

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

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January 1973

Progress Report No. 5
October - December, 1972

Division of Marine Fisheries
Department of Natural Resources
The Commonwealth of Massachusetts

Publication No. (6536) (55-80-1/73 C.R.)
Approved by Alfred C. Holland
State Purchasing Agent

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INTRODUCTION

The following is the fifth quarterly progress report of research performed by personnel of the Division of Marine Fisheries operating under contract DMF-2-72 with the New England Power Company. Included are data collected from 1 October through 31 December 1972.

To allow for more intensive investigations in the immediate area of the power plant, the geographic limits of our study were redefined to include the area west and south of a line drawn between Juniper and Fluen Points (Fig.1). The new boundary includes the area off Winter Island proposed as a discharge site for Unit 5. Stations 5 and 17 (Figs. 2 and 3) have been retained for sampling with the Peggybell; our sport fish survey will resume in the spring at the Salem Willows Public Pier; and Bowditch Ledge will continue as a release site for tagged lobsters. Incorporated into sampling routine was the addition of one bottom trawl; three mid-water trawl; and one gill net stations. Water quality analyses now include nitrites and phosphates.

At the request of the New England Power Company, an amended project proposal was drafted, including recommendations for further investigations in Salem Harbor through 1974.

Figure 1.

Study area boundary (redefined December 1, 1972).

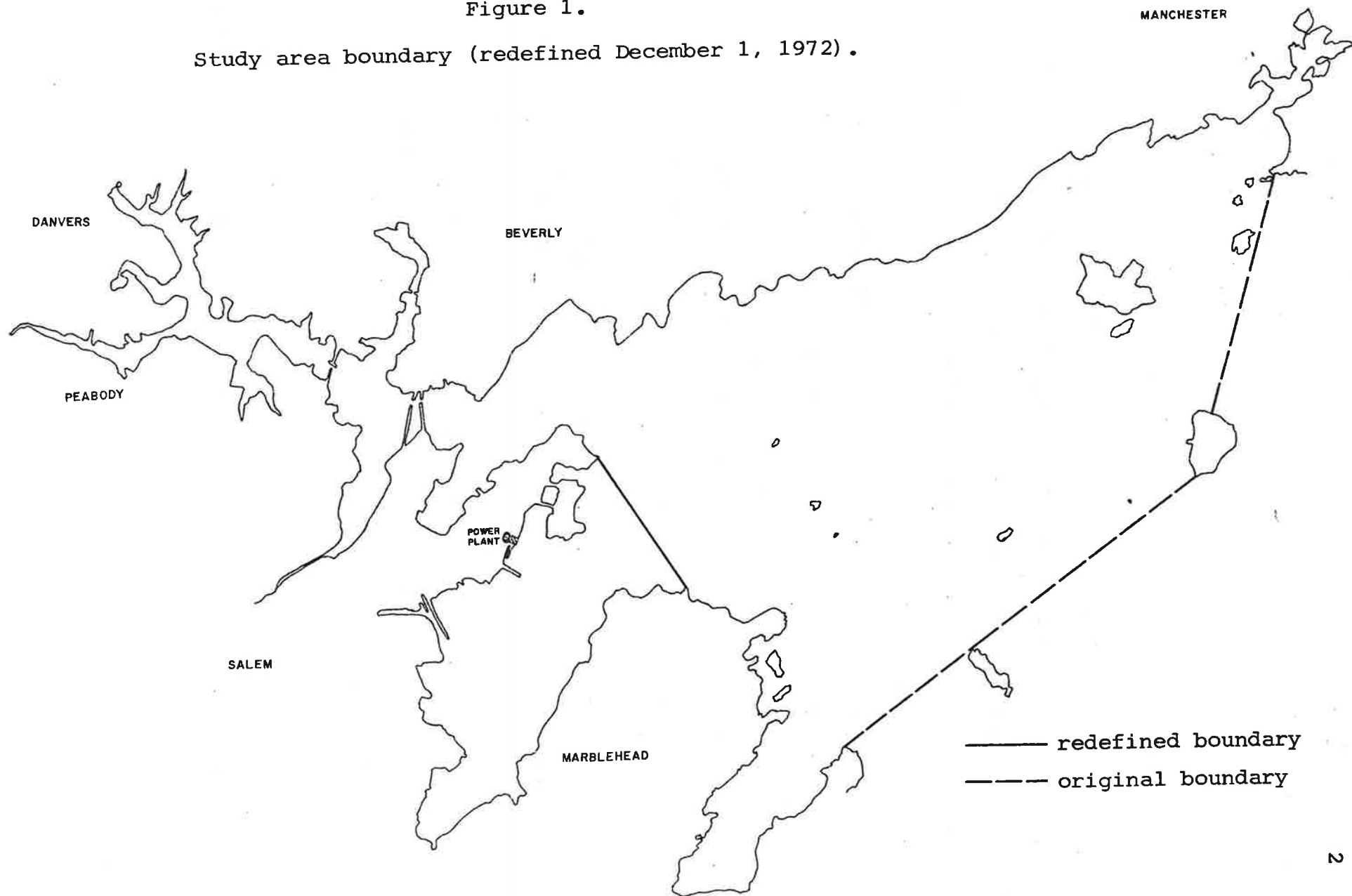


Figure 2.

Locations of water quality and finfish sampling stations outside Salem Harbor.

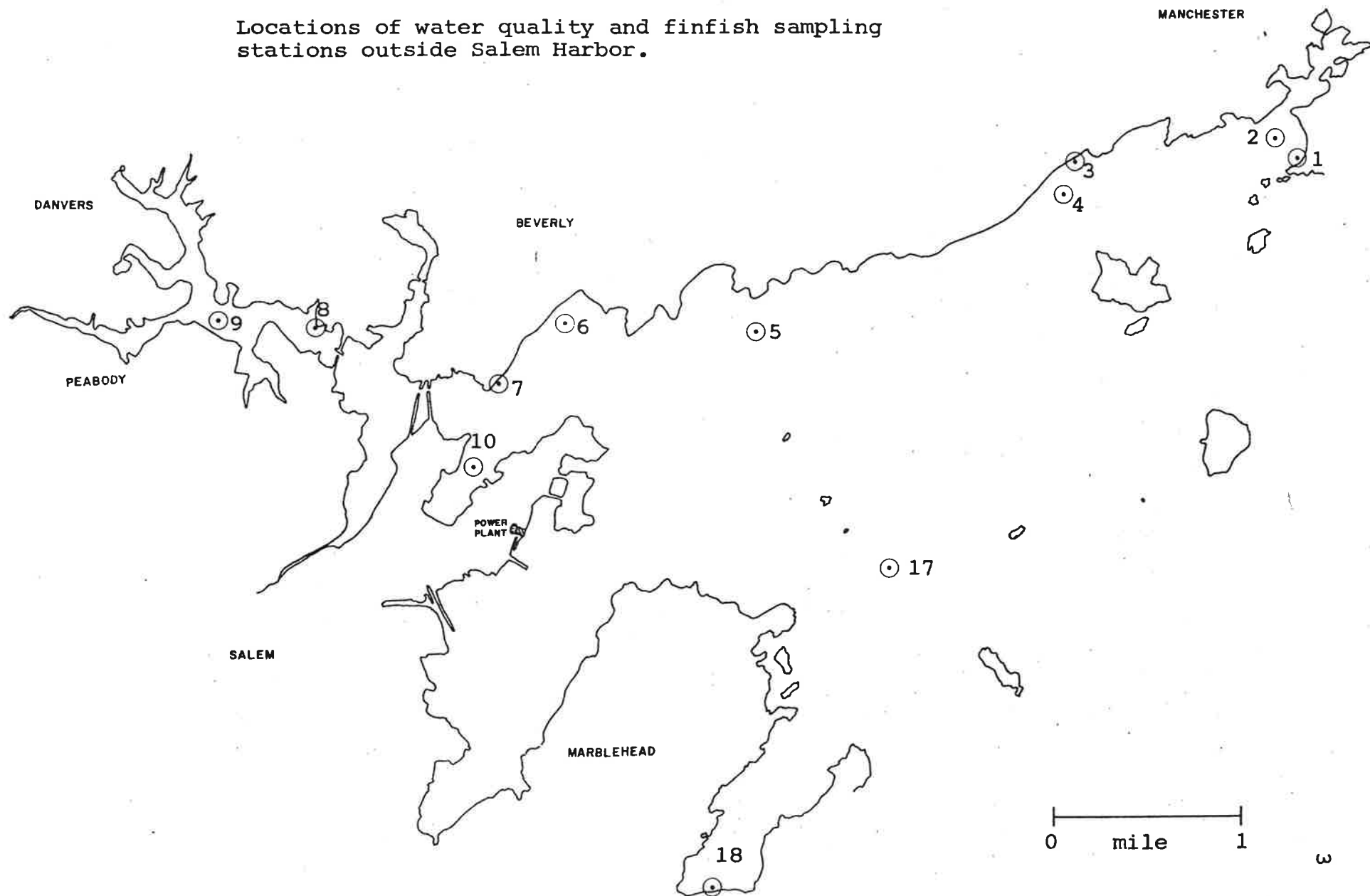
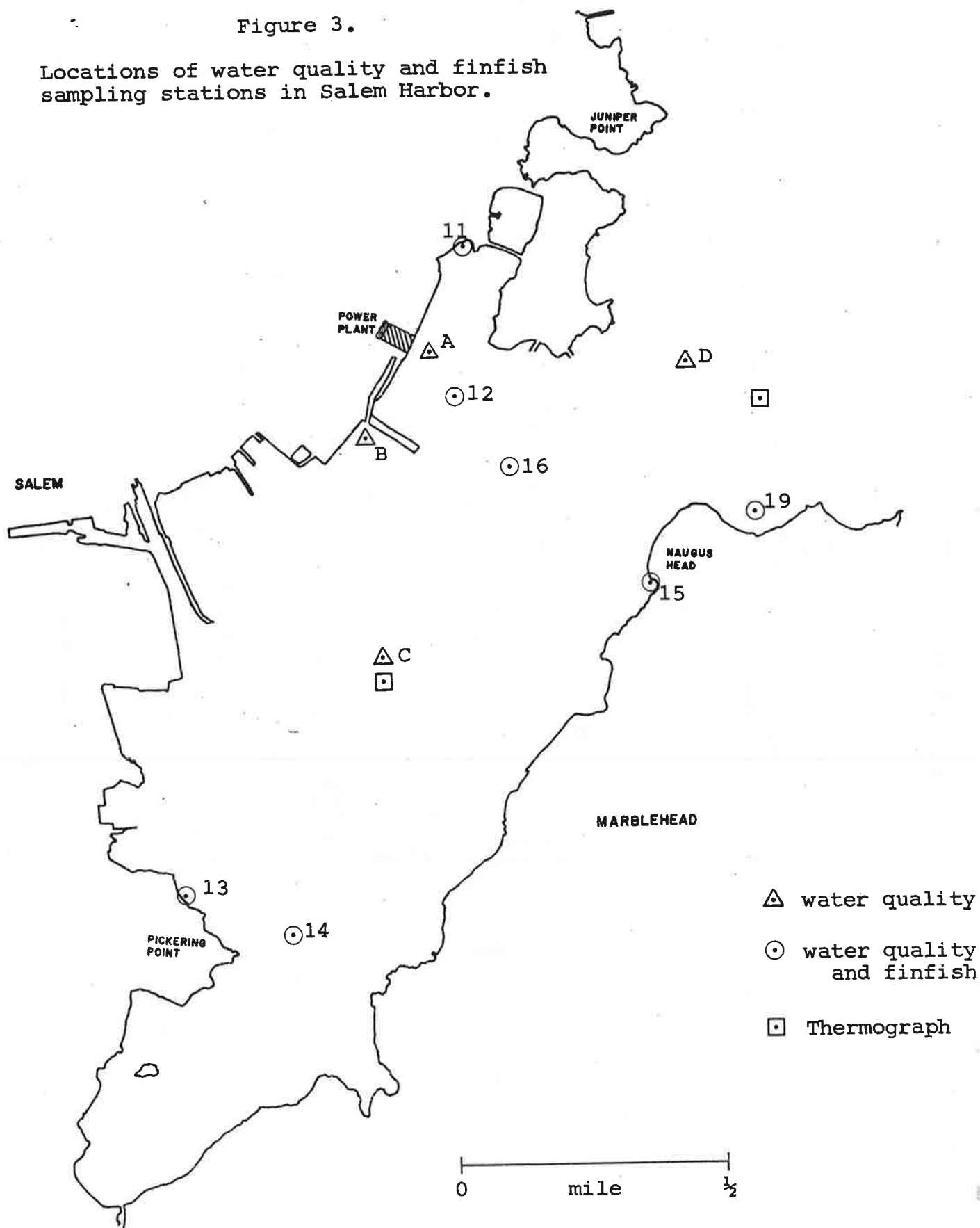


Figure 3.

Locations of water quality and finfish
sampling stations in Salem Harbor.



PERSONNEL

Mr. Barry Ketschke assumed the duties of Assistant Marine Fisheries Biologist on 26 November upon the termination of Mr. James Kinch.

