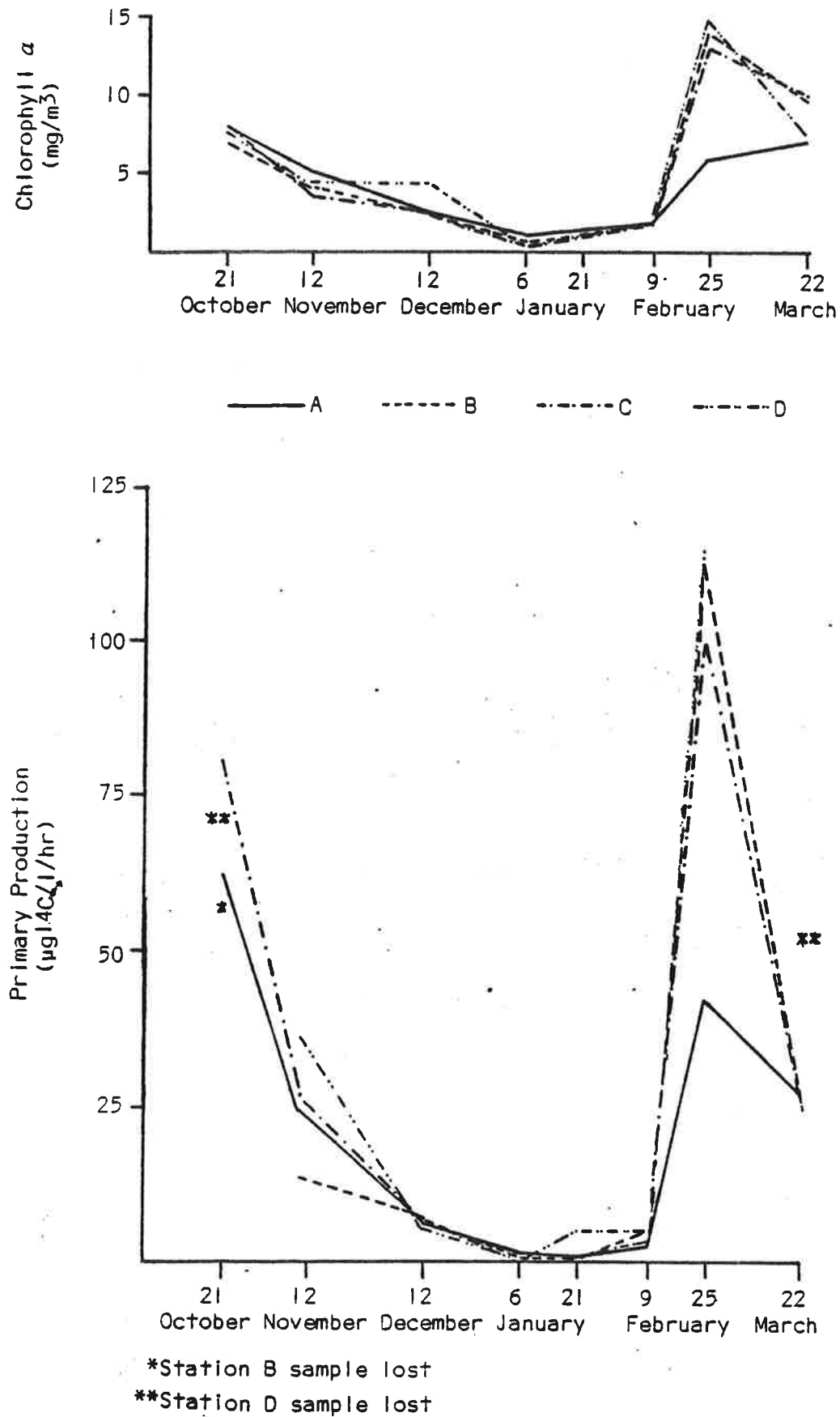


Table 3. Primary production (^{14}C) in Salem Harbor,
October 1975 - March 1976.

