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PRELIMINARY

Effect of Nuclear Power Plants on

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 JUNE 1-AUGUST 31, 1977

Quarterly

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SUMMARY OF FINDINGS

1. Shipworms in Oyster Creek declined in 1976-1977, compared with the period 1970-1975. Shipworms in Forked River remain at high levels.

2. Shipworm attack is more severe north of Oyster Creek than south of it. *B. gouldi* is the dominant species in estuaries. *T. navalis* is dominant on Long Beach Island. Shipworm settlement is patchy, and is greater where there is some water circulation than in stagnant areas.

3. *Teredo furcifera* continues to be found in Oyster Creek and Forked River.

4. *Teredo bartschi* has not been found by us in Oyster Creek since 1975.

5. Shutdown of the power plant in the spring of 1977 kept shipworms in Oyster Creek from having an early breeding season.

6. Studies of gonad biomass of the shipworms indicated no differences in reproductive output in Oyster Creek relative to control areas. All animals had much reduced gonads in August, compared with June. The end of the breeding season is correlated with gonad depletion.

7. Temperature profiles show that some of the heated effluent is drawn back into Forked River.

8. Water flow in the south branch of Forked River, in the mouth of the river, and in a canal that joins Forked River Beach and Forked River is in the direction of the power plant, when the plant is operating its pumps. Shipworm larvae are drawn up into Forked River by this current.

9. Two fouling organisms are found in Oyster Creek only when the plant is not operating.

10. The wood-boring isopod *Limnoria* does not co-occur in large numbers with shipworms. Heavy growth of tube worms (*Hydroides*) and colonial tunicates (*Botryllus*) appears to interfere with shipworm settlement on wood panels.

11. Removal of marina wood appears to have been effective in reducing the shipworm problem in Oyster Creek. It had no impact on Forked River, however.

12. Reduced temperature of the heated effluent may have been effective in reducing the shipworms' breeding season, but we need further study of this point in years when the plant is not shut down in Spring.

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INTRODUCTION

This report summarizes the first year's study of the effect of the Oyster Creek Nuclear Generating Station on populations of boring and fouling organisms. We present data from the fourth quarter's work, June 1 - August 31, 1977, then discuss the results from the entire year's work. Detailed accounts of the experimental design and the data for the first three quarters are in earlier reports and are not duplicated here. Because many of the field stations were established prior to our being funded under this contract, we are able to compare results of shipworm monitoring over several years. The primary purpose of the study at present is to discover how changes in the power plant's operations (removal of wood from Oyster Creek, reduction of the temperature of the heated effluent, measures to reduce siltation) have affected the size and reproductive potential of marine borer populations. A secondary purpose is to determine if there are community interactions between species of shipworms and fouling organisms. This question will be addressed in this report.

Shipworm station 13 at the discharge channel just below the plant was lost during the period covered by this report. All other test stations are as reported in Appendix A of our third quarterly report, reprinted here.

Multivariate analysis of the fouling communities at the fifteen stations using our first year's biological data coupled with meteorological and oceanographic data is in progress. Preliminary results are included here. One hindrance in our attempt to correlate meteorological events with water temperatures was the shutdown of the weather station at Tom's River, New Jersey, in 1976. This leaves us with only the Barnegat station, making it difficult to tell how the weather varies over the range of our test sites.

MAJOR PHYSICAL EVENTS

Temperature

Table 1 and figure 1 present temperatures recorded at the time of sampling, June - August, 1977. Missing data were due to a broken thermometer. The power plant did not operate between April 23 - August 4, 1977. The temperature differential between Oyster Creek and other stations in early August was 2 - 3° C, and was not significantly different from the temperature at Stout's Creek, an estuarine creek containing a natural thermal source.

Table 2 summarizes constant temperature recorder data over the period June 6 - September 6, 1977. When the power plant was operating, the mean temperature elevation in Oyster Creek was 3.7° C above the next highest station, which was in Forked River (station 5). Temperatures at station 14 during June 6 - July 7 are low because the pen failed to record except for the first five days of the period.