PHYSICAL INVESTIGATIONSTemperature Monitoring

Horizontal and vertical temperature data was collected November 27 along three transects at predetermined distances from the plant discharge (Fig. 4). The transects marked the axes of the thermal plume as defined by infra-red telemetry (IRT) flights on October 7 and 8, 1971. Sampling was conducted with a W&T FA-190 bathythermograph (BT) at four tidal stages. Units 1 - 4 maintained an average combined output of 175 MW while circulating 421,300 gpm of cooling water. Discharge water temperatures ranged from 14.5 - 19.0°C. 709.2

Figure 5 displays isotherms along the three transects. At low tide thermal influence is experienced up to 900 ft from the plant discharge. Influence increases to 1200 ft during mid-flood and at high tide, then diminishes to 300 ft at the mid-ebb tidal stage.

Surface configurations of the discharge thermal plume were redefined by IRT on September 6, 1972 with Units 1 - 4 operating under full load.¹ Although different in outline, rapid heat dissipation in Salem Harbor remains evident. Future IRT flights are not deemed necessary at this time, however, horizontal and vertical temperature monitoring will

¹A survey report. Airborne thermal imagery of discharge plume dispersion - Salem Harbor Power Station. November 9, 1972. Coastal Research Corporation. Lincoln, Massachusetts.

Figure 4.

Locations of bathythermograph casts
in Salem Harbor, November 27, 1972.

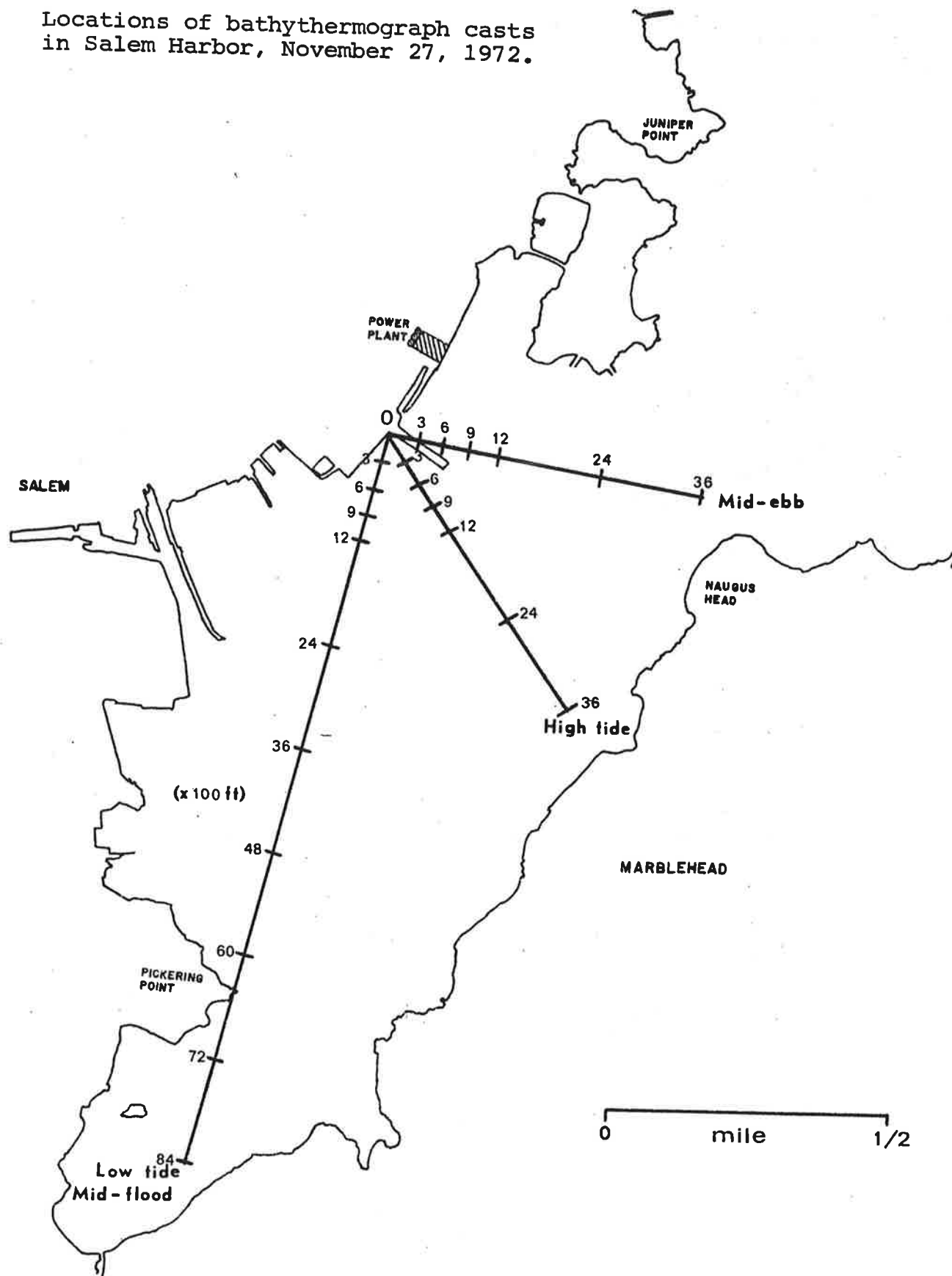
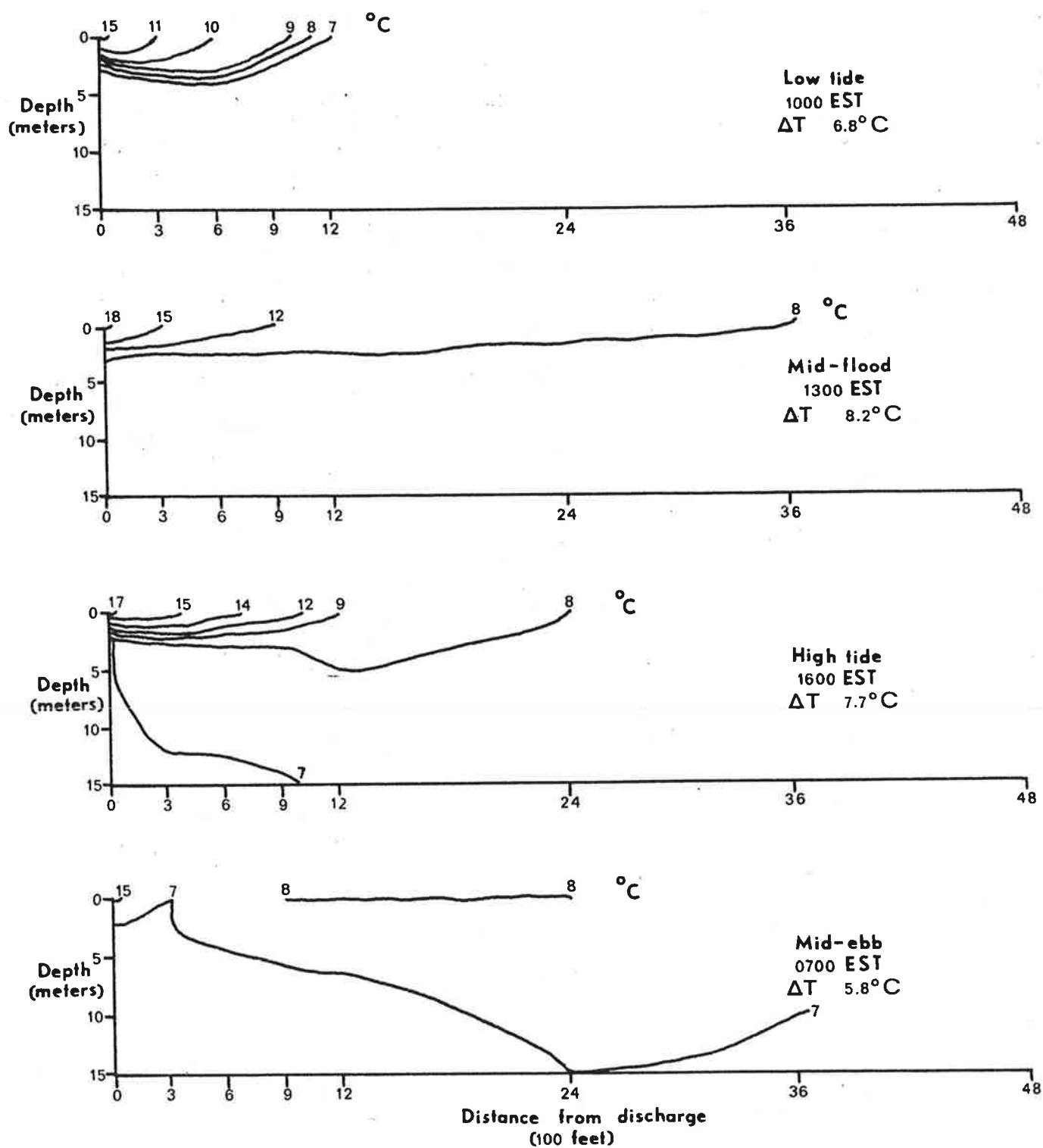


Figure 5.

Temperature isotherms ($^{\circ}\text{C}$) in Salem Harbor, November 27, 1972.



intensify to better define subsurface thermal influence.

The intake water column was isothermic on 11 November. Profiling along four parallel transects, located 10, 50, 100 and 300 ft east of unit intakes, indicated that water temperatures ranged from 8.0 to 10.5°C with a maximum variation of 1.5°C between surface and bottom. Average surface, mid-depth and bottom temperatures were 9.4, 9.4 and 9.3°C, respectively. A similar survey, conducted on 18 September, indicated temperature ranges of 15.1 to 19.6°C from surface to bottom, with a maximum change of 3.5°C.

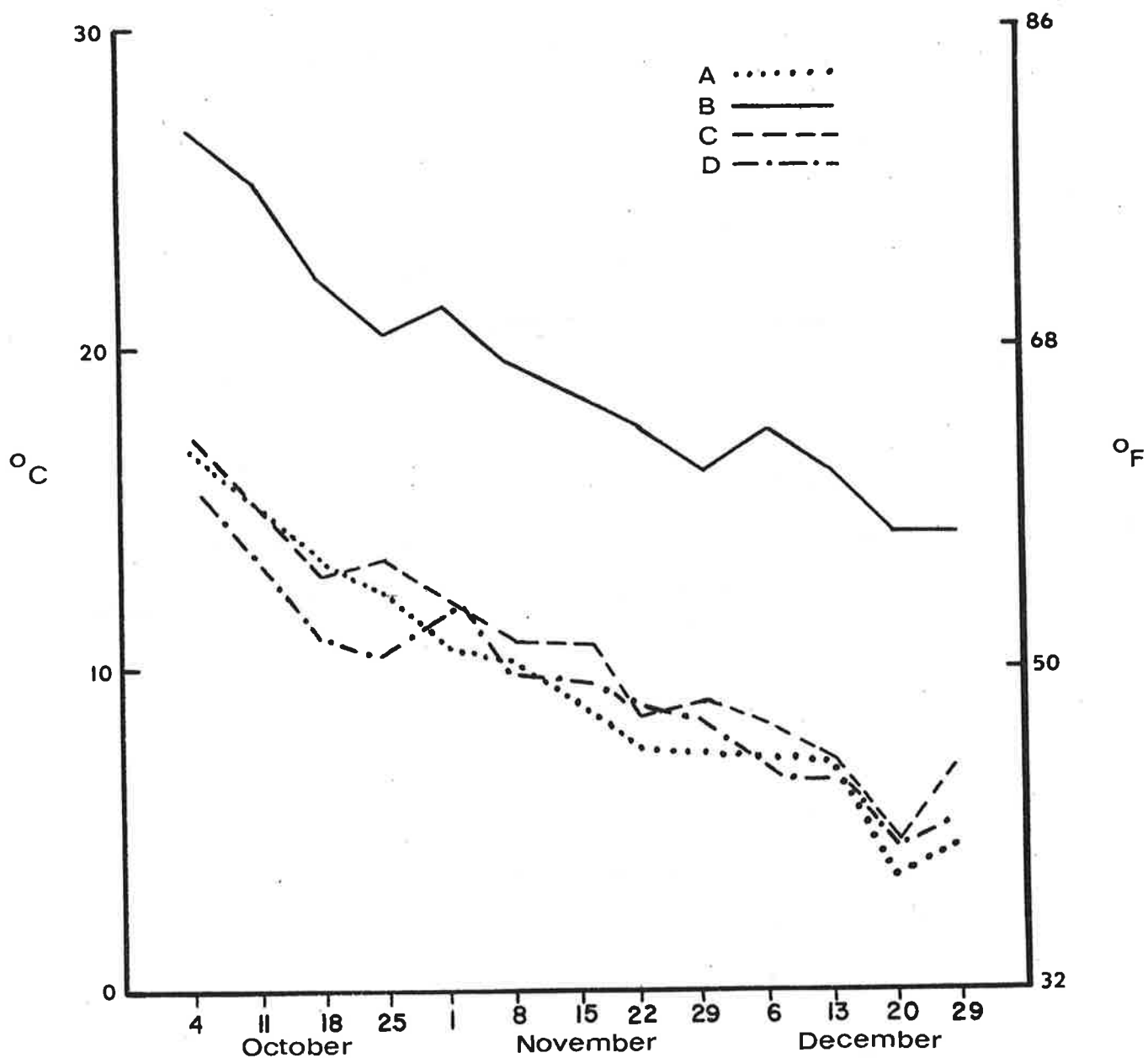
Until the intake water basin is dredged to a uniform depth, the most consistent and indicative intake temperatures can be recorded by placing a continuous monitoring probe 10 ft east and -8.0 ft MLW of the center line of the Unit 3 intake screens. Readings at this location will negate temperature differentials currently observed at the eight water intake boxes and provide consistent ambient recordings.