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature* °C	$\mu\text{g } ^{14}\text{C/L/hr}$
10/21	A	100	0	13.5	62.8
		50	3.5	13.5	58.4
		25	7.5	13.5	43.9
		10	12.0	13.5	23.9
		2	22.0	13.5	7.2
	B	100	0	22.0	lost
		50	3.5	20.0	60.2
		25	7.5	16.0	36.1
		10	12.0	13.0	36.4
		1	24.5	12.5	7.4
	C	100	0	13.5	80.4
		50	3.5	13.5	81.2
		25	7.5	13.5	66.6
		10	12.0	13.0	39.3
		1	24.5	12.5	lost
	D	100	0	13.5	lost
		50	3.5	13.5	lost
		25	7.5	13.5	69.3
		10	12.0	13.0	39.0
		1	24.5	12.5	8.5
11/12	A	100	0	13.0	23.5
		50	6.0		12.3
		25	12.0		8.5
	B	100	0	20.0	14.5
		50	6.0		18.9
		25	12.0		13.8
		10	20.0		6.7
		2	34.5		1.7
	C	100	0	12.0	27.0
		50	6.5		22.2
		25	13.0		17.6
	D	100	0	10.5	40.6
		50	6.0		46.3
		25	12.0		47.1
		10	20.0		18.5
		2	34.5		2.9

Table 3. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g }^{14}\text{C/L/hr}$
12/11	A	100	0	8.0	6.2
		50	3.5		8.9
		25	7.5		8.0
		10	12.0		4.1
		2	20.5		2.1
	B	100	0	17.5	7.1
		50	3.5		5.4
		25	6.5		7.9
		10	11.0		7.1
		1	21.5		2.8
	C	100	0	8.0	6.5
		50	4.5		6.7
		25	9.0		5.9
		10	15.0		2.3
	D	100	0	8.0	5.4
		50	4.0		5.5
		25	8.0		7.2
		10	13.5		4.4
		2	23.0		1.9
1/6	A	100	0	2.0	1.1
		50	6.5		0.6
		25	13.0		0.6
		10	21.5		<0.1
	B	100	0	11.0	0.4
		50	7.5		1.2
		25	16.5		1.0
		10	27.0		3.6
	C	100	0	3.0	1.0
		50	8.0		1.1
		25	16.0		0.9
	D	100	0	1.0	0.8
		50	8.0		lost
		25	16.0		1.7
		10	27.0		0.8

Table 3. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g } ^{14}\text{C/L/hr}$
1/21	A	100	0	1.0	0.8
		50	7.5		0.7
		25	14.5		0.9
		10	24.0		0.3
	B	100	0	9.5	0.6
		50	7.5		1.2
		25	14.5		1.2
		10	24.0		0.8
	C	100	0	1.0	1.4
		50	8.0		3.5
		25	15.0		3.3
	D	100	0	0.5	4.2
		50	7.5		0.9
		25	15.5		1.3
		10	25.5		2.3
2/9	A	100	0		3.3
		50	8.0		2.3
		25	16.5		4.2
	B	100	0		5.4
		50	7.5		5.5
		25	15.5		3.2
		10	25.5		3.4
	C	100	0		3.6
		50	8.0		5.6
		25	16.5		3.9
	D	100	0	0.0	4.8
		50	8.0		5.3
		25	16.5		5.2

Table 3. Continued

Date	Station	Light Intensity (%)	Depth (Feet)	Temperature °C	$\mu\text{g } ^{14}\text{C/L/hr}$
2/25	A	100	0	3.5	42.4
		50	6.0		41.0
		25	12.0		42.8
		10	20.5		17.6
	B	100	0	11.0	113.3
		50	5.5		135.1
		25	11.5		103.5
		10	19.0		43.4
		2	32.0		6.5
	C	100	0	3.5	99.1
		50	5.5		174.1
		25	10.5		116.5
		10	17.5		33.6
	D	100	0	3.0	115.7
		50	5.5		189.4
		25	11.5		158.2
		10	19.0		61.7
		2	32.0		15.0
3/22	A	100	0	5.0	28.1
		50	4.5		24.2
		25	9.0		35.1
		10	15.0		23.8
	B	100	0	14.0	25.6
		50	4.5		37.2
		25	9.0		40.5
		10	15.0		36.6
		1	30.0		11.2
	C	100	0	5.5	23.9
		50	4.5		55.9
		25	9.0		45.5
		10	15.0		28.4
	D	100	0	5.5	lost
		50	4.5		55.8
		25	9.0		65.0
		10	15.0		34.7
		2	25.0		3.6

*Beginning on November 12, 1975 only surface temperatures recorded.

Table 4. Mean primary production levels ($\mu\text{g}^{14}\text{C/L/hr}$) in Salem Harbor, October through December, 1975.

