NUREG/CR-0223

ANALYSIS OF POPULATIONS OF BORING AND FOULING ORGANISMS IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION

Quarterly Report
December 1, 1977 — February 28, 1978

K. E. Hoagland
L. Crocket M. Rochester

Wetlands Institute

Prepared for
U. S. Nuclear Regulatory Commission

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ABSTRACT

The growth, distribution, and species composition of marine borers (primarily shipworms) and fouling organisms are being studied in the vicinity of the Oyster Creek Nuclear Generating Station, Barnegat Bay, New Jersey. Untreated wood test panels are used to collect organisms at 18 localities. Our most recent findings covering December, 1977 - February, 1978 are that two subtropical species of the borer family Teredinidae live in Oyster Creek; one species has spread to wooden structures outside of Oyster Creek. Shipworms living in Oyster Creek show advanced gonad development over specimens collected elsewhere, but no new shipworm larvae settled on wooden test structures during the winter of 1977-78. Fouling organisms such as bryozoa and tunicates settled in Oyster Creek at higher numbers than at other stations during the winter months. Shipworm damage is highest at two control stations with high salinity and strong water currents. Shipworms still exist in Oyster Creek but at numbers lower than existed in 1974-75. Forked River, especially the lower portions, contains shipworms.

SUMMARY OF FINDINGS

The purpose of this investigation is to monitor the levels of shipworm infestation in areas adjacent to the Oyster Creek Nuclear Generating Station, particularly its water intake and discharge systems. Furthermore, we are following species composition and breeding and settlement of all boring and fouling invertebrates that associate themselves with our wooden test panels at 18 stations. We record temperature and salinity, and remove and add panels on a monthly basis, except at 4 stations where temperature and salinity are recorded constantly.

Our major findings are:

1. The power plant was operating during the period covered by this report.
2. Air temperatures were subnormal for most of the period. Ice formed at many stations, but the only station in Forked River or Oyster Creek seriously affected by icing was station 6 in a lagoon within the Forked River system.
3. Recirculation of heated effluent water was not obvious during this period of time.
4. No shipworm larvae settled on monthly panels.
5. Teredo bartschi was found in Oyster Creek. One specimen had straight-hinge larvae in the gills.
6. Teredo furcifera was found in Forked River and Long Beach Island.
7. The largest shipworms tend to be found in Oyster Creek and Forked River. There is indirect evidence that the shipworms are able to grow during winter.
8. The heaviest attack is outside of the thermal effluent on Barnegat Bay in areas of high water circulation, but significant shipworm damage occurs in Oyster Creek and the south branch of Forked River, more so than in other tidal creeks.
9. Encrusting bryozoa and solitary tunicates settled in greater numbers in Oyster Creek than elsewhere during the winter of 1977-78.
10. Our data for the winters of 1976-77 and 1977-78 are similar, except for the absence of T. bartschi in our 1976-77 panels.

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   by K. Elaine Hoagland, Ruth D. Turner, and Margaret Rochester.
   Released Jan. 1, 1977.

2. December 1, 1976 - February 28, 1977. — 61 pp.
   by K. Elaine Hoagland, Ruth D. Turner, and Margaret Rochester.
   Released June 1, 1977.

3. March 1 - May 31, 1977 — 26 pp. + 1 Appendix
   by K. Elaine Hoagland, Margaret Rochester, and Ruth D. Turner.
   Released June 21, 1977.

4. June 1 - August 31, 1977. — 48 pp.
   by K. Elaine Hoagland, Margaret Rochester, and Lauralynn Crocket.
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5. September 1 - November 30, 1977. — 43 pp.
   by K. Elaine Hoagland, Lauralynn Crocket, and Margaret Rochester.
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ANALYSIS OF POPULATIONS OF BORING AND FOULING ORGANISMS IN THE VICINITY OF THE OYSTER CREEK NUCLEAR GENERATING STATION

with Discussion of Relevant Physical Parameters
Over the Period
December 1, 1977 - February 28, 1978

INTRODUCTION

This progress report covers data collected over the period Dec. 1, 1977-Feb. 28, 1978. The methods are identical to those given in earlier reports. The period was marked by cold (subnormal) air temperatures, causing icing at stations away from the thermal effluent, especially in February. At a few stations, ice prevented sampling. Another loss in data was caused by repair of a dock; planks were pulled up during one month so that the station was inaccessible.

Data from constant recording salinometers are reported for the first time. The first two months' data are incomplete due to problems with battery life, adjustments of ink flow, and calibration of the instruments' salinity readings.

The nuclear generating station was operating during the period of this report. The locations of our stations are given in the Appendix.

MAJOR PHYSICAL EVENTS

Temperature

Table 1 shows the temperatures recorded at the time of sampling each month. Table 2 gives temperature data from the 4 constant recording instruments at stations 1, 5, 11, and 14. There was no obvious recirculation of heated effluent from Oyster Creek into Forked River during this period. The differential between Oyster Creek and control stations on Barnegat Bay was only 3-4°C on the days when sampling took place, but the more complete data for 4 stations (Table 2) show higher values. For example, the mean daily temperature at 1 PM was 8°C higher at Oyster Creek (sta. 11) than at Holly Park (sta. 1) in January.

In figure 1, it can be seen that the temperature range from Oyster Creek stations to the coolest station is 6-6.5°C in December and January, but is reduced in the coldest month, February. In the winter of 1977, December and January were cooler than February, and the average temperature differential at 1 PM between Oyster Creek and Holly Park varied from 2.3 to 5.2°C for the three months.

Salinity

Salinity records (Tables 3-5), as in previous months, place Oyster Creek in an intermediate position between the outer Barnegat Bay stations and the tidal creeks. Salinity in Oyster Creek is slightly lower than in Forked River, indicating that some fresh water does enter Oyster Creek. Table 4 reveals that variability of salinity was lower in Oyster Creek than at station 1 and usually stations 5 and 14 as well.

Constant salinity data did not show any simple correlation with tidal cycles at any one station, probably because of the complex interplay of physical factors in Barnegat Bay and the tidal creeks. Hence we simply read off the chart value for salinity at 12:00 noon as the daily estimator of salinity.

Drought

There is some reason to believe that periods of drought increase shipworm attack in coastal areas such as Barnegat Bay. This is because freshwater flow into tidal creeks is reduced and salt water penetrates

further up into the creek. The U.S. weather service's precipitation values for Long Branch and Tom's River, New Jersey, for the year 1977, are 50.90" and 52.87", respectively. This is 5.44" above normal for Long Branch and 6.69" above normal for Tom's River. We have ordered New Jersey precipitation records for the years 1969-78, to see if abnormal precipitation over this period to any degree could account for the shipworm outbreak at Oyster Creek in 1971.

Table 1

Temperature Profiles; in Degrees Centigrade

Station	December 4	January 6	February 4	Differential between months within stations
1	6.0	1.0	[a]	5.0[a]
2	6.3	2.5	1.0	5.3
3	8.1	6.2[b]	3.0	5.1
4	6.5	0.0[c]	0.0	6.5
5	6.8	1.4	1.0	5.8
6	7.7	2.1	[a]	5.6[a]
7	7.0	4.7	2.0	5.0
8	7.2	1.8	0.0	7.2
9	6.8	0.8	0.5	6.3
10	10.2	6.0	3.0	7.2
11	10.5	5.5	4.0[b]	6.5
12	11.4[b]	6.0	4.0[b]	7.4
14	8.6	5.1	1.0	7.6
15	7.2	2.4	1.0	6.2
16	6.4	2.3	[a]	4.1[a]
17	4.8[c]	3.4	-1.0[c]	5.8
18	6.7	[a]	-1.0[c]	7.7[a]
19	6.4	5.7	-1.0[c]	7.4
Differential among stations	6.6	6.2	5.0	

Note: [a]Missing data

[b]Highest monthly value

[c]Lowest monthly value

Table 2

Constant Temperature Recorder Data °C for Dec. 4, 1977 - Mar. 4, 1978
Stations 1, 5, 11, and 14

I. Temperature at 1:00 PM

	Dec 4 - Jan 6, 1978				Jan 6 - Feb 4, 1978				Feb 4 - Mar 4, 1978			
	1*	5*	11	14	1	5	11	14	1	5	11	14
Mean Daily Temp at 1 PM	-	-	8.4	3.6	-0.3	0.6	7.7	1.1	0.1	0.9	6.2	0.8
Standard Deviation	-	-	2.1	2.1	1.0	1.8	1.6	1.4	0.4	0.8	1.3	1.0
Highest value of Temp. at 1 PM	-	-	11.8	7.4	3.1	5.6	11.4	4.7	0.7	2.5	10.6	2.6
Lowest value of Temp. at 1 PM	-	-	3.6	-0.4	-1.5	-2.0	5.6	-0.7	-0.5	-0.7	3.9	-1.3
Monthly Temp. Range at 1 PM	-	-	8.2	7.8	4.6	7.6	5.8	5.4	1.2	3.2	6.7	3.9

II. Maximum Daily Temperatures

	Dec 4 - Jan 6, 1978				Jan 6 - Feb 4, 1978				Feb 4 - Mar 4, 1978			
	1*	5*	11	14	1	5	11	14	1	5	11	14
Mean value of Max Daily Temp.	-	-	9.3	4.4	-0.03	1.3	8.2	1.9	0.3	1.4	7.5	1.8
Standard Deviation	-	-	2.3	2.2	1.0	2.1	1.7	1.5	0.4	0.9	1.5	0.1
Highest value of Max. Daily Temp.	-	-	14.2	0.2	3.2	7.8	11.5	5.6	0.9	3.2	11.6	3.7
Lowest value of Max. Daily Temp.	-	-	4.6	0.7	-1.7	-1.3	5.7	-0.4	-0.2	-0.7	4.9	-1.0
Monthly Range of Max. Daily Temp.	-	-	9.6	8.5	4.9	9.1	5.8	6.0	1.1	3.9	6.7	4.7

*Missing data; recorder being repaired.