Continuous recording thermographs were installed near Stations C and D from 16 November to 19 December and reinstalled on 20 December. Data is again incomplete due to instrument malfunctions. Readings of 5°C and less at Station C were obscured on the recording film. Inaccurate synchronization of the camera shutter and flash produced illegible recordings at Station D. Both instruments will be returned to their manufacturer for abatement and an alternate means of temperature collection will be employed.

Average daily temperatures, approximately 3 ft below the surface, ranged from 5 to 17°C at Station C and from 5 to 15°C at Station D. Water temperatures recorded at Stations A through D are plotted in Figure 6. Average surface water temperatures for the quarter declined 8° to 10°C.

Figure 6.

Surface water temperatures recorded at stations A - D
in Salem Harbor, October - December, 1972.



CHEMICAL INVESTIGATIONS

Water Quality

Water quality at Stations 1 - 18 (Figures 2 and 3) exhibited the following ranges: surface water temperature, 4.0 - 17.5°C; surface salinity, 25.0 - 31.0 ‰; pH, 8.0; carbon dioxide, 5.0 - 10.0 ppm; and dissolved oxygen, 7.6 - 9.7 ppm (Table 1).

Ranges for parameters sampled at Stations A - D were: surface water temperature, 4.5 - 22.5°C; surface salinity, 29.1 - 32.5 ‰; pH, 8.0 - 8.5; carbon dioxide, 5.0 - 10.0 ppm; dissolved oxygen, 7.6 - 12.5 ppm; biological oxygen demand, 0.8 - 4.0 ppm; nitrite, 19.7 - 131.2 ppb; and phosphate, 703.8 - 3,213.0 ppb (Table 2).

Heavy Metal Analyses

Copper concentrations in soft shell clams, Mya arenaria, varied from 3.3 - 7.0 ppm; and in northern lobsters, Homarus americanus, ranged from 4.7 - 57.1 ppm (Table 3). Sediment, winter flounder, Pseudopleuronectes americanus, and soft shell clam samples are collected quarterly and analyzed at the Massachusetts Department of Public Health's Lawrence Experiment Station for concentrations of other metals. Results from August 17 are presented in Table 4.

Table 1. Water quality data for Beverly - Salem Harbor, October - December, 1972.

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	WIND DIR/VEL (MPH)	CLOUD COVER (%)	DEPTH	TEMP °C AIR WATER	SALINITY (0/00)	pH	CO ₂ (ppm)	O ₂ (ppm)
<u>Station 1</u>											
10/6	000589	1200	high +2	0	30	S	18.0 15.5	29.5	8.0	5.0	9.0
11/6	000628	1025	low +5½	0	40	S	8.5 9.5	27.5	8.0	10.0	8.4
<u>Station 2</u>											
10/20	000609	0925	high + ½		10	S	2.0 9.0		8.0	5.0	8.7
11/7	000635	1200	high + ½		40	S	9.5 10.0	28.0	8.0	5.0	9.7
<u>Station 3</u>											
10/6	000588	1115	high +1	0	40	S	16.0 17.0	29.5	8.0	5.0	8.3
10/11	000598	1115	low +4		0	S	11.5 14.0	31.0	8.0	10.0	8.6
11/6	000629	0940	low +5½		50	S	9.0 10.0	30.0	8.0	5.0	9.4
11/17	000646	1100	high +3½	0	50	S	4.0 6.5	30.0	8.0	10.0	9.6
<u>Station 4</u>											
10/20	000610	1010	high +1½		10	S	3.0 11.0	29.0	8.0	5.0	7.8
11/7	000636	1230	high +1		50	S	10.0 9.5	29.0	8.0	5.0	8.3
<u>Station 5</u>											
10/24	000613	0825	low +3		50	S	15.0 10.5	29.5	8.0	10.0	8.2
11/21	000651	0900	low +4½	W/15	0	S	2.5 7.0	30.0	8.0	5.0	9.5
12/11	000774	0930	low +1	SW/12	10	S	0.0 6.0	30.0	8.0	10.0	
<u>Station 6</u>											
10/20	000611	1040	high +2			S	2.0 10.0	29.0	8.0	5.0	8.1
11/7	000638	1305	high +1½		60	S	8.5 9.5	28.0	8.0	5.0	8.2

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	WIND DIR/VEL (MPH)	CLOUD COVER (%)	DEPTH	TEMP °C		SALINITY (0/00)	pH	CO ₂ (ppm)	O ₂ (ppm)
							AIR	WATER				
Station 7												
10/6	000590	1255	high +2½		50	S	16.5	17.0	29.5	8.0	5.0	9.0
11/6	000627	1100	high + ½			S	10.5	9.5	29.0	8.0	5.0	9.0
Station 8												
10/6	000587	1030	high	0	50	S	19.0	17.5	28.5	8.0	5.0	8.3
10/11	000599	1215	low +5			S	11.5	13.0	30.5	8.0	5.0	8.4
11/6	000626	1115	high + ½		60	S	9.0	9.5	28.5	8.0	5.0	8.6
11/17	000645	0930	high +2	0	90	S	0.0	6.5	27.0	8.0	10.0	8.6
Station 9												
10/20	000612	1140	high +3		0	S	1.5	8.5	28.0	8.0	5.0	8.1
11/7	000637	1415	high +2½			S	9.5	9.0	27.0	8.0	5.0	8.4
Station 10												
10/20	000608	0840	high		10	S	1.0	8.5	29.5	8.0	10.0	7.9
11/7	000634	1115	low		20	S	8.0	9.5	29.0	8.0	5.0	8.1
Station 11												
10/10	000591	1120	low +5	0	0	S	13.0	14.5	30.0	8.0	5.0	8.1
10/11	000601	1345	high + ½			S	12.5	16.0	30.5	8.0	5.0	8.9
11/6	000630	0915	low +5			S	8.0	11.0	29.0	8.0	5.0	7.6
11/17	000643	0710	high	0	100	S	0.0	8.5	29.5	8.0	5.0	8.4
12/4	000760	0915	low +5½	0	100	S	4.5	6.5	30.5	8.0	10.0	
12/5	000763	0930	low +5	0	100	S	0.0	6.0	30.0	8.0	10.0	

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	WIND DIR/VEL (MPH)	CLOUD COVER (%)	DEPTH	TEMP °C AIR WATER	SALINITY (0/00)	pH	CO ₂ (ppm)	O ₂ (ppm)
<u>Station 12</u>											
10/20	000607	0800	high			10	2.0 11.0	29.0	8.0	5.0	8.1
11/7	000633	1040	low +5	0		10	8.0 11.0	28.5	8.0	5.0	7.6
12/8	000767	1330	high +1	SE/10	100	S	4.5 7.0	29.0	8.0	5.0	
<u>Station 13</u>											
11/17	000644	0820	high +1	0	100	S	3.0 8.5	29.5	8.0	5.0	8.5
12/4	000762	1140	high +1½	N/11	100	S	0.0 6.0	29.5	8.0	5.0	
12/5	000765	1045	high	NW/11	100	S	-1.5 6.5	27.5	8.0	10.0	
<u>Station 14</u>											
10/20	000606	0715	low +5		10	S	1.5 11.0	30.0	8.0	5.0	7.8
11/7	000632	0950	low +4		0	S	8.0 12.0	28.5	8.0	5.0	8.4
12/8	000768	1400	high +1½	SE/11	100	S	5.0 4.0	29.0	8.0	5.0	
<u>Station 15</u>											
10/10	000592	1240	high + ½	0	0	S	9.0 15.0	30.0	8.0	10.0	8.1
11/6	000624	1230	high +1	0	70	S	11.0 12.5	28.5	8.0	5.0	8.4
12/4	000761	1030	high + ½	0	100	S	3.5 6.0	27.5	8.0	10.0	
12/5	000764	1020	high	0	100	S	0.0 5.5	27.5	8.0	5.0	
<u>Station 16</u>											
10/24	000614	1140	high	0	70	S	15.0 15.0	28.5	8.0	5.0	7.9
11/21	000652	1220	high +1½	W/16	0	S	0.5 8.0	29.5	8.0	10.0	8.0
12/11	000775	1200	low +3½	0	30	S	1.0 7.0	30.0	8.0	10.0	

Table 1. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	WIND DIR/VEL (MPH)	CLOUD COVER (%)	DEPTH	TEMP °C		SALINITY (0/00)	pH	CO2 (ppm)	O2 (ppm)
							AIR	WATER				
Station 17												
10/24	000615	1310	high +1½	0	50	S	15.0	11.5	29.0	8.0	5.0	9.0
11/21	000653	1340	high +3	W/16	0	S	3.0	8.0	30.0	8.0	5.0	9.2
12/11	000776	1325	low +5	E/14	50	S	0.0	6.0	30.5	8.0	10.0	
Station 18												
10/6	000585	0930	low +5½	0	0	S	15.5	15.0	27.5	8.0	10.0	6.7
11/6	000631	1320	high +2		60	S	7.5	9.5	25.0	8.0	10.0	8.8

Table 2. Water quality data for Salem Harbor, October - December, 1972.

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	WIND DIR/VEL (MPH)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	CO ₂ (ppm)	O ₂ (ppm)	BOD (ppm)	NO ₂ ⁻ (ppb)	PO ₄ ⁼ (ppb)
Station A														
10/5	000584	1010	high + ½	0	40	S	18.5 17.0	30.1	8.0	5.0	8.6	~~2.3~~ *		
10/13	000594	1145	low +3		60	S	8.5 14.0	31.0	8.0	5.0	8.0	0.8		
10/18	000605	0920	high +2		0	S	5.0 11.0	32.5	8.0	5.0	8.3	2.0		
10/25	000616	1230	high	0	100	S	11.0 12.0	31.4	8.0	10.0	7.6	1.2		
11/2	000622	1015	high +2			S	10.5 12.0	30.7	8.0	5.0	7.9	1.7		
11/8	000639	0940	low +3½		100	S	9.5 11.0	30.8	8.0	5.0	8.0	2.0		
11/17	000752	1255	high +5½	N/6	90	S	2.0 9.0	31.2	8.0	10.0	10.0	3.4		
11/20	000647	1235	high +2	0	90	S	10.5 9.0	30.9	8.0	10.0	9.2	1.8		
11/28	000756	0840	high +3½	S/5	100	S	8.5 8.5	31.0	8.0	5.0	9.1	1.9	88.6	703.8
12/7	000772	1015	low +4½	NW/7	0	S	0.5 7.5	31.1	8.0	10.0	9.2	1.6	42.6	1,560.6
12/15	000779	1025	high +4½	N/15	100	S	0.5 6.5	30.6	8.5	10.0	9.4	2.7	55.8	1,009.8
12/20	000784	1255	high +2½	N/12	100	S	2.0 4.5	30.6	8.5	10.0	12.5	4.0	95.1	2,050.2
12/26	000788	1350	low +4	0	100	S	3.5 5.5	31.1	8.5	10.0	10.0	2.6	19.7	2,845.8
Station B														
10/5	000581	0910	high	0	40	S	27.0 19.0	31.4	8.0	5.0	7.9	~~1.7~~ *		
10/13	000597	1225	low +4		60	S	10.5 22.5	31.3	8.0	5.0	7.7	1.1		
10/18	000602	0825	high +1½		0	S	4.0 22.5	30.6	8.0	5.0	8.5	2.1		
10/25	000617	1240	high	0	100	S	11.0 20.5	31.8	8.0	5.0	7.7	1.3		
11/2	000620	0950	high +1½		100	S	10.5 21.5	30.6	8.0	5.0	7.7	2.0		
11/8	000640	0950	low +4		100	S	9.5 20.0	30.8	8.0	5.0	7.9	1.4		
11/17	000755	1350	low + ½	0	100	S	4.0 19.0	31.3	8.0	5.0	8.6	1.6		
11/20	000648	1230	high +2	SW/8	100	S	8.0 14.5	30.8	8.0	10.0	8.9	1.4		
11/28	000757	1010	high +5	SE/7	100	S	9.0 18.0	31.1	8.0	5.0	8.5	1.8	82.0	979.2
12/7	000778	1120	low +5½	NW/5	0	S	0.0 11.0	30.6	8.0	5.0	9.3	2.2	45.9	1,591.2
12/15	000782	1100	low +5	NE/7	100	S	1.0 17.0	30.7	8.5	5.0	9.0	1.2	52.5	856.8
12/20	000785	1240	high +2	NW/6	100	S	2.5 15.0	30.5	8.5	10.0	9.7	1.7	131.2	2,295.0
12/26	000789	1330	low +4	0	90	S	4.0 15.5	30.9	8.5	5.0	9.5	2.4	23.0	2,845.8