Relative light intensity (%)	Station							
	A		B		C		D	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
100	6-63	31	*7-14	10	6-80	38	*5-41	22
50	9-58	26	5-60	28	7-81	37	*6-46	26
25	8-44	20	8-36	19	6-67	30	7-69	41
10	*4-24	14	7-36	17	*2-39	20	4-39	20
≤ 2	*2-7	4	2-7	6	††	-	2-8	4

*2 samples only

††no samples

Table 5. Mean primary production levels ($\mu\text{g}^{14}\text{C/L/hr}$) in Salem Harbor, January through March, 1976.

Relative light intensity (%)	Station							
	A		B		C		D	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
100	0.8-42	15	0.4-113	29	1 -99	26	**0.8-116	31
50	0.6-41	14	1 -135	36	1 -174	48	**0.9-189	63
25	0.6-43	17	1 -104	30	0.9-116	34	1 -158	46
10	**0 -24	10	0.8-43	18	*28 -34	31	**0.8-62	25
≤ 2	††	-	†	11	††	-	*4 -15	9

*2 samples only

**4 samples only

†1 sample only

††no samples

Figure 4. Mean primary production levels ($\mu\text{g}^{14}\text{C}/\text{l}/\text{hr}$) at relative light intensities (%) in Salem Harbor, October - December, 1975.

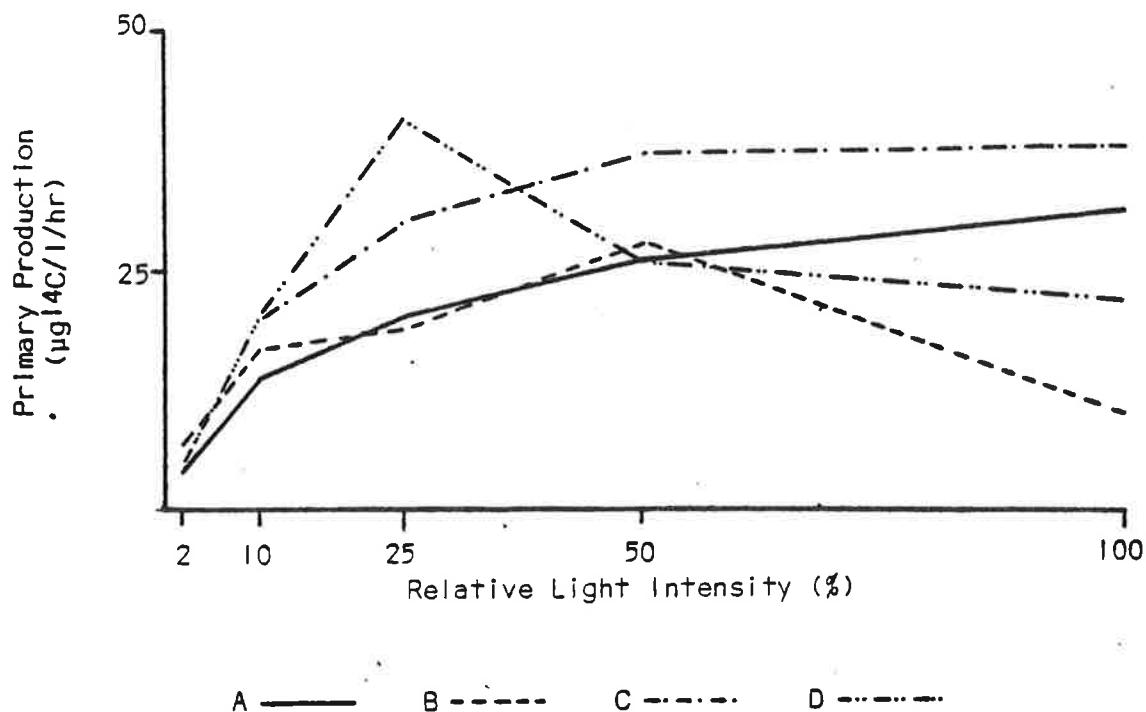
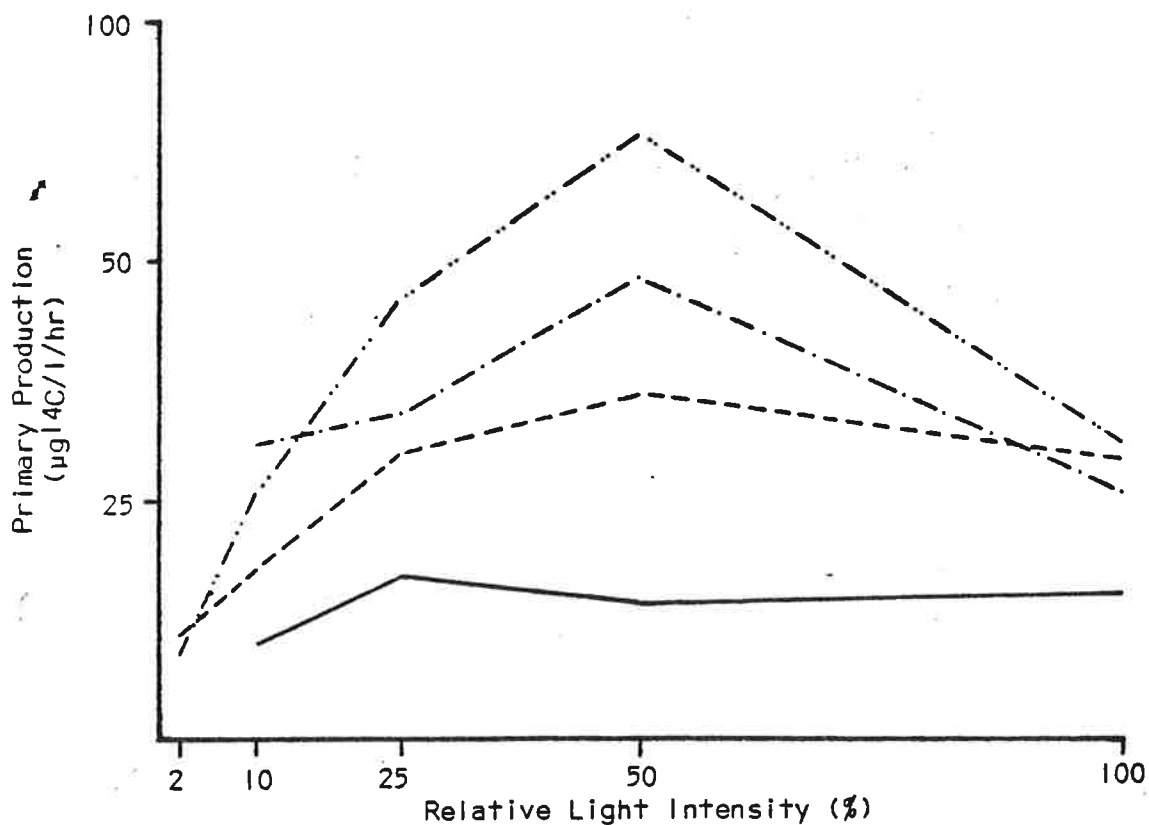