Table 2, Continued

III. Minimum Daily Temperatures

	Dec 4 - Jan 6, 1978				Jan 6 - Feb 4, 1978				Feb 4 - Mar 4, 1978			
	1*	5*	11	14	1	5	11	14	1	5	11	14
Mean value of Min. Daily Temps, 1 Mo.	-	-	7.6	3.1	-0.7	-0.7	7.3	0.6	-0.2	0.1	5.9	0.4
Standard Deviation	-	-	2.1	2.3	0.8	2.0	1.3	1.4	0.4	0.6	1.2	0.9
Highest value Min. Daily Temp.	-	-	11.6	8.1	0.7	3.4	9.9	4.6	0.4	1.5	8.4	1.8
Lowest value Min. Daily Temp.	-	-	3.4	-0.4	-2.0	-5.4	5.3	-1.4	-0.9	-0.8	3.6	-1.4
Monthly Range of Min. Daily Temp.	-	-	8.2	8.5	2.7	8.8	4.6	6.0	1.3	2.3	4.8	3.2

IV. Daily Temperature Range

	Dec 4 - Jan 6, 1978				Jan 6 - Feb 4, 1978				Feb 4 - Mar 4, 1978			
	1*	5*	11	14	1	5	11	14	1	5	11	14
Mean Daily ΔT	-	-	1.7	1.3	0.8	2.0	0.8	1.3	0.5	1.3	1.6	1.3
Standard Deviation	-	-	1.0	0.8	0.6	1.4	0.8	0.7	0.3	0.5	0.6	0.7
Largest Daily ΔT for 1 Month	-	-	5.4	2.8	2.6	6.4	2.7	2.8	1.3	2.0	3.2	3.4
Smallest Daily ΔT for 1 Month	-	-	0.5	0.2	0.1	0.5	0.0	0.1	0.1	0.0	0.7	0.4

*Missing data; recorder being repaired.

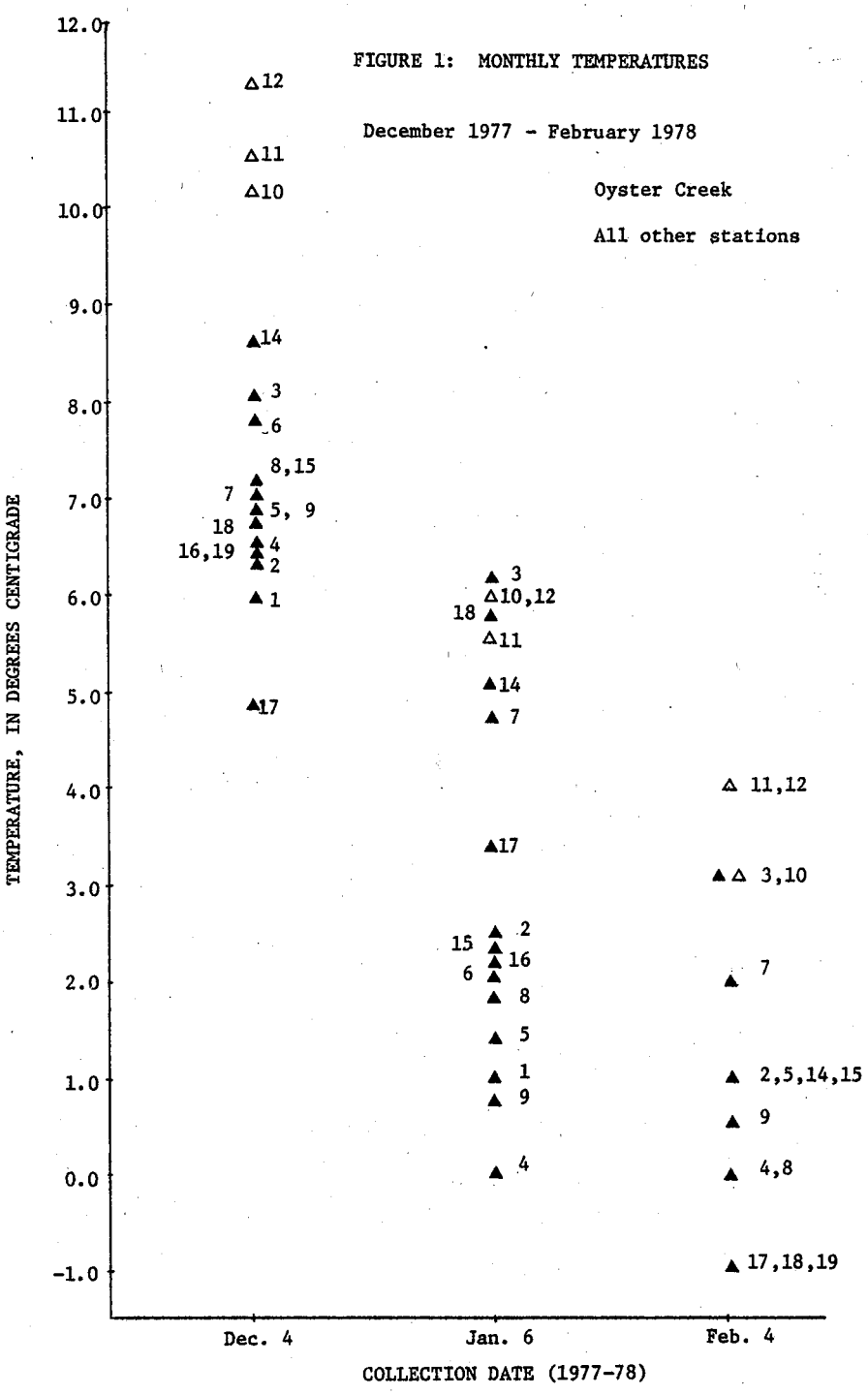


FIGURE 1: MONTHLY TEMPERATURES
December 1977 - February 1978
Oyster Creek
All other stations
TEMPERATURE, IN DEGREES CENTIGRADE
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
Dec. 4
Jan. 6
Feb. 4
COLLECTION DATE (1977-78)

Table 3

Salinity Profiles, °/100

Station	December 4*	January 6*	February 4*	Differential between months within stations
1	13.8	14.2	[a]	0.4[a]
2	15.6	14.8	[a]	0.8[a]
3	16.4	10.5	[a]	5.9[a]
4	16.5	17.1	16	1.1
5	16.4	16.6	18	1.6
6	16.3	16.3	[a]	0.0[a]
7	10.8[c]	3.8[c]	[a]	7.0[a]
8	16.9	20.6	18	3.7
9	15.9	15.3	21	5.7
10	15.6	16.2	18	2.4
11	16.5	16.2	18	1.8
12	14.5	15.1	18	3.5
14	19.1	18.6	15[c]	4.1
15	18.9	21.7	18	3.7
16	17.3	23.4	[a]	6.1[a]
17	16.2	18.6	16	2.6
18	19.7	[a]	22[b]	2.3[a]
19	20.5[b]	26.6[b]	15[c]	11.6
Differential among stations	9.7	16.1	7[a]	

Note: [a]Missing data

[b]Highest monthly value

[c]Lowest monthly value

*December--Beckman portable salinometer used
January---Beckman portable salinometer used
February--Refractometer used; lower precision but greater reliability.

Table 4

Constant Recording Salinometer Readings at 12:00 Noon
November 18, 1977 - March 5, 1978
(Parts per Thousand)

Dates	Statistic*	Sta. 1	Sta. 5	Sta. 11	Sta. 14
	N	9	18	17	27
Nov. 18-	$\bar{X}$	16.0	19.8	17.5	22.4
Dec. 14	S_X	2.3	1.5	1.4	1.4
	$S_{\bar{x}}$	0.8	0.4	0.3	0.3
Dec. 4 -	N	6	0	7	0
Jan. 6	$\bar{X}$	16.6	-	18.2	-
	S_X	3.1	-	2.0	-
	$S_{\bar{x}}$	1.3	-	0.75	-
Jan. 7 -	N	25	21	21	29
Feb. 4	$\bar{X}$	15.8	20.6	19.3	22.1
	S_X	3.4	2.6	2.1	3.4
	$S_{\bar{x}}$	0.7	0.6	0.45	0.6
Feb. 5 -	N	23	28	29	5
Mar. 5	$\bar{X}$	11.7	20.3	19.2	21.7
	S_X	2.2	1.4	1.5	2.6
	$S_{\bar{x}}$	0.5	0.3	0.3	1.2

*N, number of days recorded, indicates the extent of missing data. See text (introduction) for explanations of missing data. $\bar{X}$ = mean, S_X = standard deviation, $S_{\bar{x}}$ = standard error of the mean.