Table 2. Continued

DATE	SAMPLE NUMBER	TIME (EST)	TIDAL STAGE (HOURS)	WIND DIR/VEL (MPH)	CLOUD COVER (%)	DEPTH (FEET)	TEMP °C AIR WATER	SALINITY (0/00)	pH	CO ₂ (ppm)	O ₂ (ppm)	BOD (ppm)	NO ₂ ⁼ (ppb)	PO ₄ ⁼ (ppb)
Station C														
10/5	000582	0935	high		60	S	16.5 17.0	30.1	8.0	5.0	8.6	1.9*		
10/13	000596	1210	low +3½		60	S	9.5 14.5	30.7	8.0	5.0	8.0	1.7		
10/18	000603	0840	high +1½		0	S	4.5 13.0	31.3	8.0	5.0	8.4	1.8		
10/25	000618	1245	high		100	S	10.0 13.5	31.5	8.0	5.0	7.9	1.6		
11/2	000621	1040	high +2½			S	9.5 12.0	30.6	8.0	5.0	7.9	1.6		
11/8	000641	1000	low +4		100	S	9.5 10.5	30.6	8.0	5.0	7.8	2.6		
11/17	000754	1330	low	N/8	100	S	4.0 8.5	29.1	8.0	5.0	8.8	1.7		
11/20	000649	1215	high +1½	SW/14	100	S	8.0 9.0	30.4	8.0	10.0	9.1	1.6		
11/28	000758	0940	high +4½	SE/7	100	S	8.5 8.0	31.0	8.0	5.0	8.7	1.7	111.5	979.2
12/7	000771	1055	low +5	NW/17	0	S	0.0 7.5	30.8	8.0	5.0	9.0	1.7	55.8	1,652.4
12/15	000781	1025	high +4½	NE/15	100	S	0.5 8.0	30.5	8.5	10.0	9.2	1.2	59.0	1,009.8
12/20	000786	1230	high +2	N/16	100	S	2.5 4.5	31.4	8.5	10.0	9.8	1.5	121.4	2,172.6
12/26	000790	1440	low +5	0	100	S	3.0 7.0	31.1	8.5	5.0	9.5	2.1	26.2	2,845.8
Station D														
10/5	000583	0955	high	0		S	17.5 15.5	30.1	8.0	10.0	8.7	2.1*		
10/13	000595	1200	low +3		60	S	9.0 13.0	31.3	8.0	5.0	8.0	1.7		
10/18	000604	0900	high +2		0	S	5.0 11.0	32.2	8.0	5.0	8.7	1.9		
10/25	000619	1305	high		100	S	9.5 10.5	31.2	8.0	5.0	8.1	2.5		
11/2	000623	1025	high +2			S	9.0 12.0	30.6	8.0	5.0	8.0	1.6		
11/8	000642	1010	low +4		100	S	8.5 10.0	31.0	8.0	5.0	8.0	1.9		
11/17	000753	1315	low	N/5	100	S	2.0 9.5	30.9	8.0	5.0	9.2	1.9		
11/20	000650	1205	high +1½	SW/13	100	S	9.5 9.0	30.9	8.0	10.0	8.6	1.3		
11/28	000759	0910	high +4	SE/5	100	S	8.0 8.5	31.1	8.0	10.0	9.3	2.3	95.1	887.4
12/7	000773	1005	low +4½	NW/15	0	S	-1.0 6.5	30.6	8.0	5.0	9.5	2.5	42.6	1,683.0
12/15	000780	1000	high +4	N/11	100	S	0.5 6.5	30.7	8.5	10.0	9.5	1.6	111.5	918.0
12/20	000787	1215	high +2	N/15	100	S	2.0 4.5	31.1	8.5	5.0	11.5	3.5	111.5	1,958.4
12/26	000791	1505	low +5½	0	100	S	2.5 5.0	30.9	8.5	5.0	9.6	1.6	19.7	3,213.0

* 8-Day BOD

Table 3. Copper concentrations (ppm) in soft shell clams (Mya arenaria) and lobsters (Homarus americanus) from Salem Harbor, October - December, 1972.

Date	Station	Soft shell clam	Lobster
10/13	A	3.7	14.6
	C	5.1	21.5
	11	7.0	
	13	5.6	
11/8	A	3.3	30.6
	C	4.1	17.2
12/7	A		7.7
	B	6.4	57.1
	C	4.8	4.7

Table 4. Concentrations (ppm) of trace metals in sediment, winter flounder (Pseudopleuronectes americanus) and soft shell clams (Mya arenaria) from Salem Harbor, August 17, 1972.

	Sediment	Winter flounder	Soft shell clam
mercury	0.02	0.07	0.05
cadmium	0.1	0.1	0.1
lead	9.0	1.2	1.1
zinc	17.0	5.3	15.0
nickel	4.5	0.6	2.2
copper	4.4	1.7	3.7
chromium	6.3	0.3	3.0
arsenic	2.4		
volatile solids (%)	0.4		

BIOLOGICAL INVESTIGATIONS

Benthic Survey

A total of 52 benthic organisms were identified from July samples, an increase of 12 over March. Thirty-two organisms were identified for the first time; 19 previously identified were not observed; and 21 were common in both sampling periods. The amphipod, Leptocheirus sp. remained most abundant.

Diversity was greatest at Station B-5 (22 species) and least at Station B-1 (5 species) (Figure 7). While diversification at most stations increased from 6 to 260%, no increase in total species was noted at Station A₂ (Table 5). The only decrease was cited at Station B₁ (-44%), located closest to the power plant discharge canal. Seventy-two benthic organisms have been identified to date, including 30 Mollusca, 22 Annelida, 2 Sipuncula, 13 Arthropoda, 4 Echinodermata and 1 Rhynchocoela (Table 6).

Fall sampling was conducted during November. Copies of the second research report of the William F. Clapp Laboratories are being distributed.

Chlorophyll Analyses

Levels of chlorophyll in Salem Harbor declined steadily during this quarter (Table 7). Detected ranges were:

Chlorophyll A	0.36 - 14.13 mg/m ³
B	0.03 - 1.29 mg/m ³
C	0.31 - 6.81 mg/m ³
Carotenoids	0.08 - 6.74 mg/m ³

Levels at all stations this quarter were more consistent than

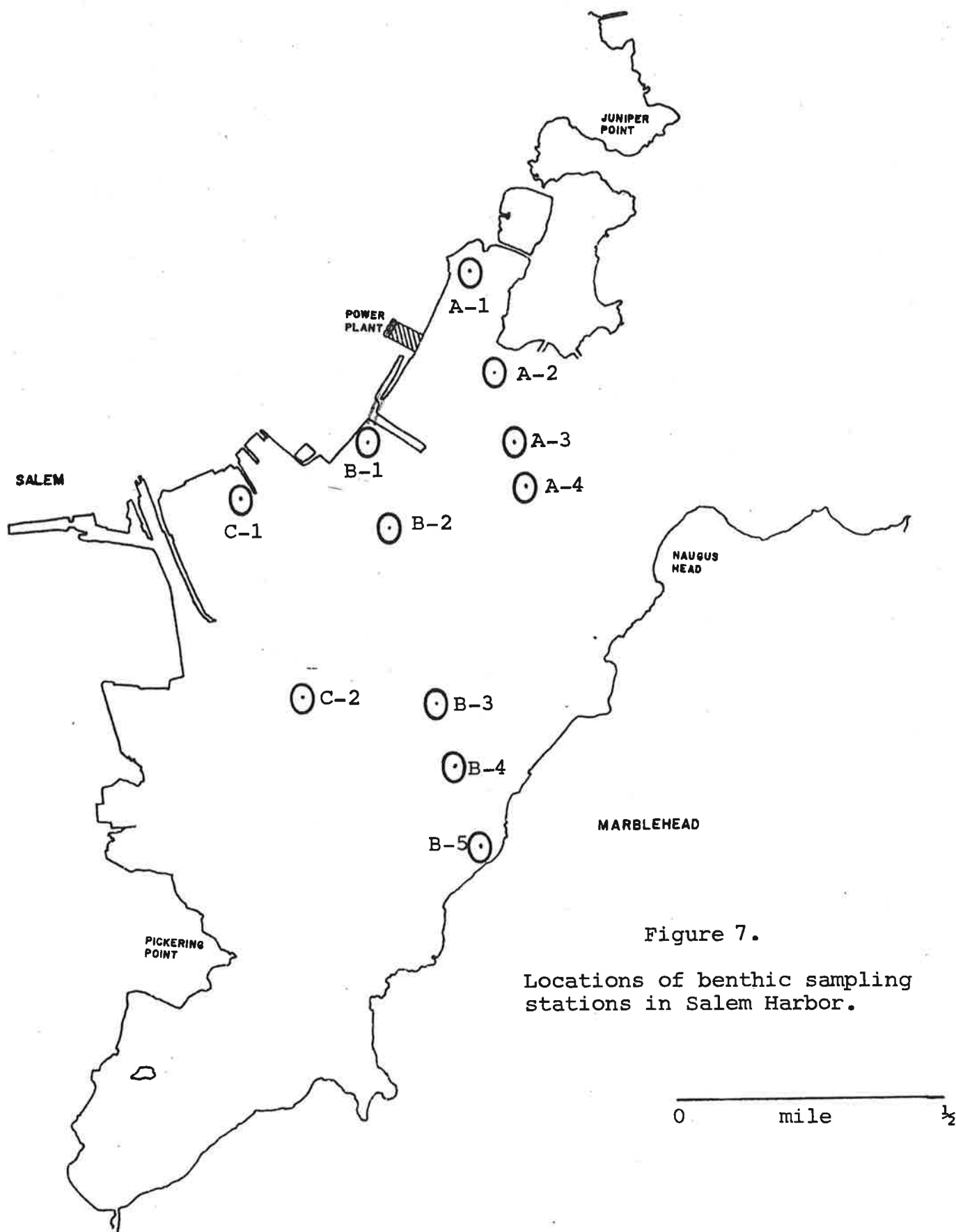


Figure 7.

Locations of benthic sampling stations in Salem Harbor.

Table 5. Diversification index of benthos fauna
in Salem Harbor, 1972.

Station	Depth (feet - MLW)	Sampling Period	
		March	July
A ₁	1	9	11
A ₂	10	11	11
A ₃	20	11	19
A ₄	30	17	18
B ₁	30	9	5
B ₂	20	6	11
B ₃	20	5	18
B ₄	10	14	18
B ₅	1	8	22
C ₁	1	5	10
C ₂	10	7	15

Table 6. Classification of benthos fauna in Salem Harbor.

Phylum: RHYNCHOCOELA

Cerebratulus sp.

Phylum: MOLLUSCA

Acmaea testudinalis

Cerastoderma pinnulatum

Fossarus clegans

Hydrobia minuta

Lacuna vincta

Lacuna sp.

Littorina littorea

Littorina sp.

Lunatia heros

Lyonsia hyaline

Macoma sp.

Margarites helicina

Mercenaria mercenaria

Mesodesma artica

Moelleria costulata

Mya arenaria

Mytilus edulis

Nassarius obsoletus

Nassarius trivittatus

Nacula tenuis

Nacula sp.

Nuculana sp.

Pandora gouldina

Pitar morrhuana

Polinices sp.

Retusa obtusa

Retusa canaliculata

Tellina agilis

Tellina sp.

Thais lapillus

Phylum: ANNELIDA

Family: Phyllodoceidae

Eteone sp.

Phyllodoce sp.

Family: Polynoidae

Harmothoe sp.

Family: Glyceridae

Glycera dibranchiata

Family: Nephtyidae

Nephtys bucera

Nephtys sp.

Table 6. Continued

	Family: Syllidae
	Family: Nereidae
	<u>Nereis virens</u>
	<u>Nereis</u> sp.
	Family: Capitellidae
	<u>Notomastus</u> sp.
	Family: Spionidae
	Family: Paraonidae
	<u>Aricidea jeffreysii</u>
	Family: Lumbrinereidae
	<u>Ninoe nigripes</u>
	Family: Orbiniidae
	<u>Scoloplos</u> sp.
	Family: Cirratulidae
	Family: Pectinariidae
	<u>Pectinaria gouldii</u>
	Family: Flabelligeridae
	<u>Pherusa affinis</u>
Phylum:	SIPUNCULA
	<u>Phascolion strombi</u>
	<u>Phascolopsis gouldii</u>
Phylum:	ARTHROPODA
	<u>Leptocheirus</u> sp.
	<u>Carcinides maenas</u>
	<u>Idotea balthica</u>
Suborder:	Gammaridae
	<u>Crangon septemspinosa</u>
	<u>Diastylus polita</u>
	<u>Orchomonella</u> sp.
	<u>Brachyura zoea</u>
Suborder:	Chiridotea
	<u>Edotea triloba</u>
	<u>Edotea</u> sp.
	<u>Aeginella</u> sp.
	Family: Caprellidae
Phylum:	ECHINODERMATA
	<u>Strongylocentrotus droebachiensis</u>
	<u>Asterias vulgaris</u>
	<u>Asterias</u> sp.
	<u>Amphipholis squamata</u>

Table 7. Chlorophyll counts (mg/m³) in Salem Harbor,
October - December, 1972.