No temperatures lethal to invertebrates were recorded during the June 6 - September 6, 1977 period. The maximum temperature was 32.3° C (90° F).

Salinity

Salinity profiles are reported in tables 3 and 4. A general increase in salinity during the summer is due to less freshwater runoff. Stations 3 and 7, high up in tidal creeks, have the lowest salinity, as seen in our previous reports. The new stations on Long Beach Island (18 and 19) have the highest salinity as expected from their positions offshore. In June, Oyster Creek stations were lower in salinity than usual. Plant maintenance operations curtailed the flow of water through the plant circulation pumps during this period, according to M. Roche (personal communication). In August, salinity levels in Forked River and Oyster Creek were again at bay levels.

Some of the variation between and within stations is caused by tidal effects, since the stations cannot be sampled simultaneously on the same tide. A correction factor will be possible when constant recording conductivity instruments are operating. These instruments were received in mid September, 1977, and are now being placed at four stations. The salinity differential within stations is lowest

for bay stations and highest for those on creeks or rivers.

Suspended Solids

In table 5 are data on suspended solids. After completing a year of such tests, we have decided that individual sample variation makes interpretation of the quantitative data difficult, hence we have discontinued taking silt samples. The overall pattern has been high silt in Oyster Creek (especially station 11) and at station 17 (Manahawkin), with high silt also in Forked River when power plant pumping was curtailed. If there is any change in plant operations, if dredging is done, or if we notice changes in existing siltation or erosion patterns, we will reinstitute quantitative sampling of suspended solids. Meanwhile, we are performing turbidity tests in the field using a Sechi disk.

Plant Operations

Data provided by M. Roche of Jersey Central Power and Light Company on flow rates and plant outages are provided in table 6. Circulation pumps were out of service while the condensers were serviced in the spring of 1977.

TABLE 1:

TEMPERATURE PROFILES, IN DEGREES CENTIGRADE

Station	June 6	July 7	August 8	Differential within stations
1	a	23.9	27.0	3.1[a, b]
2	a	24.4	29.0	4.6[a]
3	20.0	25.5	31.0	11.0
4	25.0[c]	25.0	28.0	3.0
5	23.9	25.0	27.5	3.6
6	17.8[b]	24.4	28.5	10.7
7	18.9	25.5	28.0	9.1
8	24.4	24.4	28.0	3.6
9	17.8[b]	25.0	28.0	10.2
10	18.9	26.1	31.5	12.6[c]
11	18.9	25.8	31.0	12.1
12	22.2	26.1	32.5[c]	10.3
13	21.4	d	d	d
14	19.4	28.0[c]	29.0	7.6
15	18.9	25.0	29.5	10.6
16	18.9	25.5	29.5	10.6
17	18.9	25.0	28.0	9.1
18	a	20.5[b]	25.5[b]	5.0[a]
19	a	21.1	27.0	5.9[a]
	7.2	7.5	7.0	
State of Power Plant	off	off	recently on	