Table 5

Ranking of Stations by Salinities,
Low to High

Rank	December 4	January 6	February 4
1	7	7	14
2	1	3	19
3	12*	1	4, 17
4	2, 10*	2	
5		12*	5, 8, 10*, 11*, 12*, 15
6	9	9	
7	17	10*, 11*	
8	6		
9	3, 5	6	
10		5	9
11	4, 11*	4	18
12		14, 17	[b]
13	8		
14	16	8	
15	15	15	
16	14	16	
17	18	19	
18	19	[a]	

*Oyster Creek stations.

[a]No data, station 18.

[b]No data, stations 1, 2, 3, 6, 7, 16.

SHIPWORMS

Monthly Panels

There were no shipworms in any monthly panels during the winter of 1977-78. The same was true in 1977.

Yearly Panels

Panels submerged in the winter of 1976-77 and removed in the winter of 1977-78 are described in Tables 6-9. As in past months, shipworm attack was very light at control stations #3, 7, 15, 16, and 17, and heavy at stations 2 and 11. Yearly panels removed between September and February all had the same pattern of shipworm attack, with the following exceptions: (1) stations 6 and 16 showed an increase in the December and January panels, but the number of shipworms per panel remains less than 10. (2) Station 10 has decreased from 1 per panel (Sept.-Nov.) to none per panel (Dec.-Feb.). (3) Attack at station 11 declined to 7 shipworms in February, from a high of 32 in November. (4) Station 14 suffered an increased attack in the Dec.-Feb. yearly panels.

Since the Bankia gouldi settlement period for all these panels was primarily June-early September, 1978, we would expect that these differences between panels taken from the same station represent random patterns in settlement, plus perhaps differences in settlement of Teredo species in September-October, 1976, versus the same months of 1977.

Species ratios were similar over the 6-month span of data; Teredo Spp were relatively more abundant in February's panel, but that was an artifact of the lack of data from stations 1 and 2 that always contain populations of Bankia gouldi. Teredo bartschi was found in two of the yearly panels in Oyster Creek. T. furcifera is found consistently at stations 4, 5, and 12.

Mortalities (Table 8) were highest in the panel collected February 4, 1978. This can be attributed to the sustained low temperatures and freezing at some stations during late January and early February. However, mortality at Oyster Creek cannot be explained this way.

The largest B. gouldi found in yearly panels come from Oyster Creek and Forked River (Table 9). The largest Teredo specimens are from Forked River or, in December's panel, Holly Park. Bankia gouldi

retrieved in winter months tend to be larger than those retrieved in Fall (compare 5th quarterly report, Table 8). This difference can be explained if the B. gouldi settled in June-August, 1977 and continued growing to some extent during November 1977-February 1978.

Species composition summed over all our stations has changed slightly from the 1976 cumulative series to the 1977 series, due to our inclusion of stations 18 and 19 that have a preponderance of T. navalis. Station-by-station, species composition has not changed significantly. T. navalis appears to be present in Oyster Creek to a greater extent than T. furcifera, which instead occupies the mouth and lower portion of Forked River. Teredo Spp. are less common than Bankia gouldi in Oyster Creek.

Cumulative Panels

The results of the cumulative panel experiments are presented in Tables 10-12. Additionally, we would like to amplify a statement in our fifth report. At that time, a technician tentatively identified one Teredo bartschi from station 18. This identification has been confirmed; 5 T. bartschi were also identified at station 12 in a panel retrieved on November 5, 1977. They had originally been identified as T. navalis. T. bartschi was found at stations 10 and 11 in the panels removed in January.

Bay stations 2 and 18 continue to be the most heavily attacked. Additional submergence time has not significantly changed the numbers of shipworms found in the panels, except that the number of shipworms has increased at station 16 and declined in panels at stations 2 and 18. There probably was mortality and decay of small specimens inhabiting the panels removed from stations 2 and 18 in winter months that could not be detected in the nearly riddled panels. Stations 11 and 12 have more shipworms than station 10 in a lagoon near the mouth of Oyster Creek. Mortalities are greatest in panels crowded with shipworms. One anomaly is the number of shipworm deaths at station 19 (Table 12). We are investigating the cause of this exceptionally high mortality.

Figure 3 presents size data on shipworms removed during the period of this report. Comparing the data with similar figures in our quarterly report for winter 1976-77, we see that the B. gouldi population in the 1977-78 cumulative panels from station 2 has the same general distribution, but has a lower mean length. B. gouldi in Oyster Creek shows a narrower size range in the 1977-78 cumulative panel series. The size distribution at Oyster Creek in both the cumulative and

yearly series does not approach a normal distribution such as we find at station 2 in December, 1976 and 1977, or at station 1 in December and January, 1977. There is a hint of a skewed distribution or of biomodality in some of the data, probably representing sex differences. The females of this protandrous species are larger. Of course, there can be only one year-class in the cumulative panels.

Wood Destruction

A quantitative estimate of wood borer damage is presented in Table 13. The highest damage was at stations 18, 2, 11, 12, 5, 4, and 10, in that order. Panels suffering the most damage correspond to those with the most shipworms, except that there is more damage per worm in Oyster Creek (especially stations 11 and 12) than elsewhere.

Gonad Weights

Table 14 gives dry weights of gonads and somatic tissues for some of the specimens of Bankia gouldi analyzed to date, at key stations. The percentage of the ash-free body weight that is gonad weight declines over the period June-August, due to spawning. Percentage of the body weight that is ash is highly variable and is not correlated with the thermal plume, nor with the time of year.

In June and July, stations in Oyster Creek had the highest mean gonad weight (disregarding sex of the shipworms). A part of this difference can be attributed to the greater proportion of large females in Oyster Creek relative to stations 1 and 2, for example. Data are as yet insufficient to say whether or not the percentage gonad weight is higher in Oyster Creek B. gouldi.

Table 6

Numbers of Living Shipworms in Panels Submerged for One Year

Date Removed:	December 4, 1977				January 6, 1978				February 4, 1978				
Station	B.g.	T.f.	T.n.	Total	B.g.	T.f.	T.n.	Total	B.g.	T.b.	T.f.	T.n.	Total
1	5	0	1	6	2	0	0	2	a		a	a	a
2	96	0	0	96	86	0	0	86	a		a	a	a
3	0	0	0	0	0	0	0	0	0		0	0	0
4	4	0	0	4	3	1	1	5	5		1	1	7
5	8	1	0	9	4	0	0	4	6		2	0	8
6	7	0	0	7	5	0	0	5	a		a	a	a
7	1	0	0	1	0	0	0	0	2		0	0	2
10	0	0	0	0	0	0	0	0	0		0	0	0
11	20	0	0	20	16	0	1	17	5	1*	0	1	7
12	4	0	2	6	2	1	0	3	5	1	0	1	7
14	5	0	0	5	3	0	0	3	6		0	0	6
15	0	0	0	0	1	0	0	1	4		0	0	4
16	1	0	0	1	2	0	0	2	a		a	a	a
17	0	0	0	0	0	0	0	0	0		0	0	0
Totals	151	1	3	155	124	2	2	128	33	2	3	3	41

[a]Panel not removed due to winter conditions.

*Straight-hinge larvae in gill.

T.b. = Teredo bartschi; T.f. = Teredo furcifera; T.n. = Teredo navalis; B.g. = Bankia gouldi.

Table 7

Number of Living Shipworms Plus Empty Tubes,
Panels Submerged for One Year

Date Removed:	December 4, 1977				January 6, 1978				February 4, 1978				
Station	B.g.	T.f.	T.n.	Total	B.g.	T.f.	T.n.	Total	B.g.	T.b.	T.f.	T.n.	Total
1	5	0	1	6	2	0	0	2	a		a	a	a
2	110	0	0	110	86	0	0	86	a		a	a	a
3	0	0	0	0	0	0	0	0	0		0	0	0
4	5	0	0	5	4	1	1	6	5		1	1	7
5	8	1	0	9	4	0	0	4	6		2	0	8
6	7	0	0	7	5	0	0	5	a		a	a	a
7	1	0	0	1	0	0	0	0	3		0	0	3
8	*	*	*	*	*	*	*	*	*		*	*	*
10	0	0	0	0	0	0	0	0	0		0	0	0
11	20	0	0	20	17	0	1	18	5	1	0	1	7
12	4	0	2	6	2	2	0	4	5	1	0	3	9
14	5	0	0	5	3	0	0	3	7		0	0	7
15	0	0	0	0	1	0	0	1	7		0	0	7
16	1	0	0	1	2	0	0	2	a		a	a	a
17	0	0	0	0	0	0	0	0	0		0	0	0
Total	166	1	3	170	126	3	2	131	38	2	3	5	48

[a]Panel not removed due to winter conditions.

*Rack containing panels lost April 1977.