Date	Station	Chlorophyll a	Chlorophyll b	Chlorophyll c	Carotenoids
10/5	A	12.13	0.29	5.42	5.57
	B	11.33	1.02	6.23	4.76
	C	13.30	0.90	6.15	6.40
	D	14.13	0.90	6.81	6.74
10/18	A	5.56	0.17	2.12	2.75
	B	3.80	0.25	0.59	1.36
	C	5.01	0.52	1.51	1.99
	D	5.77	0.72	2.63	2.28
11/2	A	5.38	0.52	1.20	2.77
	B	2.73	0.20	0.40	1.63
	C	5.04	0.57	1.28	2.73
	D	5.30	1.29	2.14	2.52
11/17	A	1.58	0.37	0.41	0.91
	B	0.80	0.03	0.17	0.61
	C	0.94	0.29	1.67	0.10
	D	0.36	0.12	0.17	0.62
11/28	A	1.40	0.33	0.85	0.60
	B	0.73	0.41	0.31	0.15
	C	1.26	0.57	0.54	0.56
	D	1.42	0.36	1.24	0.75
12/15	A	1.41	0.39	2.50	0.28
	B	1.19	0.58	0.91	0.16
	C	1.15	0.32	1.47	0.49
	D	1.58	0.77	3.05	0.44
12/26	A	1.01	1.16	1.66	0.16
	B	0.56	0.41	0.10	0.11
	C	0.89	0.63	1.06	0.08
	D	1.09	1.03	1.71	0.36

recordings from April through October. Lowest counts were evident adjacent to the discharge canal.

Figure 8 displays graphically the rate of decline in Chlorophyll A levels at stations A - D. Concurrent plankton samples are being analyzed.

Bioassays

Resulting from a series of malfunctions, delivery delays of salt water circulating pumps, and seasonal disappearance of required finfish species, thermal bioassays have been suspended until Spring. Investigations to date indicate that mummichogs, Fundulus heteroclitus, survive temperatures to 4°C, however, become inactive. Atlantic silversides, Menidia menidia, experienced 33% mortality following 96 hours at 4°C. Preliminary experiments on winter flounder, Pseudopleuronectes americanus, and threespine sticklebacks, Gasterosteus aculeatus, have been conducted. Intensive experiments will be initiated, in the spring to fulfill project requirements.

Finfish

Of 10,888 finfish collected (excluding sluiceway investigations) 6,924 (64%) were sampled in Salem Harbor and 3,964 (36%) were captured outside Salem Harbor (Tables 8 and 9). Atlantic silversides and winter flounder predominated in Salem Harbor, totalling 90% of the captures (Figure 9). Atlantic menhaden, Brevoortia tyrannus, were most abundant outside Salem Harbor, totalling 51% of the finfish sampled. Winter flounder, formerly the dominant species sampled outside the harbor totalled 16%.

Figure 8.

Chlorophyll a counts in Salem Harbor, October - December, 1972.

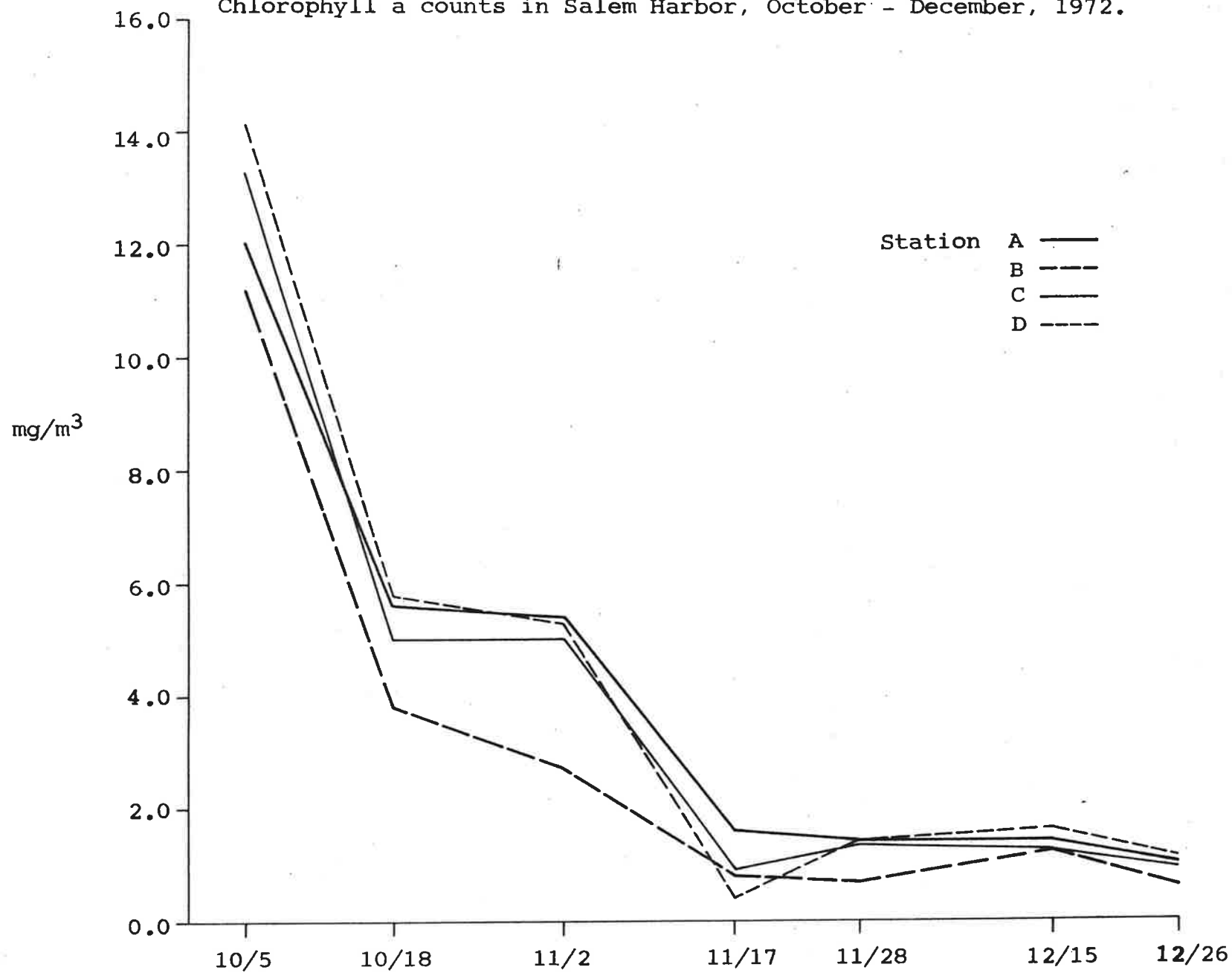


Table 8. Rank of finfish species collected in
Salem Harbor, October - December, 1972.

Species	Method of Capture					Totals
	50-ft Seine	120-ft Seine	30-ft Trawl	49-ft Trawl	Gill Net	
1. Atlantic silverside	657	3,253	27			3,937
2. winter flounder		37	14	2,269	5	2,325
3. striped killifish	221	5				226
4. Atlantic cod				5	93	98
5. skate*			1	47	1	49
6. fourspine stickleback		3	45			48
7. mummichog	27	20				47
8. threespine stickleback		14	29			43
9. blueback herring		37			1	38
10. northern pipefish			31			31
11. rainbow smelt			4	10	6	20
12. windowpane				12		12
13. Atlantic tomcod		2	7			9
14. pollock					8	8
15. ninespine stickleback	2	2	3			7
16. Atlantic menhaden	1	1			3	5
17. grubby			4			4
sea raven				3	1	4
18. ocean pout				3		3
19. alewife		2				2
goosefish				2		2
20. Atlantic mackerel					1	1
northern searobin				1		1
longhorn sculpin				1		1
silver hake					1	1
striped bass				1		1
yellowtail flounder				1		1
Totals	908	3,376	165	2,355	120	6,924

*Not separated by species

Table 9. Rank of finfish species collected outside
Salem Harbor, October - December, 1972.

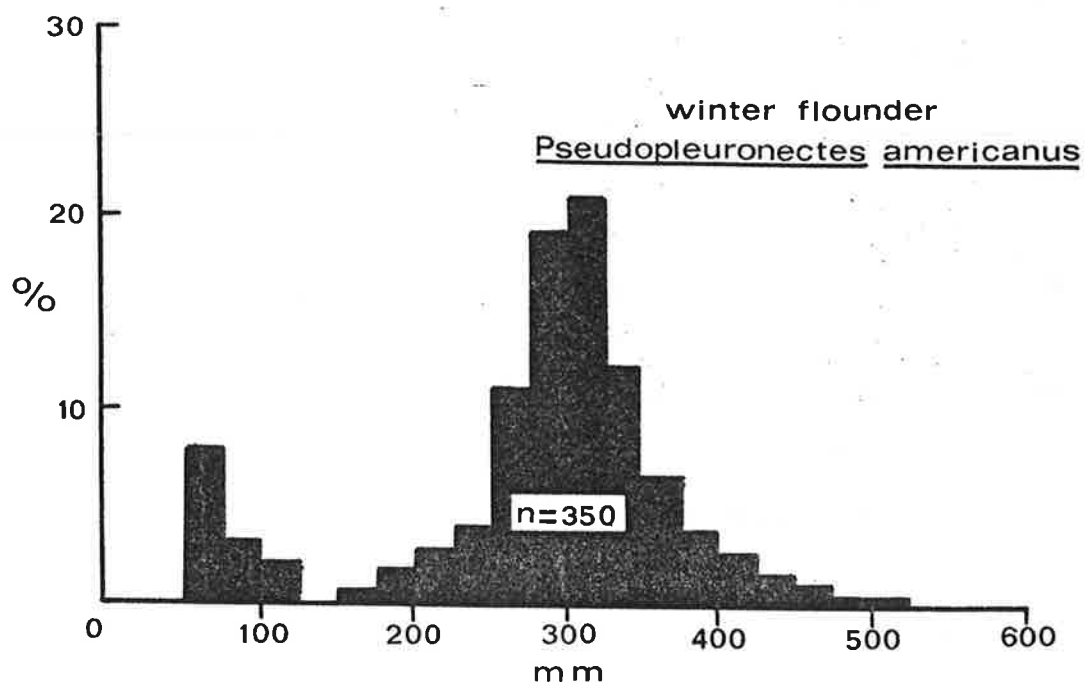
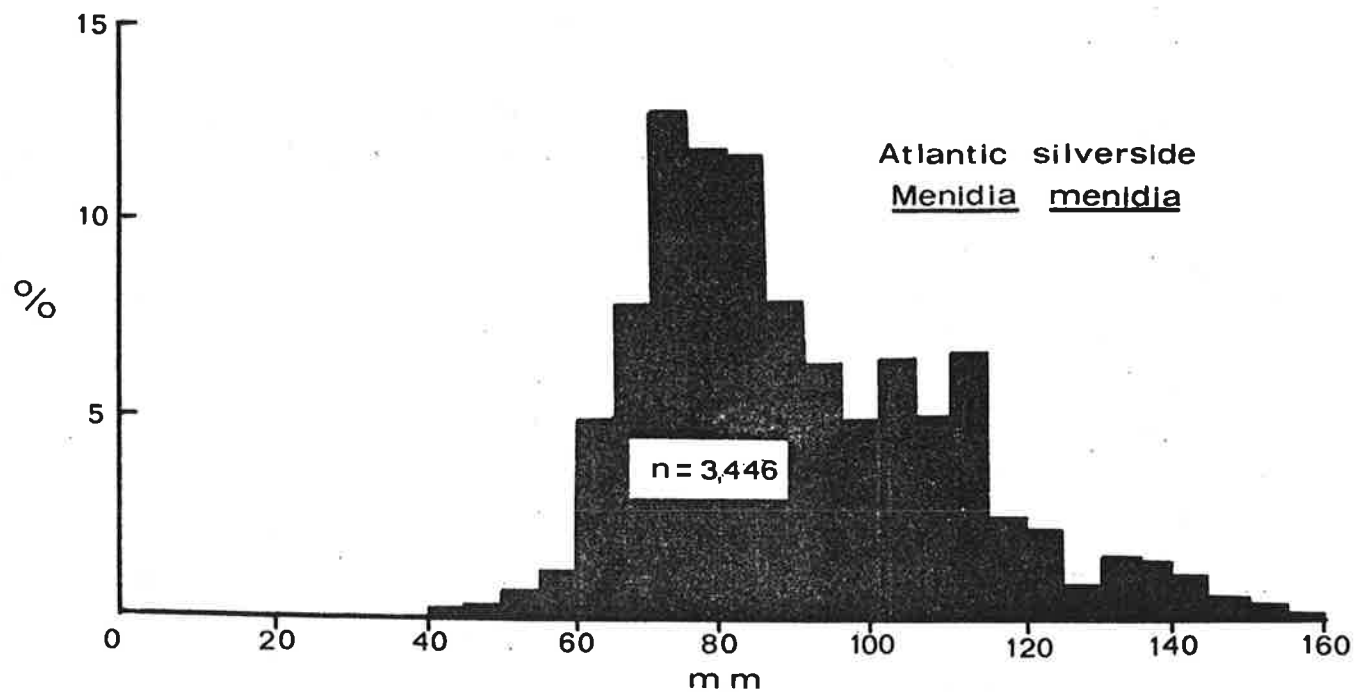
Species	Method of Capture				Totals
	50-ft** Seine	120-ft** Seine	30-ft** Trawl	49-ft Trawl	
1. Atlantic menhaden	51	1,960	2		2,013
2. Atlantic silverside	580	253	90		923
3. winter flounder		14	107	502	623
4. threespine stickleback	2		126		128
5. yellowtail flounder				119	119
6. Atlantic cod				37	37
7. mummichog	26		3		29
8. windowpane				18	18
9. Atlantic tomcod			15		15
10. ninespine stickleback			9		9
ocean pout				9	9
11. cunner			2	6	8
12. skate*				6	6
13. blueback herring		3			3
grubby			3		3
northern pipefish			3		3
14. fourspine stickleback		2			2
goosefish				2	2
longhorn sculpin				2	2
American sand lance			2		2
sea raven				2	2
15. fourbeard rockling	1				1
ninespine stickleback			1		1
rock gunnel				1	1
seasnail			1		1
silver hake				1	1
striped killifish	1				1
striped seasnail				1	1
white mullet	1				1
Totals	662	2,232	364	706	3,964

*Not separated by species

**Sampling terminated November 30, 1972

Figure 9.