Note: [a]missing data [b]lowest monthly value

[c]highest monthly value [d]station lost

FIGURE 1:
MONTHLY TEMPERATURES, JUNE-AUGUST, 1977

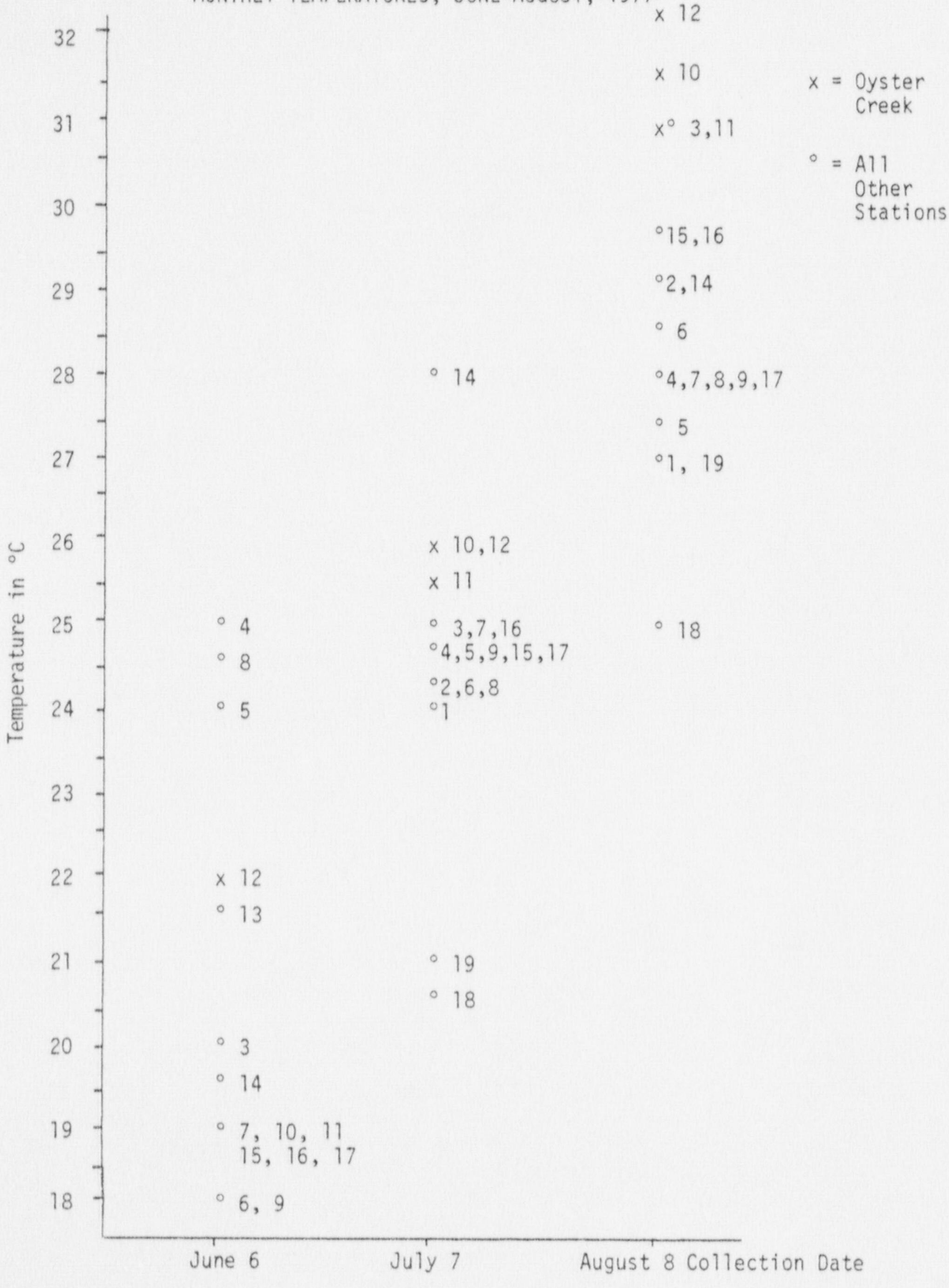


TABLE 2:

CONSTANT TEMPERATURE RECORDER DATA, °C, FOR JUNE 6, 1977-SEPT. 6, 1977
STATIONS 1, 5, 11 AND 14

I. Temperature at 1:00 PM

	June 6-July 7				July 7-Aug. 8				Aug. 8-Sept. 6			
	1	5	11	14	1	5	11	14	1	5	11	14
Mean Daily Temp. at 1 PM	22.2	22.3	22.6	--*	24.9	25.8	25.1	26.6	23.5	26.5	30.2	26.0
Standard Deviation	2.9	2.7	3.2	--*	1.7	1.9	2.2	1.9	1.6	1.8	1.3	1.4
Highest value of Temp. at 1 PM	25.8	26.9	25.9	18.6*	28.0	28.5	28.6	30.4	26.4	29.7	32.0	29.8
Lowest value of Temp. at 1 PM	16.3	16.8	15.7	16.4	21.9	22.1	21.7	23.8	21.1	22.9	27.2	23.5
Monthly Temp. Range at 1 PM	9.5	10.1	10.2	2.2*	6.1	6.4	6.9	7.6	5.3	6.8	4.8	6.3