Figure 5. Mean primary production levels ($\mu\text{g}^{14}\text{C}/\text{l}/\text{hr}$) at relative light intensities (%) in Salem Harbor, January - March, 1976.



with the lowest levels occurring at all stations in January (Table 6).

Although ATP levels differed from station to station, a 'student's' t test of the mean ATP levels at all stations showed no statistically significant differences between any of the stations ($p = 0.05$). This indicates, as does past ATP data analysis, that there was no significant mortality of phytoplankton caused by passage through the plant's intake - condenser system.

4.3 Impingement Investigations

Random Sampling

Numbers of finfish sampled during random hours at the Units 3 and 4 sluiceways remained low (Table 7). A total of 79 individuals (16 species) were taken at both sluiceways; the threespine stickleback, *Gasterosteus aculeatus*, and winter flounder, *Pseudopleuronectes americanus*, comprised 46% of the total.

Unit 3, monitored for 72 hours, yielded 47 finfish (10 species). Unit 4 yielded 32 finfish (12 species) during 42 hours of sampling. Impingement rates for Units 3 and 4 were 0.7 fish/hr. and 0.8 fish/hr., respectively. Observed mortality, based on absence of opercula beats, was 19% at Unit 3 and 50% at Unit 4.

24-hr Investigations

Impingement investigations were conducted at the Units 3 and 4 sluiceways for 24 hrs on November 6 - 7, 1975 and on February 5 - 6, 1976. However, Unit 4 was not operating during the February study dates and therefore was not sampled.