Length frequency histograms for Atlantic silversides (Menidia menidia), and winter flounder (Pseudopleuronectes americanus) collected in Salem Harbor, October - December, 1972.



No change was noted in species dominance at the 50-ft seine and 49-ft trawl stations. Juvenile blueback herring, Alosa aestivalis, replaced striped killifish, Fundulus majalis, as a dominant species sampled by the 120-ft seine. Winter flounder and ninespine stickleback, Pungitius pungitius, abundance at the 30-ft trawl stations was exceeded by Atlantic silversides and northern pipefish, Syngnathus fuscus. Atlantic cod, Gadus morhua, dominated November and December catches by gill net (Tables 10 - 14). Species diversification remained greatest at the 30-ft trawl stations (Table 15).

Fourbeard rockling, Enchelyopus cimbrius; white mullet, Mugil curema; northern searobin, Prionotus carolinus and striped seasnail, Liparis liparis, collected for the first time this quarter, brings our classification listing to 50 (Table 16). Table 17 compares species occurrence in Beverly - Salem Harbor for 1965, 1971, and 1972.

Sluiceway Investigations

Unit 3 and 4 intakes were monitored for 84 hours (Table 18). Of 231 finfish captured (22 species) 78% were collected from Unit 4 and 22% were taken from Unit 3.

Cunner, Tautogolabrus adspersus, Atlantic menhaden, rainbow smelt, Osmerus mordax, and Atlantic silverside were most common. Sixty-four percent of all finfish suffered mortality from entrapment and/or impingement upon travel screens. Mortality from Unit 4 was greater than from Unit 3;

Table 10. Dominant finfish species collected in Salem Harbor
with the 50-ft seine, October - December, 1972.

Atlantic silverside (<u>Menidia menidia</u>)					mummichog (<u>Fundulus heteroclitus</u>)			striped killifish (<u>Fundulus majalis</u>)		
Date	Set No.	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)
<u>Station 11</u>										
10/10	1	2	40-69	54						
	2				2	25-34	30			
12/5	2	3	70-84	75						
<u>Station 13</u>										
10/6	1	142	45-129	71	17	30-59	42	221	45-94	71
	2	30	45-139	70	1	-	37			
11/6	1	2	-	80						
	2	71	40-149	74						
12/5	1	1	-	62						
	2	23	60-104	81						
<u>Station 15</u>										
10/10	1	118	35-104	75	3	45-54	50			
	2	4	20-89	50	4	40-54	47			
11/6	2	261	55-124	86						

Table 11. Dominant finfish species collected in Salem Harbor with the 120-ft seine, October - December, 1972.

Atlantic silverside (<u>Menidia menidia</u>)					blueback herring (<u>Alosa aestivalis</u>)			mummichog (<u>Fundulus heteroclitus</u>)			winter flounder (<u>Pseudopleuronectes americanus</u>)		
Date	Set No.	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)
Station 11													
10/11	1	115	40-144	69				5	30-54	49	3	55-69	62
11/17	1	26	60-149	87				4	45-89	61			
	2	55	70-134	95	7	60-104	79				6	65-99	78
12/4	1	3	65-79	72									
Station 13													
10/11	1	29	45-94	68							5	55-84	66
	2	248	40-124	74				10	35-49	41	11	50-79	73
11/17	1	673	50-144	76							2	70-84	77
	2	755	50-154	80	29	50-99	74				3	65-84	72
12/4	1							1	-	67	1	-	62
	2										3	95-114	102
Station 15													
12/4	1	367	60-114	80							2	75-79	77
	2	982	75-159	111	1	-	82				1	-	192

Table 12. Dominant finfish species collected in Salem Harbor with the 30-ft trawl, October - December, 1972.

Atlantic silverside (<u>Menidia menidia</u>)					fourspine stickleback (<u>Apeltes quadracus</u>)			northern pipefish (<u>Syngnathus fuscus</u>)			threespine stickleback (<u>Gasterosteus aculeatus</u>)		
Date	Set No.	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)	Total Collected	Size Range (mm)	Mean (mm)
Station 12													
11/7	1	9	85-109	96	1	-	42	3	130-154	144	1	-	52
12/8	2	14	80-119	101				1	-	127			
											13	50-74	58
Station 14													
10/20	1	1	-	67	23	30-57	43	11	107-192	119	14	40-64	51
	2				3	25-44	35	6	35-174	101			
11/7	1				12	30-54	46	8	115-194	160			
	2				2	-	42	2	130-149	140			
12/8	1	3	95-117	109	2	32-62	47				1		52
	2				2	42-59	50						

Table 13. Dominant finfish species collected in Salem Harbor with the 49-ft trawl, October - December, 1972.

winter flounder (<u>Pseudopleuronectes americanus</u>)				
Date	Set No.	Total Collected	Size Range (mm)	Mean (mm)
<u>Station 16</u>				
10/24	1	684	180-489	320
	2	773	160-544	319
11/21	1	341	210-514	310
	2	426	195-469	295
12/11	1	23	280-384	320
	2	22	210-394	292

Table 14. Dominant finfish species collected in Salem Harbor with gill nets, October - December, 1972.

Atlantic cod (<u>Gadus morhua</u>)			
Date	Total Collected	Size Range (mm)	Mean (mm)
<u>Station 20</u>			
11/20	83	280-419	346
<u>Station 21</u>			
12/7	10	300-754	382

Table 15. Diversification index of finfish species by method of capture, Salem Harbor, October - December, 1972.

Date	50-ft Seine	120-ft Seine	30-ft Trawl	49-ft Trawl	Gill Net
10/6	7				
10/10	2				
10/11		7			
10/20			14		
10/24				7	
11/6	4				
11/7			12		
11/17		9			
11/20					7
11/21				9	
12/4		9			
12/5	2				
12/6					
12/7					3
12/8					3
12/11			7		
				5	

Table 16. Classification of additional finfish species collected in Beverly - Salem Harbor.

Class: OSTEICHTHYES

Order: GADIFORMES

Family: Gadidae - codfishes

Enchelyopus cimbrius (Linnaeus) fourbeard rockling

Order: PERCIFORMES

Family: Mugilidae - mullets

Mugil curema Valenciennes - white mullet

Family: Triglidae - searobins

Prionotus carolinus (Linnaeus) - northern searobin

Family: Cyclopteridae - lumpfishes and snailfishes

Liparis liparis (Linnaeus) - striped seasnail

Table 17. Finfish species occurrence in Beverly - Salem Harbor, 1965, 1971, and 1972.

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
alewife					—		—			—	—	—
American eel	—		—			—	—	—	—			
American sand lance							—			—		
Atlantic cod	—		—	—	—	—	—	—	—	—	—	—
Atlantic herring					—	—		—	—		—	—
Atlantic mackerel						—			—		—	
Atlantic menhaden									—	—	—	
Atlantic moonfish										—		
Atlantic silverside	—	—	—	—	—	—	—	—	—	—	—	—
Atlantic tomcod			—	—	—	—	—	—	—	—	—	—
bay anchovy										—		
blueback herring				—				—	—	—	—	—
bluefish							—		—	—		
crevalle jack								—				
cunner						—	—	—	—	—	—	—
flying gurnard								—	—	—	—	—
fourbeard rockling										—	—	—

Table 17. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
fourspine stickleback		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
goosefish					-----	-----	-----	-----	-----	-----	-----	-----
grubby					-----	-----	-----	-----	-----	-----	-----	-----
haddock						-----	-----	-----	-----	-----	-----	-----
longhorn sculpin	-----			-----	-----	-----	-----	-----	-----	-----	-----	-----
lumpfish				-----	-----	-----	-----	-----	-----	-----	-----	-----
mackerel scad								-----	-----	-----	-----	-----
mummichog			-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
ninespine stickleback	-----			-----	-----	-----	-----	-----	-----	-----	-----	-----
northern pipefish				-----	-----	-----	-----	-----	-----	-----	-----	-----
northern searobin					-----	-----	-----	-----	-----	-----	-----	-----
ocean pout	-----		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
pollock					-----	-----	-----	-----	-----	-----	-----	-----
rainbow smelt	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
red hake					-----	-----	-----	-----	-----	-----	-----	-----
rock gunnel							-----	-----	-----	-----	-----	-----
rough scad								-----	-----	-----	-----	-----

Table 17. Continued

Species	⁵ Jan	¹ Feb	⁷ Mar	¹² Apr	¹⁸ May	¹⁵ June	¹² July	¹⁰ Aug	⁷ Sept	¹⁴ Oct	⁸ Nov	⁵ Dec
sea raven	— ---				— ---			— ---		— ---		
seasnail					— ---			---				
shorthorn sculpin			— ---								— ---	
silver hake						— ---				— ---		
skate*			— ---	— ---	— ---			— ---	— ---	— ---	— ---	— ---
spiny dogfish						— ---						
striped bass												
striped killifish	— ---				— ---			— ---	— ---	— ---		
striped mullet									— ---			
striped seasnail										— ---		
threespine stickleback	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---
white hake					— ---	— ---	— ---					
white mullet										— ---		
windowpane	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---
winter flounder	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---
yellowtail flounder	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---	— ---

*Not separated by species

— 1972
 --- 1971 (Sampling conducted from July - December)
 - - - - 1965

Table 18. Finfish species collected in the Unit 3 and 4 sluiceways, Salem Harbor, October - December, 1972.

Species	October 11		October 12										TOTALS*	
	(EST)	2300	0100	0300	0500	0700	0900	1100	1300	1500	1700	1900		2100
	Tidal Stage	0100	0300	0500	0700	0900	1100	1300	1500	1700	1900	2100		2300
		High			Low			High			Low			
					<u>Unit 3</u>									
Atlantic menhaden				1							1	3	5 (4)	
Atlantic tomcod												2	2	
northern searobin				1									1	
striped killifish						2	1						3	
winter flounder	1		1				1	1	3			4	1 12	
					<u>Unit 4</u>									
Atlantic menhaden	1	1			1	2	1			8		1	15 (15)	
Atlantic silverside		1					1		3	3			8 (7)	
bay anchovy									1				1 (1)	
blueback herring					1					1			2 (2)	
cunner	2	2	1	1				1	11	12	2	1	33 (33)	
grubby	1												1 (1)	
moonfish	1	2							1				4 (3)	
mummichog		1	1										2 (2)	
northern pipefish	6		3	6	1								16 (4)	
rainbow smelt										2			2 (2)	
sea raven												1	1	
striped killifish									1	1		1	3 (2)	
white hake									1				1 (1)	
winter flounder		1							5	7			13 (9)	

Table 18. Continued

Species	(EST)	November 14								November 15				TOTALS*	
		0800	1000	1200	1400	1600	1800	2000	2200	2400	0200	0400	0600		0800
		1000	1200	1400	1600	1800	2000	2200	2400	0200	0400	0600	0800		
		Low				High				Low					High
Tidal Stage															
<u>Unit 3</u>															
Atlantic menhaden										2			1	3 (3)	
Atlantic silverside							1							1 (1)	
blueback herring			1											1	
grubby								1						1	
lumpfish			1											1	
rainbow smelt										1				1 (1)	
threespine stickleback			1											1	
<u>Unit 4</u>															
American eel					1	1								2	
Atlantic menhaden			1							1				2 (2)	
Atlantic silverside					1									1 (1)	
Atlantic tomcod						10	2							12 (2)	
blueback herring						1								1 (1)	
cunner						1								1 (1)	
fourspine stickleback				1										1	
grubby						2							1	3 (2)	
mummichog						1								1 (1)	
ninespine stickleback												1		1 (1)	
northern pipefish									1					1 (1)	
pollock					1	6								7 (2)	
rainbow smelt			1	2	3		5	3				1	1	16 (16)	
threespine stickleback						2	1							3	

Table 18. Continued

Species	(EST)	December 12			December 13						TOTALS*
		1800	2000	2200	2400	0200	0400	0600	0800	1000	
		2000	2200	2400	0200	0400	0600	0800	1000	1200	
		Low			High						
Tidal Stage											
				Unit 3							
blueback herring		2			1	1	1		1		6 (3)
grubby		1			1	1					3
silver hake					1						1
winter flounder								1		1	2
				Unit 4							
Atlantic menhaden						1	1				2 (2)
Atlantic silverside			1								1
blueback herring		1	1			1					2 (2)
grubby											3 (3)
lumpfish					1						1 (1)
northern pipefish					1						1
winter flounder		2	1								1 (1)
											3

Table 18. Continued

	12/1	12/5	12/6	12/14	12/20	12/20	12/21	12/29	
	0900	0900	0700	0700	0900	1100	1500	1100	
	1100	1100	0900	0900	1100	1300	1700	1300	
Tidal Stage (Hours)	high +2	low +5½	low +3	high +3	high	high +1½	high +4	low	
Species									TOTALS*
	<u>Unit 3</u>								
Atlantic tomcod				1					1
blueback herring				3					3
grubby					1				1
threespine stickleback		1							1
winter flounder								1	1
	<u>Unit 4</u>								
Atlantic silverside						1	2		3 (3)
blueback herring				1	1				2 (2)
grubby							1		1 (1)
rainbow smelt						1			1 (1)
threespine stickleback					4	1	1		6 (6)
winter flounder				1				1	2

* Number of dead finfish shown in parenthesis.