Table 8

Percentage of Specimens in Yearly Panels that were Alive when Collected

Month Collected:	December 4, 1977			January 6, 1978			February 4, 1978		
Station	Number Living Specimens	Total No. Tubes Observed	% Alive	Number Living Specimens	Total No. Tubes Observed	% Alive	Number Living Specimens	Total No. Tubes Observed	% Alive
1	6	6	100	2	2	100	a	a	a
2	96	110	87.2	86	86	100	a	a	a
3	0	0	-	0	0	-	0	0	-
4	4	5	80	5	6	83.3	7	7	100
5	9	9	100	4	4	100	8	8	100
6	7	7	100	5	5	100	a	a	a
7	1	1	100	0	0	-	2	3	66.7
8	*	*	*	*	*	*	*	*	*
10	0	0	-	0	0	-	0	0	-
11	20	20	100	17	18	94.4	7	7	100
12	6	6	100	3	4	75	7	9	77.8
14	5	5	100	3	3	100	6	7	85.7
15	0	0	-	1	1	100	4	7	57.1
16	1	1	100	2	2	100	a	a	a
17	0	0	-	0	0	-	0	0	-
Totals	155	170	91.1	128	131	97.7	41	48	85.4

*Rack containing yearly panels lost April 1977.

[a]Panel not removed due to winter conditions.

Table 9

Length Ranges of Living Shipworms, in mm, Yearly Panels

Date Removed:	December 4, 1977			January 6, 1978			February 4, 1978			
Station	B.g.	T.f.	T.n.	B.g.	T.f.	T.n.	B.g.	T.f.	T.n.	T.b.
1	69-193		164*	172-193						
2	8-129			10- 78						
3										
4	22-340*			77-148	94*	78*	145-223	160	148*	
5	74-210	145*		140-225			24-295	109-200*		
6	68-230			169-242						
7	321						250-278			
10										
11	73-218			68-320*		17	170-363*		44	5
12	185-310		1.5-2	300-310	21		150-315		38	7
14	158-220			134-188			5-213			
15				12			63-290			
16	77			87-142						
17										

*Largest specimen each month, each species.

Table 10

Number of Living Shipworms, Cumulative Panels Submerged May 27, 1977

Date Removed:	December 4, 1977					January 6, 1978					February 4, 1978				
Station	B.g.	T.f.	T.n.	T.sp.	Total	B.g.	T.b.	T.f.	T.n.	Total	B.g.	T.f.	T.n.	T.sp.	Total
1	0	0	1	0	1	2		0	1	3	a	a	a	a	a
2	97	1	1	0	99	52		0	0	52	54	0	0	0	54
3	0	0	0	0	0	0		0	0	0	1	0	0	0	1
4	0	2	2	0	4	3		2	0	5	7	0	0	0	7
5	5	0	3	0	8	3		0	0	3	2	0	1	0	3
6	2	0	0	0	2	4		0	0	4	a	a	a	a	a
7	2	0	0	0	2	1		0	0	1	0	0	0	0	0
8	5	1	0	0	6	10		0	1	11	1	0	1	0	2
9	2	0	0	0	2	1		0	0	1	0	0	0	0	0
10	1	0	0	0	1	1		0	0	1	3	0	0	0	3
11	11	0	0	0	11	7	1	0	0	8	12	0	0	0	12
12	4	0	0	0	4	4	1	0	0	5	3	0	0	0	3
14	1	0	0	0	1	1		0	0	1	0	0	0	0	0
15	0	1	0	0	1	0		0	0	0	0	0	3	0	3
16	4	0	0	0	4	4		0	0	4	a	a	a	a	a
17	1	0	0	0	1	0		0	0	0	0	0	0	0	0
18	0	-	-	193	193	a		a	a	a	0	-	-	213	213
19	1	0	4	0	5	0		0	0	0	0	0	1	0	1
Totals	136	5	11	193	345	93	2	2	2	99	83	0	6	213*	302

*Some too small for identification, but most identified as T. navalis; a few identified as T. furcifera. No T. bartschi.

[a]Panel not removed due to winter conditions.

Table 11

Living Shipworms Plus Empty Tubes, Cumulative Panels Submerged May 27, 1977

Date Removed:	December 4, 1977					January 6, 1978					February 4, 1978				
Station	B.g.	T.f.	T.n.	T.sp.	Total	B.g.	T.b.	T.f.	T.n.	Total	B.g.	T.f.	T.n.	T.sp.	Total
1	0	0	1	0	1	2		0	1	3	a	a	a	a	a
2	106	1	1	0	108	52		0	0	52	61	0	0	0	61
3	0	0	0	0	0	0		0	0	0	1	0	0	0	1
4	0	2	2	0	4	3		3	0	6	8	0	0	0	8
5	5	0	3	0	8	3		0	0	3	2	0	1	0	3
6	2	0	0	0	2	4		0	0	4	a	a	a	a	a
7	2	0	0	0	2	1		0	0	1	0	0	0	0	0
8	5	1	0	0	6	10		0	1	11	1	0	1	0	2
9	2	0	0	1	3	1		0	0	1	0	0	0	0	0
10	1	0	0	0	1	1		0	0	1	3	0	0	0	3
11	11	0	0	0	11	7	1	0	0	8	14	0	0	0	14
12	4	1	0	0	5	5	1	0	0	6	3	0	0	0	3
14	1	0	0	0	1	1		0	0	1	0	0	0	0	0
15	0	1	0	0	1	0		0	1	1	0	0	3	0	3
16	4	0	0	0	4	4		0	0	4	a	a	a	a	a
17	1	0	0	0	1	0		0	0	0	0	0	0	0	0
18	0	-	-	226	226	a		a	a	a	0	-	-	233	233
19	1	0	4	0	5	0		0	8	8	0	0	1	8	9
Totals	145	6	11	227*	389	94	2	3	11	110	93	0	6	241*	340

*Some too small for identification, but most identified as T. navalis; a few identified as T. furcifera.

[a]Panel not removed due to winter conditions.