Thirty-nine finfish (9 species) were taken on November 6 - 7 at the Unit 3 sluiceway and 64 finfish (13 species) at the Unit 4 sluiceway (Table 8). A total of 17 species were collected. Seven species comprised 84% of all finfish taken, namely red hake, *Urophycis chuss*; winter flounder; blueback herring, *Alosa aestivalis*; grubby, *Myoxocephalus aeneus*; rainbow smelt, *Osmerus mordax*; pollock, *Pollachius virens*; and windowpane, *Scophthalmus aquosus*. Impingement rates were 1.6 fish/hr (Unit 3) and 2.7 fish/hr (Unit 4). Mortality was 56% at the Unit 3 sluiceway and 72% at the Unit 4 sluiceway. As noted in previous progress reports, the greater incidence of mortality experienced at the Unit 4 sluiceway is attributed to an increase in physical stress.

At the Unit 3 sluiceway on February 5 - 6, 239 finfish (6 species) were taken (Table 9). Threespine stickleback comprised 76% of the total catch. Mortality was 7% and the impingement rate was 10.0 fish/hr.

A northern puffer, *Sphaeroides maculatus*, was taken during the 0600 - 0800 sampling interval on November 7. This species is uncommon north of Cape Cod

Table 6. Adenosine triphosphate (mgATP/L) levels in Salem Harbor, October 1975 through March 1976.

Station	10/21	1975				1976		
		11/12	12/11	1/6	1/21	2/9	2/25	3/22
1	710	390	310	260	210	410	200	750
2	470	340	220	260	210	350	790	1200
3	430	250	280	90	160	310	800	750
4	460	220	100	50	210	370	1320	1080
5	570	350	220	260	190	290	1440	990

Table 7. Total numbers of finfish taken in Units 3 and 4 sluiceways, October 1975 through March 1976.

Species	(EST)	10/3		10/6		10/10		10/16		10/20		10/28		10/29		11/4		11/5		11/17		Totals*
		0700	0900	0900		0700		1300		0700		1400		1000		1200		0800		1200		
		0900	1100	1100		0900		1500		0900		1600		1200		1400		1000		1400		
	Tidal Stage (Hrs)	L+5 1/2	H+1	L+4 1/2	H+5 1/2	H+5 1/2				L+3	L+4	H+5	L+1	L+4	H+1	H+3						
<u>Unit 3</u>																						
mummichog		1				1														†		2
blueback herring						2						1										3
Atlantic silverside						2				1		1			1							5 (3)
rainbow smelt						1						2				1						4 (3)
winter flounder										1				2								3
alewife										1												1 (1)
<u>Unit 4</u>																						
red hake						1																1
blueback herring														1		1						2 (2)
grubby														1								1
winter flounder														1		1						2
Atlantic menhaden																				5		5 (2)

Table 7. Continued

[illegible]

Table 7. Continued

Species	(EST)	1/16	1/23	1/26	1/30	2/3	2/16	2/20	2/24	3/1	3/5	3/18	3/26	3/26	Totals*							
		1200	1000	1000	1200	1200	1000	1000	1400	1200	1400	0800	1000	1400								
		1400	1200	1200	1400	1400	1200	1200	1600	1400	1600	1000	1200	1600								
Tidal Stage (Hrs)		H+3	L+1	H+4	1/2	H+2	1/2	H	L+5	1/2	L+2	1/2	L+2	H+1	1/2	H+1	1/2	L+2	1/2	H+3	L+	1/2
<u>Unit 3</u>																						
rainbow smelt		1																				1
threespine stickleback		1	2	6		1																10 (1)
<u>Unit 4</u>																						
		**	**	**		**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Atlantic silverside																		1				1 (1)
winter flounder																		2		8		10 (3)
windowpane																				1		1 (1)
threespine stickleback																						1 (1)
rainbow smelt																						

*Number of dead fish shown in parenthesis.

†Traps removed by Power Plant personnel.

**Unit shut down

Table 8. Total numbers of finfish taken in Units 3 and 4 sluiceways during a continuous 24-hr investigation, November 6 - 7, 1975.

Species	Time (EST)	November 6 (0800 EST) - November 7 (0800 EST)												Totals*
		0800 1000	1000 1200	1200 1400	1400 1600	1600 1800	1800 2000	2000 2200	2200 2400	2400 0200	0200 0400	0400 0600	0600 0800	
<u>Unit 3</u>														
blueback herring		1					3			1	1			8 (7)
winter flounder		1								1		1		3
unidentifiable		1												1 (1)
skate†					1									1 (1)
windowpane							3	1	1	1	1			7
threespine stickleback							1							1
red hake							1			1	3	2	1	8 (7)
grubby							1	2	2					5 (1)
rainbow smelt†										1		3		4 (4)
northern puffer													1	1 (1)
<u>Unit 4</u>														
winter flounder		3	1	3			2	1			1		2	13 (3)
cunner		2											1	3 (2)
grubby		1						1				1		3 (2)
red hake			1	5	2		1	1			1		9	20 (18)
blueback herring			1					4						5 (4)
lumpfish				1										1
rainbow smelt†				2						1			1	4 (4)
pollock				6								1		7 (7)
Atlantic silverside								1	1			1		3 (3)
northern pipefish									1					1
white hake										1				1 (1)
alewife										1			1	2 (2)
silver hake										1				1

*Number of dead fish shown in parenthesis.