74 and 26% respectively. This three-fold differential in mortality may be associated with the 50% greater intake water velocity for Unit 4 (.97 : 1.47 fps MLW). Although adult finfish were observed, juveniles appear most susceptible to entrapment and subsequent death (Figure 10). Approximately 42% of all finfish were captured between 1400 and 1800 EST (Figure 11).

Lobster Tagging

Lobster tag returns reached 149 (30%). Fishing intensity diminished throughout the area and is not expected to resume until March. Approximately 500 additional sub-legal sized lobsters will be tagged in the spring.

Figure 10.

Length frequency histograms for dominant finfish species collected in the Unit 3 and 4 sluiceways, Salem Harbor, October - December, 1972.

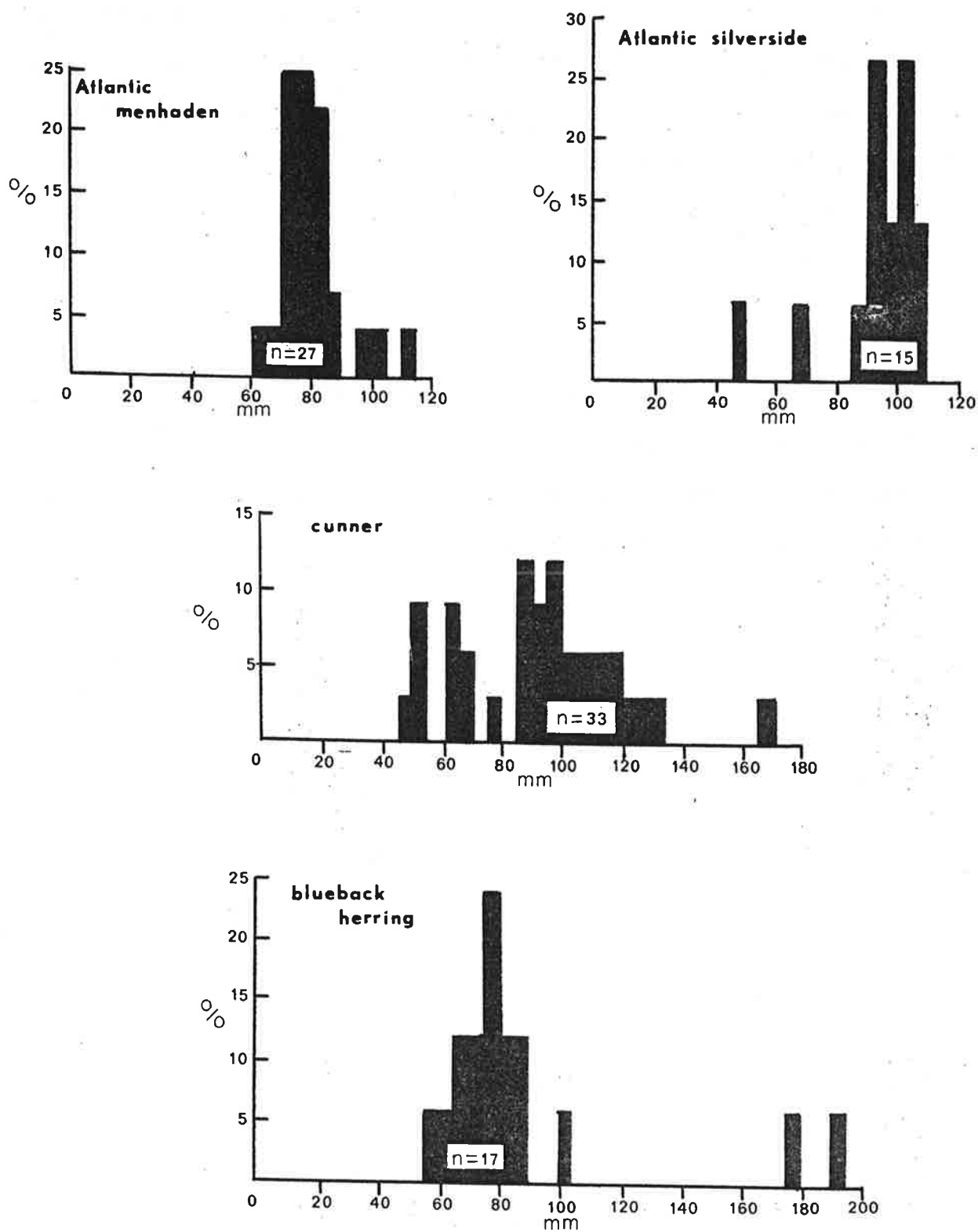


Figure 10. Continued

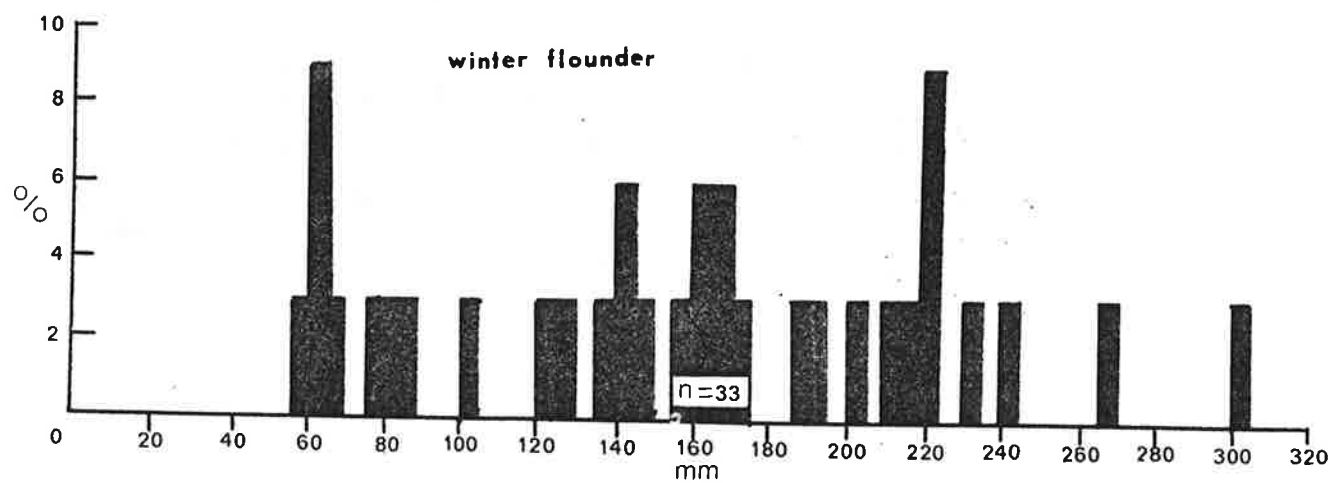
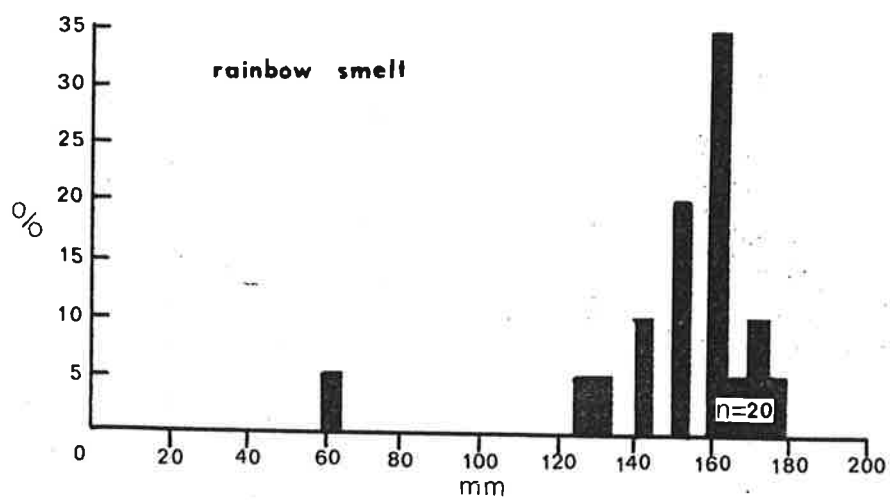
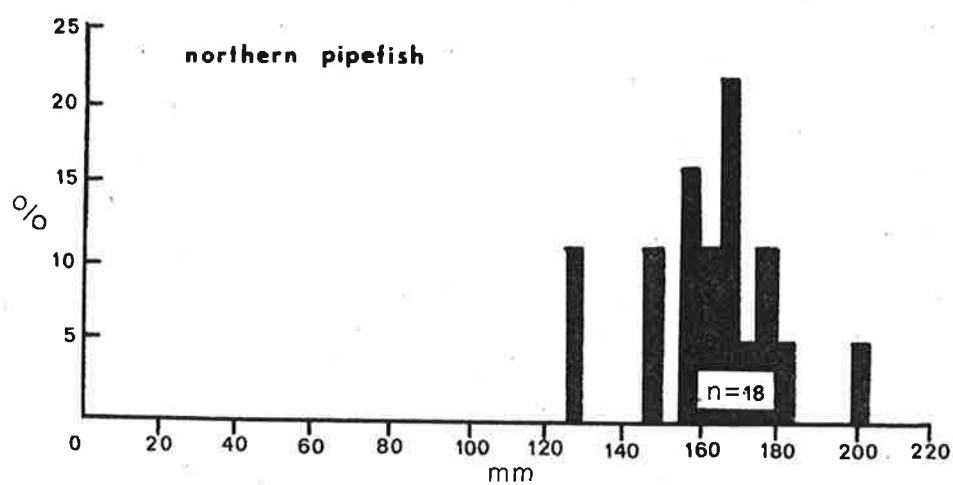


Figure 10. Continued

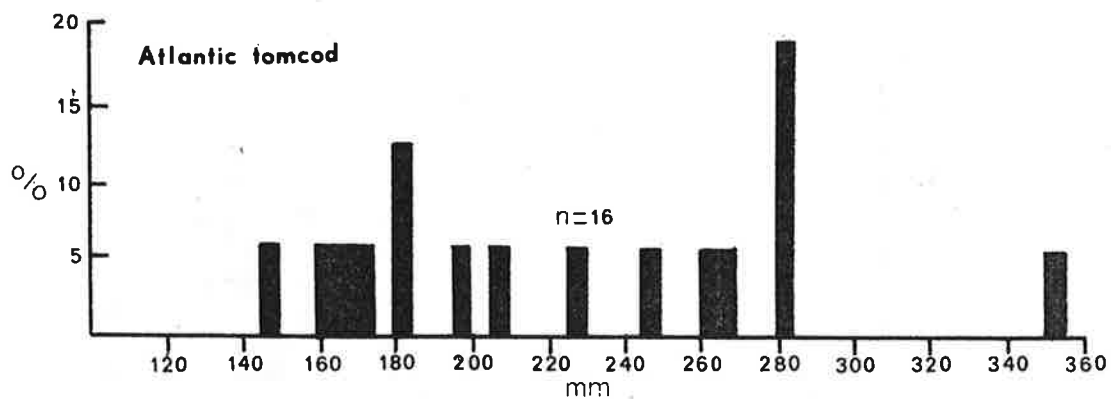
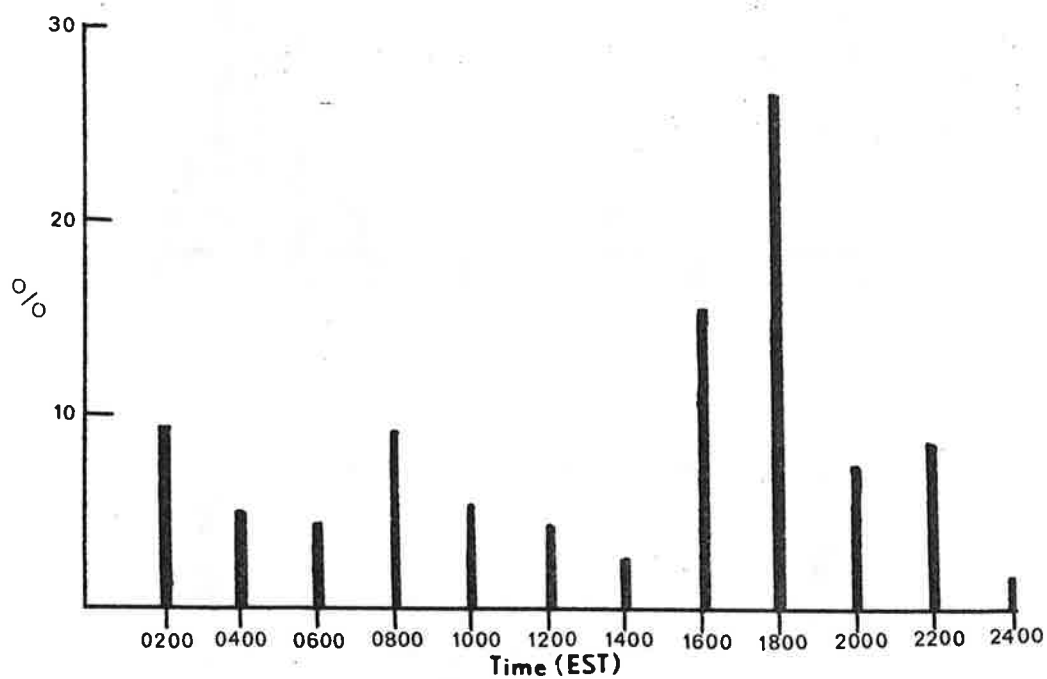


Figure 11.