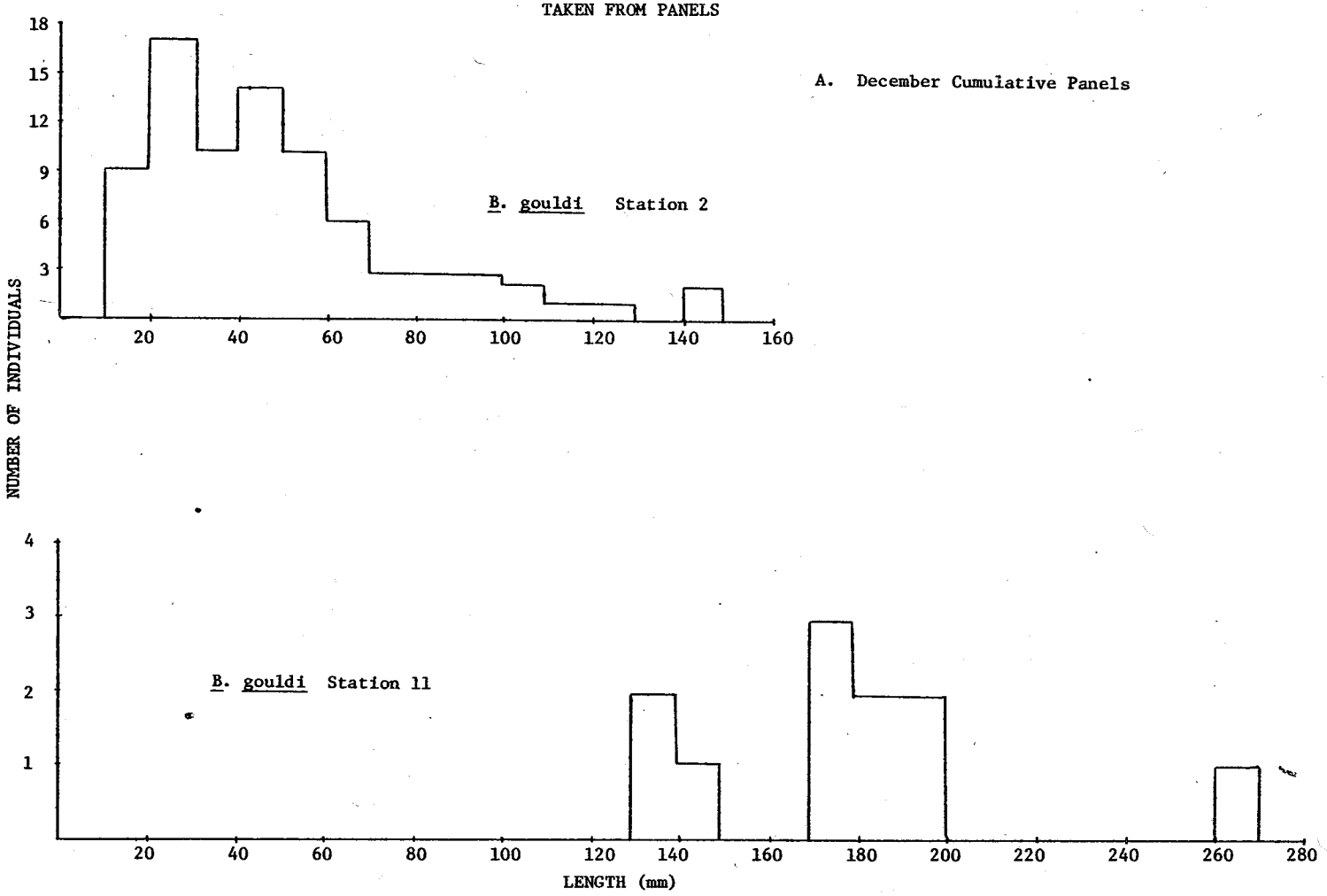
Table 12

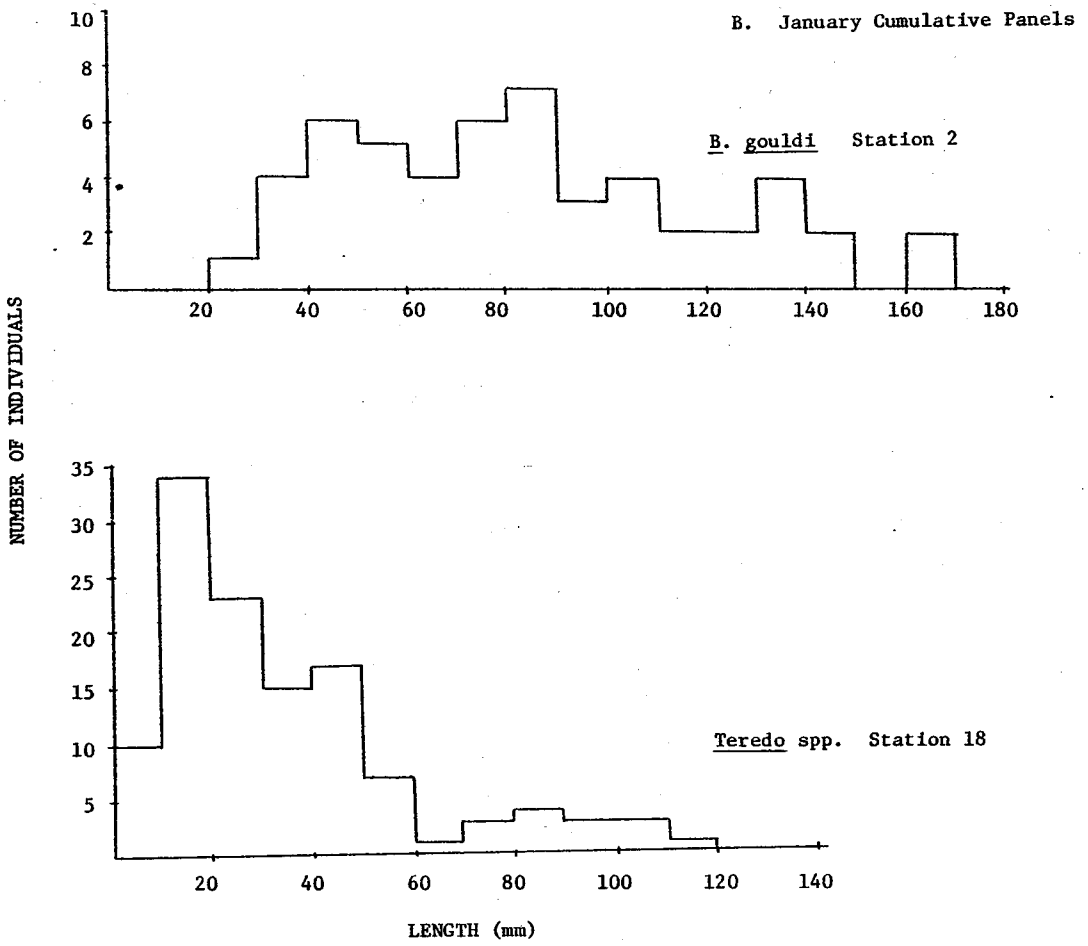
Percentage of Specimens in Cumulative Panels that were Alive when Collected

Month Collected:	December 4, 1977			January 6, 1978			February 4, 1978		
Station	Number Living Specimens	Total No. Tubes Observed	% Alive	Number Living Specimens	Total No. Tubes Observed	% Alive	Number Living Specimens	Total No. Tubes Observed	% Alive
1	1	1	100	3	3	100	a	a	a
2	99	108	91.7	52	52	100	54	61	88.5
3	0	0	-	0	0	-	1	1	100
4	4	4	100	5	6	83.3	7	8	87.5
5	7	7	100	3	3	100	3	3	100
6	2	2	100	4	4	100	a	a	a
7	2	2	100	1	1	100	0	0	-
8	6	6	100	11	11	100	2	2	100
9	2	3	66.7	1	1	100	0	0	-
10	1	1	100	1	1	100	3	3	100
11	11	11	100	8	8	100	12	14	85.7
12	4	5	80	4	5	80	3	3	100
14	1	1	100	1	1	100	0	0	-
15	1	1	100	0	1	0	3	3	100
16	4	4	100	4	4	100	a	a	a
17	1	1	100	0	0	-	0	0	-
18	193	226	85.4	a	a	a	213	233	91.4
19	5	5	100	0	8	0	1	9	11.11
Totals	344	388	88.7	98	109	89.9	302	340	88.8

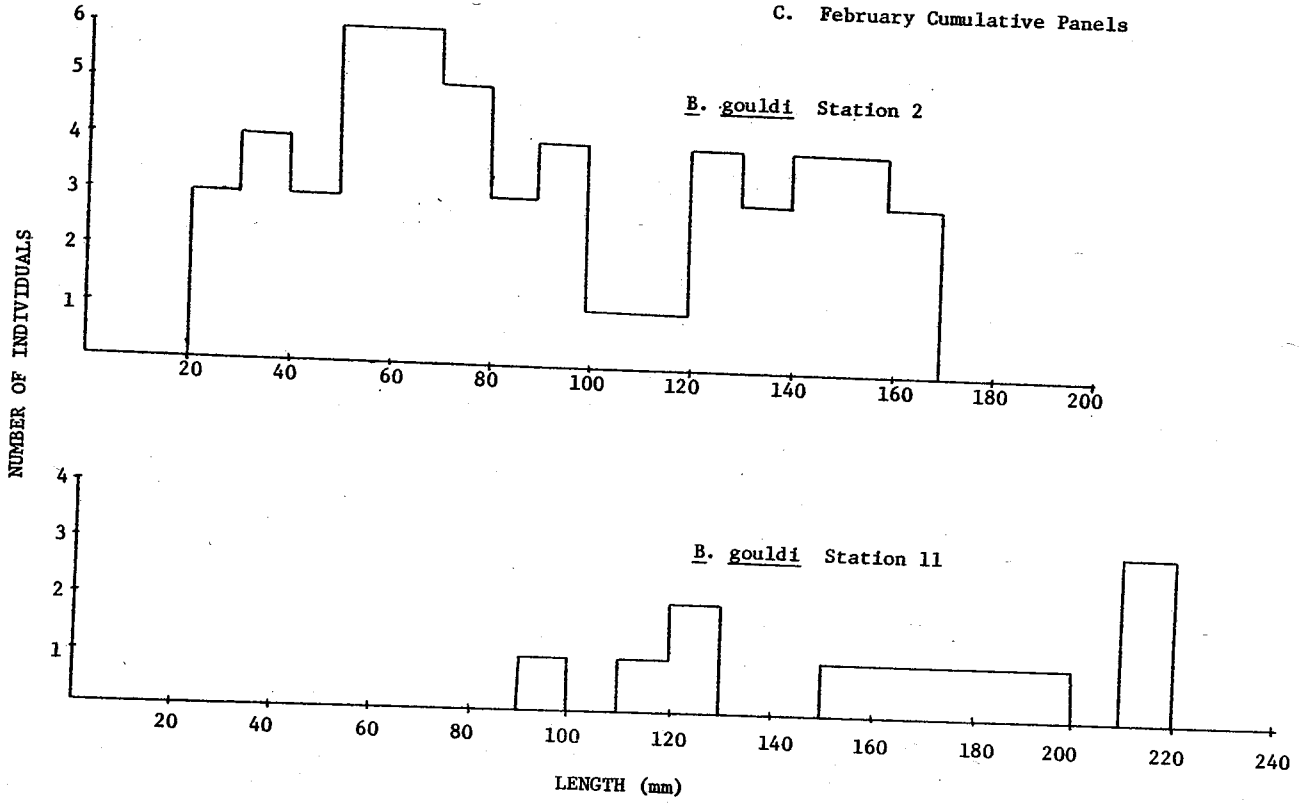
[a]Panel not removed due to winter conditions.