II. Maximum Daily Temperatures

	June 6-July 7				July 7-Aug. 8				Aug. 8-Sept. 6			
	1	5	11	14	1	5	11	14	1	5	11	14
Mean value of Max. Daily Temperatures 1 Month	23.0	23.7	23.0	--*	25.8	27.5	26.7	26.8	24.3	27.4	30.9	26.2
Standard Deviation	2.9	3.2	3.2	--*	1.5	1.8	2.0	1.8	1.5	1.6	1.2	1.6
Highest value of Max. Daily Temperatures	26.6	27.4	26.4	19.3*	28.4	31.0	30.9	30.4	27.3	29.7	32.3	30.0
Lowest value of Max. Daily Temperatures	16.9	17.2	16.3	16.6	23.4	25.1	24.1	23.9	22.2	24.3	28.4	23.8
Monthly range of Max. Daily Temperatures	9.7	10.2	10.1	2.7*	5.0	5.9	6.8	7.5	5.1	5.4	3.9	6.2

TABLE 2: CONTINUED

III. Minimum Daily Temperature

	June 6-July 7				July 7-Aug. 8				Aug. 8-Sept. 6			
	1	5	11	14	1	5	11	14	1	5	11	14
Mean value of Min. Daily Temperatures, 1 month	21.8	21.5	20.6	--*	24.5	25.0	24.6	25.0	23.2	25.7	29.7	24.9
Standard Deviation	3.0	3.1	3.2	--*	1.6	1.6	1.7	1.4	1.7	1.9	1.5	1.5
Highest value of Min. Daily Temperature	25.1	26.5	25.2	17.2*	27.4	27.4	28.5	27.4	25.8	28.4	31.0	28.1
Lowest value of Min. Daily Temperature	16.1	15.5	14.7	16.0	21.3	21.9	21.7	22.9	20.8	22.1	26.4	22.6
Monthly range of Min. Daily Temperatures	9.1	11.0	10.5	1.2*	6.1	5.5	0.8	4.5	5.0	6.3	4.6	5.5

IV. Daily Temperature Range

	June 6-July 7				July 7-Aug. 8				Aug. 8-Sept. 6			
	1	5	11	14	1	5	11	14	1	5	11	14
Mean Daily ΔT	1.2	2.3	2.4	--*	1.3	2.5	2.1	1.8	1.1	1.7	1.2	1.3
Standard Deviation	0.7	0.8	1.2	--*	0.7	1.0	0.8	0.7	0.6	0.7	0.6	0.8
Largest Daily ΔT for 1 Month	2.8	3.5	7.4	1.5*	2.9	4.6	3.4	3.4	2.2	2.8	2.2	4.1
Smallest Daily ΔT for 1 Month	0.3	0.5	1.1	0.6	0.4	1.0	0.5	0.5	0.0	0.6	0.2	0.4

*Thermometer did not record beyond June 10, 1977.

TABLE 3:

SALINITY PROFILES, in °/oo

Station	June 6	July 7	August 8	Differential within stations
1	22.0	25.0	27.25	5.3
2	21.3	28.0	26.0	6.7
3	20.3[a]	20.0[a]	25.2	5.2
4	27.0	28.0	29.75	2.8
5	28.5	27.5	28.0	1.0
6	27.8	25.5	28.5	3.0
7	21.3	23.0	24.5[a]	3.2
8	28.0	28.0	29.5	1.5
9	26.0	b	29.0	3.0[b]
10	23.0	26.5	27.0	4.0
11	25.0	27.0	28.0	3.0
12	24.5	28.0	28.5	4.0
13	24.0	b	b	b
14	26.5	29.0	29.5	3.5
15	28.8	30.0	31.0	2.2
16	30.0[c]	29.5	30.0	0.5
17	29.5	32.0[c]	32.0	2.5
18	b	32.0[c]	32.5[c]	0.5[b]
19	b	32.0[c]	32.5[c]	0.5[b]
	9.7	12.0	8.0	

Note: [a]lowest monthly value

[b]missing data

[c]highest monthly value

TABLE 4:

RANKING OF STATIONS BY SALINITY, LOW TO HIGH

Rank	June 6	July 7	August 8
1	3	3	7
2	7	7	3
3	2	1	2
4	1	6	10*
5	10*	10*	1
6	13*	11*	5, 11*
7	12*	5	
8	11*	2, 4, 8, 12*	6, 12*
9	9		
10	14		9
11	4		8, 14
12	6	14	
13	8	16	4
14	5	15	16
15	15	17, 18, 19	15
16	17		17
17	16		18, 19
18			

*Oyster Creek

TABLE 5:

SUSPENDED SOLIDS (Turbidity)[a]

Station	June 6	July 7	August 8
1	2.2	13.0[b]	2.3
2	3.9	6.0	3.8
3	8.6	8.0	3.2
4	11.5[b]	4.6	5.5
5	12.0[b]	15.5[b]	3.3
6	11.9[b]	4.2	2.3
7	5.4	4.0	2.3
8	13.2[b]	3.4	3.3
9	5.0	5.6	7.8
10	4.8	4.9	2.3
11	3.6	3.6	4.9
12	26.0[b]	5.0	26.0[b]
13	6.3	c	c
14	5.7	3.7	2.5
15	4.3	2.5	2.6
16	4.1	1.7	3.7
17	3.0	4.4	66.0[b]
18	c	2.9	2.1
19	c	1.8	5.3

Note: [a]Values are in nephelometric units, and are the average of two samples.

[b]High values.

[c]No data.

TABLE 6:

OYSTER CREEK STATION

Month	Avg. No. Dilution Pumps Per Month	Gal/Min. Dilution Pumps[a]	Avg. No. Circulation Pumps Per Month	Gal/Min. Circ. Pumps[b]	Total Pumping Gal/Min. Per Month	Avg. Chlorine Discharge Per Month, ppm
1976						
Jul.	1.83	475,800	4	460,000	935,800	.05
Aug.	1.92	499,200	4	460,000	959,200	.04
Sept.	1.55	403,000	4	460,000	863,000	.07
Oct.	1.43	371,800	4	460,000	831,800	.05
Nov.	2	520,000	3.99	458,850	978,850	.08
Dec.	1.92	499,200	3.84	441,600	940,800	.11
1977						
Jan.	1.01	262,600	3.23	371,450	634,050	.12
Feb.	1.43	371,800	3.49	401,350	773,150	.09
Mar.	1.89	491,400	4	460,000	951,400	.07
Apr.	1.63	423,800	3.77	433,550	857,350	.07
May	----	-------	----	-------	-------	---
Jun.	----	-------	----	-------	-------	---
Jul.	----	-------	----	-------	-------	---

Outage dates

Jul 28 - Jul 31, 1976

April 23 - Aug 4, 1977

Note: [a]260,000 gal/min. per pump

[b]115,000 gal/min. per pump

(Data from J. C. P. & L. Co.)

SHIPWORMS

Data on shipworms are summarized in tables 7-16. Only in August and only at station 2 was there a large set of young shipworms on year-old panels. B. gouldi is by far the dominant species among the older specimens. Mortality rates of B. gouldi are in the same range as those of T. furcifera (table 9). Regardless of month of submergence, populations of shipworms within test panels are similar in density and size ranges after a full year in the water. Greater density of shipworms seems to be correlated with higher mortality rates.

Tables 10-12 present initial data from the panel series begun on May 27, 1977. Panels retrieved in June contained no shipworms, showing that there was no early breeding season due to the power plant's operations. But neither was the power plant operating during this period.

Between June 6 and July 7, shipworm settlement began. Teredo species were too small to identify positively. The pattern of Teredo settlement is as in the summer of 1976, except that none so far have been found at the mouth of Oyster Creek (station 10). We predicted that Teredo settlement would be heavy at Long Beach Island relative to the more inshore species B. gouldi. Indeed this is borne out (station 18). At the time we established the Long Beach Island stations, the marina owners told us that station 18 has long had serious shipworm problems, but station 19 has no recent history of shipworm attack. Our first three months' data support this account. We are preparing to examine local current patterns and water quality to try to explain the patchy settlement of shipworms on Long Beach Island.