Percent of finfish taken at various hours in the Unit 3 and 4 sluiceways, Salem Harbor, October - December, 1972.



SUMMARY

With the exception of difficulties encountered with our continuous recording thermographs, and delays hampering thermal bioassay experiments, field sampling is progressing smoothly and with increased impetus.

Our study area boundary was redefined to allow for greater concentrated effort in the immediate vicinity of the Salem Harbor power station. Effects from the operation of generating units 1 - 4 were not detected outside Salem Harbor during the first 18 months of investigation. Additional bottom trawl, mid-water trawl, and gill net sampling sites were established. Water quality analyses was expanded to include data on nitrites and phosphates.

At the request of the New England Power Company, amendments to our project contract were drafted and submitted for review. Recommendations for increased sampling were included. It is requested that the Technical Advisory Committee review our recommendations before implementation.

Following two temperature profiling surveys in the intake area, it is recommended that a permanent continuous monitoring probe be installed 10 ft east and -8.0 ft MLW of the center line of the Unit 3 intake screens. This location will provide more consistent recordings of ambient water temperatures for Salem Harbor than currently observed.

Future IRT flights of the area can be delayed in lieu of intensified subsurface temperature sampling. Earlier

reconnaissances were essential in determining surface thermal dispersion at various tidal stages. Once identified, however, emphasis should be directed toward temperature profiling and relationship to current direction and velocity. Such surveys are planned during the next quarter.

Benthos fauna was greatest in July when diversification at 9 stations increased in magnitudes of 6 to 260%. A 44% reduction in diversity at the station closest to the power plant discharge will prompt closer examination.

The siltation buildup occurring at the harbor end of the discharge canal appears to have no adverse biological effects. Citation of this occurrence in our last report was only to alert individuals interested in the canal maintenance of possible long-range effects. Although not documented, it appears that shallowing of the south end of this canal is forcing warm discharge water to the surface, thereby supplementing heat dissipation and stratification.

ERRATA

The following corrections should be noted in Progress Report No. 4, October, 1972.

1. Page 6, Table 2, Station C, 1400 EST. Substitute 29.7 for mid-depth salinity.
2. Page 7, Table 2, Station D, 1500 EST. Substitute 8.0 for mid-depth temperature.

APPENDIX

SAMPLING PROCEDURES

CHLORINITY

Field Collection: 300 ml/sample of seawater.

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

SALINITY

Field Analysis: Direct reading from a G.M. hydrometer, calibrated from 0 - 45 ‰.

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.

CARBON DIOXIDE

Field Analysis: Hach Chemical Company test kit, Model CA-10.

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.

BIOLOGICAL OXYGEN DEMAND

Field Collection: 300 ml/sample of seawater.

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

COPPERField Collection:

Water - 1 liter/sample collected in a nalgene bottle.

Soft shell clam - 6/sample, approximately 2" in length.

Lobster - 1/sample, approximately 3" in carapace length.

Laboratory Analysis: Utilizing a modified Strickland and Parsons (1968) 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: Ultraviolet spectrophotometric method from Standard Methods (1971).

NITRITE

Field Collection: 300 ml/sample of seawater.

Laboratory Analysis: Modified Griess Diazo reaction from Griess (1858).

INORGANIC PHOSPHATES

Field Collection: 300 ml/sample of seawater.

Laboratory Analysis: Colorimetric determination of reduced phosphomolybdate complex from Fiske and Subba Row (1925).

BENTHIC

Field Collection: Benthic algae and invertebrates are 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° counter-clockwise from the former. This procedure is repeated until 5-1/4m² samples are collected within each circle. Samples are stored and frozen in plastic bags until analyses.

PLANKTON

Field Collection: Phytoplankton and zooplankton are collected in an 80 micron mesh nytex plankton net. Tows are made for 2 minutes at selected sites and strained water volume is recorded on an 8.5 cm T.S. flow meter attached to a one meter ring. Samples are transferred to 250 ml nalgene bottles containing a 5% glutaraldehyde solution, and refrigerated 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 (1968).

FINFISH

Field Collection: Duplicate sets are made at selected sites with gear of the following desing:

50 x 4 ft seine, with 1/8 in mesh;

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

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

49 x 38 ft trawl with 5 in mesh wings and 4 in mesh cod end.

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.

Gill nets are set at selected sites for 24 hours. All gill nets are constructed of monofilament and measure 100 x 10 ft. Stretched mesh size range from 1-1/2 to 3-1/2 in.

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

SPORT FISH SURVEY

Starting Date: mid-April

Ending Date: mid-October

Area: Salem Harbor, inside or west of a line drawn between Fort Pickering Light on Winter Island to Naugus Head in Marblehead; and the easterly shorelines of Winter Island and Salem Neck from the Fort Pickering Light to, and including, the public pier at the north end of Salem Neck.

Procedure: Instantaneous fishermen counts are conducted three times during each survey day at randomly selected hours.

Fishermen interviews are conducted throughout the survey day. Survey data is recorded on forms provided for a minimum of 10 percent of all shore and boat fishermen.

Children who are fishing are included in the instantaneous counts, and a separate tally noted. Children are not interviewed when fishing in the accompaniment of an adult.

Schedule: One weekday and one weekend day is surveyed each week. All holidays are surveyed. Selection of day, and 8-hour shift (6 - 2 or 10 - 6), is made at random at 4-week intervals. Changes in routine are made only at time of schedule selections.

FISH EGG AND LARVAE

Field Collection: Procedures employed in collecting and handling fish egg and larvae are identical to plankton, except for use of a 153 micron mesh nytex net.

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 3/16 in stretched mesh nylon net, are periodically placed in the respective sluiceways for one hour intervals. All organisms are identified, enumerated and measured. Water temperature and salinity is recorded during each sampling interval.

LOBSTER TAGGING

Field Collection: Division personnel, aboard commercial vessels, collect sub-legal sized lobsters (3 - 3-1/8 in) from Beverly and Salem Harbors. Lobsters are then transferred to a Division boat or returned to our Cat Cove Laboratory for tagging with a fluorescent orange spherion tag.

Tagging Procedure: Tags are attached by securing a stainless steel anchor (.014 dia.) in the body muscle beneath the abdomen with the aid of a #20 hypodermic needle. Each tag is imprinted with a number and the legend "Div. Mar. Fish., Salem, Mass." Tagged lobsters are then released at selected sites in Beverly and Salem Harbors. Sex, carapace length (in millimeters), date, and release point are recorded.

Return Procedure: Through a public awareness program, including personal letters to commercial lobstermen known to fish Beverly - Salem Harbors; distribution of posters and tag reporting forms; and articles in the local news media; individuals are requested to return lobster tags to our laboratory or to a cooperating fish dealer. All returns are acknowledged in writing, and tags are placed on a map designating the point of capture. Records are updated on growth and movements of each recapture.

THERMAL BIOASSAY

Field Collection: Finfish species are collected by seines and trawls and transported to the laboratory in aerated containers of seawater.

Laboratory Experiment: Following acclimation to room temperature (about 18°C), 96 hour tolerance levels for each species are determined for abrupt and gradual changes in water temperature. Effects are noted for each 5°C gradient over the range -1.0 to 32.0 °C.

THERMAL BIOASSAYS

Purpose: To determine upper and lower thermal tolerance limits of certain finfish species. Experiments will determine effects of thermal shock through a $\pm 16.5^{\circ}\text{C}$ (30°F) range following acclimation to temperatures approximating high ambient, 21.0°C (70°F), and low ambient plus the operating ΔT of the plant, 10.0°C (50°F); and effects of gradual change varying to $\pm 16.5^{\circ}\text{C}$ (30°F) of 15.5°C (60°F).

Procedure: The following, outlined from Standard Methods (1971), will prevail throughout all experiments.

1. 96-hour flow-through bioassays.
2. 20 finfish of same species and of uniform size (largest < 1.5 times the length of the smallest).
3. Total weight of all fish will not exceed 1g/l of test water.
4. Water depth in test tanks will be > 15 cm.
5. Test fish will show no signs of disease or abnormalities.
6. Finfish will be acclimated for 10 days prior to experiment. Incidence of disease or death among acclimatized fish, within 4 days preceding experiment, will be $< 5\%$.
7. Finfish will be fed at least 3 times/week and all nonconsumed food will be removed at end of day. Test fish will not be fed during experiment.
8. Individuals of each finfish species will be utilized for only one experiment and will subsequently be released or disposed thereof.
9. Unnecessary handling of finfish will be avoided. Transfer from reserve to experiment tanks will be by dip net.
10. Dead finfish will be removed at each check interval.

11. Controls will be maintained for all experiments and performed in exactly the same manner as the test. Mortality of $>10\%$ in any control will invalidate the respective experiment.
12. Temperature adjustments will approximate 1°C (2°F) per day. Temperature during experiments will be maintained at $\pm 0.3^{\circ}\text{C}$ (0.5°F).
13. In thermal shock experiments, controls will be maintained at 10.0°C (50°F) and 21.0°C (70°F). In thermal tolerance experiments a reserve of finfish will be maintained at gradual increases from 21.0°C (70°F) and decreases from 10.0°C (50°F).
14. Temperature bracketing is permitted to establish tolerance ranges. Experiments of 1°C (2°F) increase or decrease will be performed at thermal extremes.
15. Data will be recorded on bioassay record sheets (sample attached) and will include:
 - a. Date and starting hour of experiment
 - b. biologist or technician's name
 - c. temperature of experiment water ($\pm 0.3^{\circ}\text{C}$)
 - d. Test species, source of supply, mean length and mean weight (determined only upon death or termination of experiment), condition and behavioral observations (symptoms of distress and loss of equilibrium)
 - e. daily physical and chemical properties of test water (temperature, salinity, pH and dissolved oxygen)
 - f. percent of finfish surviving at 3, 6, 24, 48, 72 and 96 hours
 - g. results expressed in tolerance limit (TL).

BIOASSAY RECORD

Test: _____ Water Temp: _____ °C

Biologist: _____

Starting Date: _____ Starting Time: _____

Ending Date: _____ Ending Time: _____

Test species: _____

Source of supply: _____

Mean length (mm): _____ Mean weight (g): _____

EXPERIMENT

	3	6	24	48	72	96 (Hours)
Percent surviving						
Temperature (°C)						
Salinity (0/00)						
DO (ppm)						
pH						

CONTROL

	3	6	24	48	72	96 (Hours)
Percent surviving						
Temperature (°C)						
Salinity (0/00)						
DO (ppm)						
pH						

REMARKS: _____

Project expenditures as of December 31, 1972 were:

	<u>Total Allotted</u>	<u>Total Expended</u>	<u>Balance</u>
Salaries	\$ 52,600.00	\$50,804.75	\$ 1,795.25
Travel	1,500.00	900.10	599.90
Office & Laboratory Supplies	4,500.00	2,999.90	1,500.10
Equipment	20,500.00	16,952.99	3,547.01
Maintenance	2,000.00	1,380.25	619.75
Overhead	<u>32,000.00</u>	<u>7,331.78</u>	<u>24,668.22</u>
Subtotal	\$113,100.00	\$80,369.77	\$32,730.23
Contracts	\$ <u>36,780.00</u>	\$ <u>8,150.00</u>	<u>\$28,630.00</u>
TOTAL	<u>\$149,880.00</u>	<u>\$88,519.77</u>	<u>\$61,360.23</u>