FIGURE 2: HISTOGRAMS OF LENGTHS OF SHIPWORMS TAKEN FROM PANELS

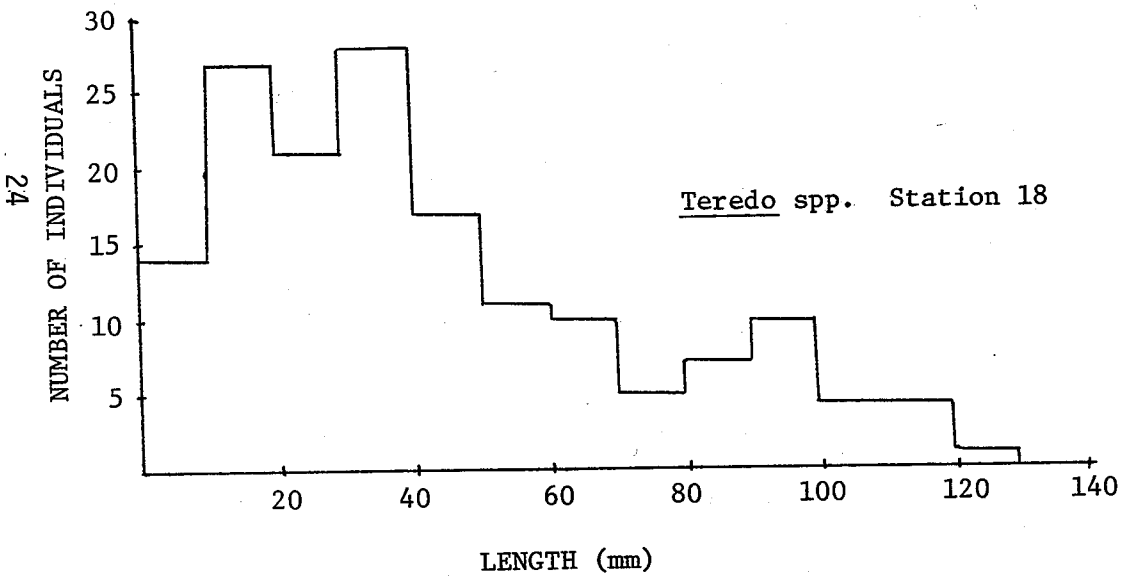



B. January Cumulative Panels
B. gouldi Station 2
Teredo spp. Station 18
NUMBER OF INDIVIDUALS
LENGTH (mm)
10
8
6
4
2
20
40
60
80
100
120
140
160
180
35
30
25
20
15
10
5

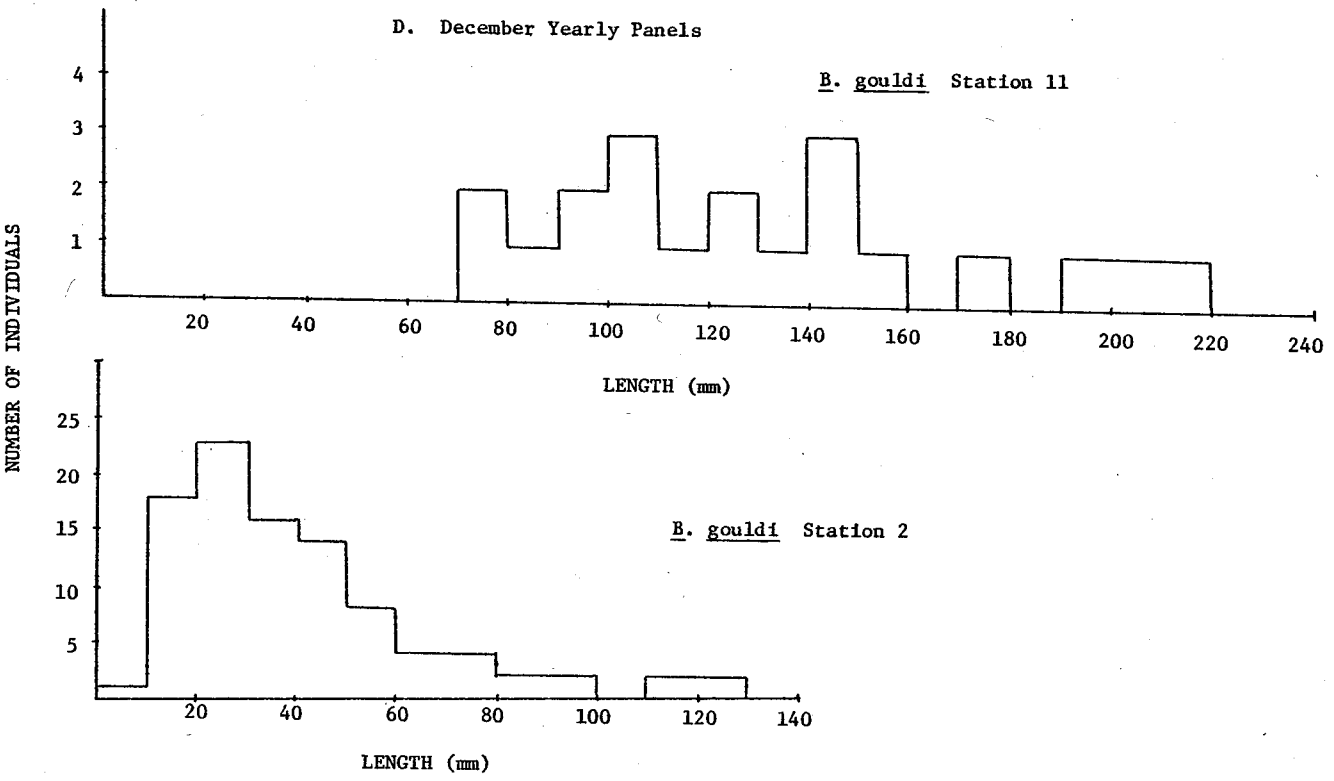
C. February Cumulative Panels



C. February Cumulative Panels, Continued



D. December Yearly Panels



E. January Yearly Panels

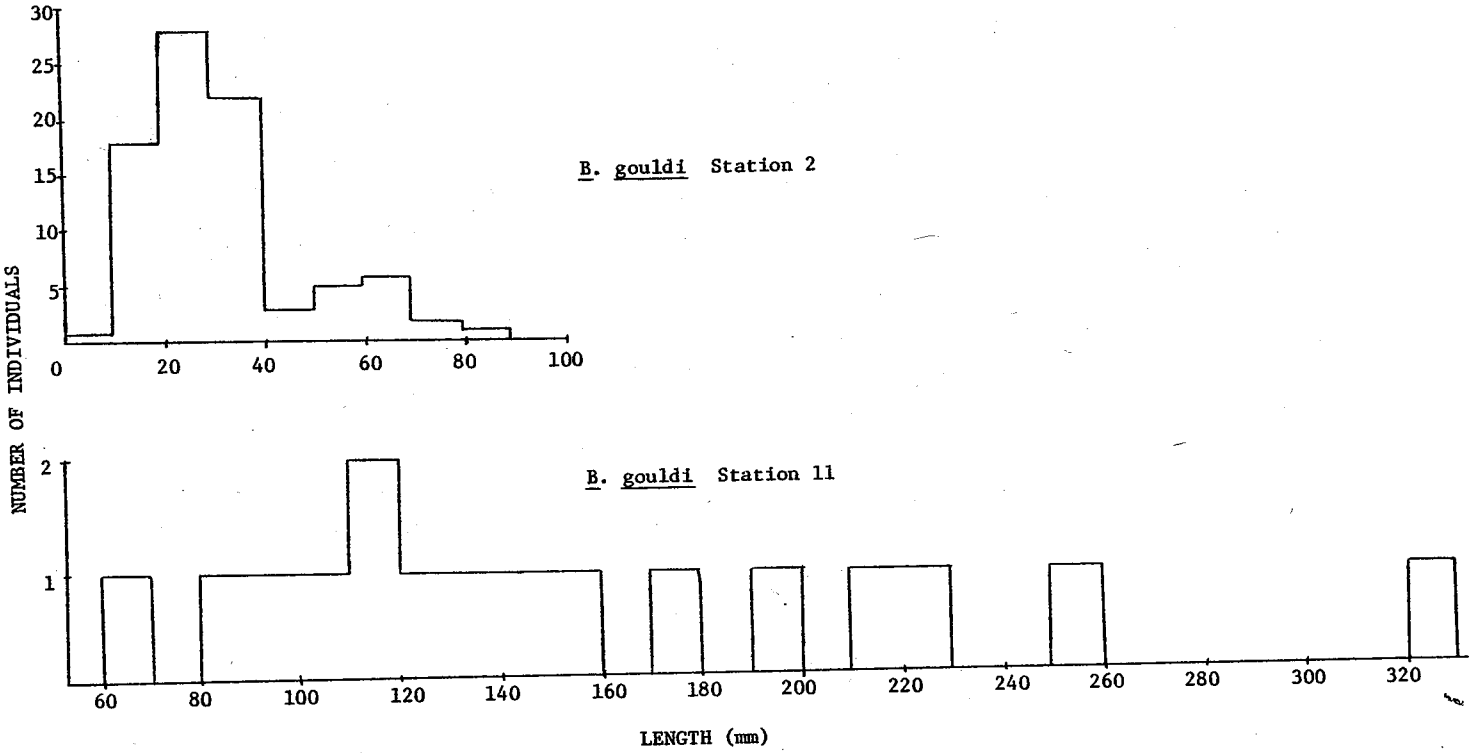


Table 13

Percentage Weight Loss by Cumulative and Yearly Panels

Station	Mar. 27, 1977 Cumulative Series Removed			Yearly Series Removed	
	Dec.	Jan.	Feb.	Dec.	Jan.
1	3.61	5.90	a	6.35	5.04
2	59.60*	53.70*	53.43*	30.37*	73.03*
3	4.01	1.98	1.24	3.68	1.18
4	5.90	7.54	5.08	7.37	15.70*
5	11.00	5.16	4.91	31.89*	0
6	7.96	10.84	a	8.48	11.94
7	8.10	4.91	4.49	7.46	1.75
8	10.15	13.39	4.25	a	a
9	a	a	a	a	a
10	1.66	3.65	15.30*	3.13	0
11	36.18*	18.50*	48.49*	49.80*	45.60*
12	18.54*	19.67*	16.86*	12.98	19.05*
14	4.34	2.99	1.50	7.48	2.31
15	0	0.23	3.36	2.08	0
16	0	4.48	a	0.21	2.46
17	1.45	0.90	1.38	2.53	0.99
18	74.70*	a	70.60*	a	a
19	3.49	7.93	6.25	a	a

*More than 15% weight loss.