†little or winter skate

Table 9. Total numbers of finfish taken in Units 3 and 4 sluiceways during a continuous 24-hr investigation, February 5 - 6, 1976.

Species	Time (EST)	February 5 (1000 EST) - February 6 (1000 EST)												Totals*
		1000 1200	1200 1400	1400 1600	1600 1800	1800 2000	2000 2200	2200 2400	2400 0200	0200 0400	0400 0600	0600 0800	0800 1000	
		<u>Unit 3</u>												
threespine stickleback				1			12	16	56	41	27	26	2	181 (9)
rainbow smelt					1	3	2			1	1	4	1	13 (3)
ninespine stickleback					5	15								20 (4)
winter flounder					1	10	2	1	1	1	1			17 (1)
grubby						2	1	3	1					7
fourspine stickleback								1						1
		<u>Unit 4</u>												
		(Unit shut down)												

*Number of dead fish shown in parenthesis.

(Bigelow and Schroeder, 1953) and is therefore considered as a rare occurrence for Salem Harbor.

Diurnal Patterns

During the 24-hour investigation conducted in November, 40% of the total catch was obtained during the period 1 1/2 hour after sunset to 1/2 hour before sunrise (12 hours).

A total of 198 finfish were taken during the period one hour after sunset to one hour before sunrise (12 hours) in February. This represents 83% of all finfish collected on this date. The threespine stickleback comprised 77% of the nocturnal catch.

Mortality

Certain finfish appear to be more susceptible to impingement induced mortality. For this reporting period those species most susceptible were pollock (100%); red hake (86%); Atlantic silverside, *Menidia menidia* (82%); blueback herring (74%); and rainbow smelt (59%). Those less susceptible to mortality included ninespine stickleback, *Pungitius pungitius* (20% mortality); grubby (19%); winter flounder (15%); threespine stickleback (5%); and windowpane (0%). The percent mortality for each species is presented in Table 10.

Table 10. Total numbers of finfish taken and percent mortality observed in Unit 3 and 4 sluiceways during random and 24-hour investigations October 1975 - March 1976.

Species	Unit 3	Unit 4	Unit 3 and 4
threespine stickleback	206 (5) [†]	1 (100)	207 (5)
winter flounder	23 (4)	25 (24)	48 (15)
rainbow smelt	22 (45)	7 (100)	29 (59)
red hake	8 (88)	21 (86)	29 (86)
ninespine stickleback	20 (20)		20 (20)
blueback herring	12 (67)	7 (86)	19 (74)
grubby	12 (8)	4 (50)	16 (19)
Atlantic silverside	5 (60)	6 (100)	11 (82)
windowpane	8 (0)	1 (0)	9 (0)
pollock		7 (100)	7 (100)
Atlantic menhaden		5 (40)	5 (40)
cunner		4 (50)	4 (50)
alewife	1 (100)	2 (100)	3 (100)
fourspine stickleback	2 (0)		2 (0)
mummichog	2 (0)		2 (0)
white hake	1 (0)	1 (100)	2 (50)
American eel		1 (100)	1 (100)
lumpfish		1 (0)	1 (0)
mackerel scad		1 (100)	1 (100)
northern pipefish		1 (0)	1 (0)
northern puffer	1 (100)		1 (100)
silver hake		1 (0)	1 (0)
skate*	1 (100)		1 (100)

[†]Percent mortality in parenthesis

*Not separated by species

5.0 APPENDIX ISAMPLING PROCEDURESSALINITY

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

HYDROGEN ION

Laboratory Analysis: Determined with a Beckman Model 3500 digital pH meter. Adjusted for salinity and temperature according to Strickland and Parsons (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.

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.*).

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.*).

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 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 bioluminescence system outlined by Strehler (1968).

¹⁴C

Field Collection: At depths determined by a 30 cm secchi disc (100, 50, 25, 10, 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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