[a]Missing data.

Table 14

Ash-free Gonad and Whole Body Weights, Yearly Panel Series, Yearly Panel Series, Adult Specimens of *B. gouldi* Only*
Summer, 1976-77

Mo.	Sta.	Mean Gonad Wt. ± S.D.	Mean Gonad Wt/ Total Weight ± S.D.	Body % Ash	N
June	1	.0189 ± .0103	.537 ± .087	29.4 ± 4.7	11
	2	-	-	29.5 ± 7.4	4
	10	.0989	.535	25.0	2
	11	.0226 ± .0102	.479 ± .147	33.9 ± 3.0	5
	12	.0993 ± .0801	.546 ± .042	33.0 ± 0.7	3
	14	.0186	.394	30.0	1
	15	.0129	.259	21.7	2
	16	.0799 ± .0113	.423 ± .082	20.4	3
July	1	.0070 ± .0030	.169 ± .046	40.9 ± 6.3	7
	2	.0029 ± .0019	.230 ± .111	47.3 ± 5.6	9
	5	.0047	.433	21.8	1
	10	.0395	.306	29.8	2
	14	.0214	.467	36.6	2
	17	.0222	.317	36.1	2
Aug.	1	.0050	.115	27.5	2
	4	-		28.1	2
	5	.0086	.251	43.4	2
	11	-		20.5 ± 7.8	8
	12	-		27.0	1
	17	-		24.9	2

*All specimens in each panel were examined, unless a specimen was partially decayed or broken.

FOULING ORGANISMS

Tables 15-21 give presence-absence data for the most common fouling organisms in Barnegat Bay. The format is the same as in our earlier reports.

The bryozoan Electra crustulenta began new colonies during the winter, particularly in Oyster Creek. This did not happen in the winter of 1976-77, when water temperatures were colder. E. crustulenta normally settles in fall. When fouling is relatively undisturbed, as on the yearly panel rack, E. crustulenta is widespread at all our stations. Therefore it is a species able to withstand competition from other organisms. It forms a calcareous layer on wood surfaces that makes penetration by shipworm pediveligers difficult.

Hydroides dianthus settles in summer and fall. Occassional settlement on monthly panels in January did occur, but these were cases of overgrowth from an adjoining cumulative panel. Stations of low salinity have less H. dianthus than other stations, but distribution does not depend on the thermal effluent. Like E. crustulenta, H. dianthus discourages shipworm settlement on wood, but is a troublesome fouling organism due to the massive amounts of calcium carbonate that it secretes. H. dianthus is more abundant in Oyster Creek now than in the previous year.

The pattern of colony initiation of Botryllus schlosseri was the same in the winters of 1976-77 and 1977-78. New colonies were found at a few stations in December, but not in the succeeding two months. No B. schlosseri is found in Oyster Creek or in our control creeks, but it is found in Forked River and Waretown stations adjacent to Oyster Creek.

Enteromorpha species were found on cumulative panels at most stations throughout the winter, but never conspicuously. Some of the zeros in Table 18 are probably due to the rarity of Enteromorpha and its small size at this time of year, rather than to the lack of it.

Balanus eburneus does not settle onto wood in winter. It is patchy in distribution along the coast of New Jersey in 1978, following heavy mortality in the previous winter. This large barnacle is most abundant in Oyster Creek, Holly Park (sta. 1), and upstream portions of Forked River (stas. 6, 7). B. eburneus settles on the metal racks preferentially over the wooden panels.

In 1977-78, Balanus improvisus was a winter invader whereas in 1976-77, the winter barnacle was B. balanoides. Both are smaller than

B.eburneus and are crowded out in the summer months. Stations 10-14 contained the greatest concentrations of B. improvisus.

A few Molgula manhattensis settled over winter at southern stations (14-16 and 18). It was much more common on cumulative panels in 1977 than in 1976. Lacking at control creek stations, it was most abundant in Oyster Creek. Here there could be a link with the thermal effluent. Polysiphonia, on the other hand, was less common in 1977 than in previous years.

In general, cumulative and yearly panels at a given station have similar fouling communities because many fouling organisms such as Botryllus, Hydroides, and Balanus act as annuals, dying in winter or being preyed upon or out-competed for living space in summer. The thermal plume at Oyster Creek causes more sponge and algae to grow there in spring and summer, but does not seem to control the pattern of settlement of any major fouling organism in Barnegat Bay itself. The boring isopod Limnoria tripunctata has not spread into Oyster Creek, though a few specimens were found two years ago. Encrusting bryozoa and solitary tunicates are more abundant in Oyster Creek than elsewhere during winter.

Table 15

Distribution of Some Common Fouling Organisms
Electra crustulenta

	Stations																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
December 4	x	x	x	x	x	x	x	-	-	x	x	x	x	x	x	x	-	-
January 6	x	x	x	x	x	x	x	-	-	x	x	x	x	x	x	x	-	-
February 4	a	-	x	x	x	a	x	-	-	x	x	x	x	x	a	x	-	-
B. Cumulative:																		
December 4	x	x	0	x	x	0	0	x	x	x	0	x	0	0	0	0	0	x
January 6	x	x	0	x	x	0	0	x	x	x	x	x	x	0	x	x	a	0
February 4	a	x	0	x	x	a	x	x	0	x	x	x	xR	x	a	x	x	0
C. Monthly:																		
December 4	0	0	0	0	0	0	0	xR	0	xR	xR	x	0	0	0	xR	0	0
January 6	0	0	0	0	0	0	0	0	0	x	0	x	0	x	0	x	a	0
February 4	a	0	0	0	0	a	0	0	0	x	x	x	0	0	a	x	0	0

- : No panel.
a : Panel not removed due to weather conditions.
x : Organism present.
xR: Present but rare.
0 : Absent.

Table 16

Distribution of Some Common Fouling Organisms
Hydroides dianthus

	Stations																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
December 4	x	x	x	x	x	x	x	-	-	x	x	x	x	x	x	x	-	-
January 6	x	x	x	x	x	x	x	-	-	x	x	x	x	x	x	x	-	-
February 4	a	-	0	x	x	a	xR	-	-	x	x	x	x	x	a	x	-	-
B. Cumulative:																		
December 4	x	x	x	x	x	x	0	x	xR	x	x	x	x	x	x	x	x	x
January 6	x	x	x	x	x	x	0	x	0	x	x	x	x	x	x	x	a	x
February 4	a	x	x	x	x	a	xR	x	0	x	x	x	x	x	a	x	x	x
C. Monthly:																		
December 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
January 6	0	0	0	0	0	0	0	0	0	0	0	0	xR	x	0	x	a	0
February 4	a	0	0	0	0	a	0	0	0	0	0	0	0	0	a	0	0	0
D. On Rack or Cement Only:																		
December 4																		
January 6									x									
February 4									x									

- : No panel.
a : Panel not removed due to weather conditions.
x : Present.
xR: Present but rare.
0 : Absent

Table 17

Distribution of Some Common Fouling Organisms
Botryllus schlosseri

	Stations																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
December 4	0	x	0	x	xR	x	0	-	-	0	0	0	x	0	x	0	-	-
January 6	0	0	0	0	x	x	0	-	-	0	0	0	x	0	0	0	-	-
February 4	a	-	0	0	x	a	0	-	-	0	0	0	x	0	a	0	-	-
B. Cumulative:																		
December 4	x	x	0	0	x	x	0	x	0	0	0	0	x	0	0	0	0	x
January 6	x	x	0	0	x	x	0	x	0	0	0	0	x	0	0	0	a	0
February 4	a	x	0	0	x	a	0	x	0	0	0	0	x	0	a	0	x	x
C. Monthly:																		
December 4	0	0	0	0	x	xR	0	xR	0	0	0	0	xR	0	0	0	0	0
January 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	0
February 4	a	0	0	0	0	a	0	0	0	0	0	0	0	0	a	0	0	0
D. On Block or Rack Only:																		
December 4									x									
January 6				x														
February 4															x			x

- : No Panel
a : Panel not removed due to weather conditions.
x : Present.
xR: Present but rare.
0 : Absent.

Table 18

Distribution of Some Common Fouling Organisms
Enteromorpha spp.

	Stations																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
December 4	0	0	x	x	0	x	x	-	-	x	x	0	x	0	xR	0	-	-
January 6	0	0	x	0	x	x	x	-	-	x	x	x	0	x	x	0	-	-
February 4	a	-	x	0	x	a	x	-	-	x	x	x	0	0	a	0	-	-
B. Cumulative:																		
December 4	0	0	x	x	0	x	x	x	x	0	x	x	0	x	x	0	x	x
January 6	0	0	x	x	0	x	0	0	0	x	0	x	x	0	0	0	a	x
February 4	a	x	x	0	xR	a	x	0	xR	x	x	0	0	x	a	xR	x	x
C. Monthly:																		
December 4	0	0	xR	0	0	0	0	xR	0	0	0	0	0	0	x	0	0	x
January 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	0
February 4	a	0	xR	0	0	a	0	0	0	0	0	0	0	0	a	0	xR	0
D. On Block or Rack Only:																		
December 4	x																	
January 6																x		
February 4																		

- : No Panel.
a : Panel not removed due to weather conditions.
x : Present.
xR: Present but rare.
0 : Absent.

Table 19

Distribution of Some Common Fouling Organisms
Balanus eburneus

		Stations																
		1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A.	Yearly:																		
	December 4	x	x	x	0	0	x	x	-	-	x	x	x	xR	0	x	0	-	-
	January 6	x	x	x	0	x	x	x	-	-	x	x	x	x	x	x	xR	-	-
	February 4	a	-	x	0	x	a	x	-	-	x	x	x	x	x	a	0	-	-
B.	Cumulative:																		
	December 4	x	x	x	0	0	x	x	0	0	x	x	x	x	0	0	0	x	x
	January 6	x	x	x	0	0	x	x	0	0	x	x	x	x	0	0	0	a	x
	February 4	a	x	x	0	xR	a	x	x	0	x	x	x	x	0	a	x	x	x
C.	Monthly:																		
	December 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	January 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	a	0
	February 4	a	0	0	0	0	a	0	0	0	0	0	0	0	0	a	0	0	0
D.	On Block or Rack Only:																		
	December 4					x			x	x					x		x		
	January 6								x	x									x
	February 4									x									

- : No Panel.
a : Panel not removed due to weather conditions.
x : Present.
xR: Present but rare.
0 : Absent.

Table 20

Distribution of Some Common Fouling Organisms
Balanus improvisus

	Stations																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
December 4	x	0	0	x	xR	0	x	-	-	x	x	x	x	x	x	0	-	-
January 6	0	0	0	xR	x	x	0	-	-	x	x	x	x	0	x	0	-	-
February 4	a	-	0	x	x	a	x	-	-	0	0	0	0	x	a	0	-	-
B. Cumulative:																		
December 4	0	x	x	x	x	0	xR	x	xR	x	x	x	x	0	0	0	x	0
January 6	x	0	0	x	0	0	0	x	0	x	x	x	xR	0	0	0	a	0
February 4	a	xR	0	0	xR	a	0	0	0	x	0	0	x	0	a	0	0	0
C. Monthly:																		
December 4	x	x	0	x	0	xR	xR	x	0	x	xR	x	x	x	xR	0	x	x
January 6	0	0	0	0	0	xR	0	x	0	xR	xR	x	x	xR	x	0	a	0
February 4	a	0	0	0	0	a	0	0	0	0	xR	xR	0	0	a	0	x	0

- : No Panel.
a : Panel not removed due to weather conditions.
x : Present
xR: Present but rare
0 : Absent.

Table 21

Distribution of Some Common Fouling Organism
Molgula manhattensis

	Stations																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
December 4	x	x	0	x	x	x	0	-	-	x	x	x	x	x	x	0	-	-
January 6	x	x	0	0	x	x	0	-	-	x	x	x	x	x	x	0	-	-
February 4	a	-	0	x	x	a	0	-	-	x	0	x	x	x	a	0	-	-
B. Cumulative:																		
December 4	x	x	0	0	x	x	0	x	0	x	x	x	x	x	x	0	0	x
January 6	x	x	0	0	x	x	0	x	0	x	x	x	x	x	x	0	a	x
February 4	a	x	0	0	x	a	0	x	0	x	x	xR	x	x	a	0	0	x
C, Monthly:																		
December 4	0	0	0	0	0	0	0	0	0	0	0	0	xR	xR	x	0	0	0
January 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	xR	0	a	0
February 4	a	0	0	0	0	a	0	0	0	0	0	0	0	0	a	0	xR	0
D. On Rack or Block Only:																		
December 4																		
January 6				x														
February 4																		

- : No Panel.
a : Panel not removed due to weather conditions.
x : Present.
xR: Present but rare.
0 : Absent.

DISCUSSION

Our data, both physical and biological, are similar for the winters of 1976-77 and 1977-78. Marine borers are not proliferating during winter months, and fouling activity is light and limited to a few species. Oyster Creek has higher species diversity in winter than in summer. The fouling fauna of Oyster Creek continue to possess elements typical of tidal creeks and of the open bay.

We have confirmed that a few Teredo bartschi are still to be found in Oyster Creek. We have evidence that the species is breeding in the creek. One specimen collected in January contained straight-hinge larvae in the gill. The major difference between our reports of the past 1 1/2 years and those of Battelle, Clapp Laboratories (1) is the species composition of the shipworm community in Barnegat Bay. Since January 1976 we regularly have found Teredo furcifera at stations outside Oyster Creek, for example in the mouth of Forked River and at Long Beach Island (rarely). Clapp Labs have reported T. bartschi from Oyster Creek more consistently than we have, and T. furcifera only occasionally at the mouth of Oyster Creek. We have written to the Clapp Laboratories for specimens to compare identifications. We have rechecked our own specimens and find no T. bartschi other than those mentioned in this report.

Our specimens of T. bartschi are very small, usually less than 10 mm long, and have proportionally smaller pallets than do specimens of T. navalis or T. furcifera. The pallets themselves are proportionally wider, and are covered distally by dark brown periostracum. Therefore the species is easy to recognize. On the other hand, T. navalis and T. furcifera are difficult to separate on the basis of pallets alone.

REFERENCES

1. Richards, B. R., A. E. Rehm, C. I. Belmore, and R. E. Hillman, 1976 (Nov. 30). Annual Report for the period June 1, 1975 to May 31, 1976, on Woodborer Study Associated with the Oyster Creek Generating Station, to Jersey Central Power and Light Company. Report Number 14729, 15 pp. and 4 Appendices.

APPENDIX

STATION NUMBER	NAME	DESCRIPTION	COORDINATES
1	Holly Park	Dick's Landing Island Drive Bayville, N.J. Bay control	Lat. 39° 54' N Lon. 74° 8.1' W
2	Cedar Creek	Last Lagoon toward mouth South Side Estuarine control	39° 52' N 74° 8.5' W
3	Stout's Creek	End of Raleigh Drive Gustav Walters' residence Estuarine control	39° 50.7' N 74° 9' W
4	Mouth of Forked River	South Shore Developed property Possible temperature increase; increased oceanic influence due to reverse flow	39° 49.4' N 74° 9.8' W
5	Leilani Drive	At branch point of Forked River	74° 49.6' N 74° 10.9' W
6	Elk's Club	South Branch Forked River Increase in salinity due to plant intake canal	39° 49.4' N 74° 10.9' W
7	Grant's Boats	Middle Branch, Forked River just S. of State Marina	39° 49.6' N 74° 11.6' W
8	Bayside Beach Club	On bay between Oyster Creek and Forked River across from 1815 Beach Blvd., Forked River, N.J. Temperature increase since plant operation.	39° 49.0' N 74° 9.7' W
**9	Intake Canal	House closest to intake canal Salinity effect; strong current upstream	39° 49.2' N 74° 12.2' W

**Stations new as of May 27, 1977

STATION NUMBER	NAME	DESCRIPTION	COORDINATES
10	Kochman's Residence	End of Compass Rd. on #1 Lagoon, Oyster Creek, Waretown, N.J. Temperature, salinity, siltation increase	Lat. 39° 48.5' N Lon. 74° 10.9' W
11	Crisman's Residence	Dock Ave. on Oyster Creek, Waretown, N.J. Temperature, salinity, siltation increase	39° 48.5' N 74° 11.0' W
12	Gilmore's Residence	20 Dock Ave. on Oyster Creek, Waretown, N.J. Temperature, salinity, siltation increase	39° 48.5' N 74° 11.3' W
**13	Rte 9 Bridge	Oyster Creek just below discharge canal Temperature, salinity increase	39° 48.7' N 74° 12' W
14	Cottrell's Clam Factory	End of North Harbor Rd. Waretown, N.J. (Mouth of Waretown Creek) Within reported thermal plume	39° 47.7' N 74° 10.9' W
15	Carl's Boats	Washington & Liberty Sts. Waretown, N.J. (on the bay) To test for tropical species and increases in populations of borers as a result of breeding elsewhere	39° 47' N 74° 11' W
16	Iggie's Marina	East Bay Ave, Barnegat, N.J. Same purpose as Loc. 15	39° 45' N 74° 11.5' W
17	Manahawkin Bay	At bridge to Long Beach Island Same purpose as Loc. 15	39° 40' N 74° 13' W
**18	Barnegat Light	Marina adjacent to Coast Guard Station	39° 15' N 74° 53' W
**19	Long Beach Island	Bayview Marina	39° 17.4' N 74° 54' W

**Stations new as of May 27, 1977

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