Shipworm settlement in Oyster Creek and Forked River is not at outbreak level as it is at stations 2 (mouth of Cedar Creek) and 18 (near Barnegat Light). However, both Oyster Creek and Forked River have more shipworms than estuarine control station 3 (Stout's Creek). Shipworm settlement at station 7 (Middle Branch, Forked River) is unusual compared with 1976, and may be due to low rainfall and higher-than-usual salinity.

Table 12 shows that some mortality of B. gouldi occurred almost immediately upon settling. This is a natural phenomenon, unrelated to power plant operation.

Shipworm size in yearly panels is complicated by the presence of

two year classes (table 13). This causes the scatter below the diagonal in figure 2. In panels not containing the 1977 year class (e.g., June panels), Oyster Creek specimens tend to be larger than specimens from other panels with the same degree of crowding (e.g., stations 14, 15, and 16). The largest specimens recorded in table 13 were from Oyster Creek.

Tables 14 and 15, mean lengths and ranges of 1977-year class shipworms, indicate that initial settlement and growth of Teredo species was faster than that of Bankia gouldi. B. gouldi is normally the larger species. Because the power plant was not operating except for the last few days of the period, we do not expect and do not see any growth differential between Oyster Creek and the other stations.

Figure 3 presents size-class histograms for shipworms at stations when $N \geq 10$. The entrance of the second year class is seen in figure 3-C. The majority of the first year class has died.

Estimation of the amount of wood destroyed (table 16) from x-ray negatives reveals Oyster Creek yearly panels roughly in an intermediate position between the northern stations (1, 2, 4) and the southern (15-17) and estuarine control (3, 7) stations.

Beginning in June, 1977, the gonads of adult Bankia gouldi were dissected from the body, and both body and gonad were dried and weighed. Proportionally, gonad weight tends to increase with body weight and length. The ratio of gonad weight to body weight in Oyster Creek and Forked River was not significantly different from other stations. In June, the gonads comprised about 45% of the total body weight. In July, the value was down to about 20%, except at station 14 where it remained at 43%, down from 48%. In August, most values were below 20%, indicating continued spawning over the summer period.

TABLE 7:

NUMBERS OF LIVING SHIPWORMS IN PANELS SUBMERGED FOR ONE YEAR

Date Removed	JUNE 6, 1977				JULY 7, 1977				AUGUST 8, 1977			
STATION	B.g.	T.f.	T.n.	TOTAL	B.g.	T.f.	T.n.	TOTAL	B.g.	T.f.	T.n.	TOTAL
1	14	0	0	14	7	0	0	7	9	0	0	9
2	14	0	0	14	19	0	0	19	106	1	0	107
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	6	2	0	8
5	0	0	0	0	1	0	0	1	9	0	0	9
6	0	0	0	0	0	0	0	0	1	0	0	1
7	0	0	0	0	0	0	0	0	0	0	0	0
8	*	*	*	*	*	*	*	*	*	*	*	*
10	2	0	0	2	3	0	0	3	0	0	0	0
11	9	0	0	9	2	0	0	2	13	0	0	13
12	3	0	0	3	0	0	0	0	3	0	0	3
14	3	0	1	4	2	1	1	4	1	0	0	1
15	2	0	0	2	1	1	0	2	1	0	0	1
16	3	0	0	3	0	0	0	0	1	0	0	1
17	0	0	0	0	5	0	0	5	2	0	0	2
	50	0	1	51	40	2	1	43	152	3	0	155

*Rack containing yearly panels lost April 1977.

B.g. = *Bankia gouldi* T.n. = *Teredo navalis* T.f. = *Teredo furcifera*

TABLE 8:

NUMBERS OF LIVING SHIPWORMS PLUS EMPTY TUBES, PANELS SUBMERGED FOR ONE YEAR

Date Removed	JUNE 6, 1977				JULY 7, 1977				AUGUST 8, 1977			
STATION	B.g.	T.f.	T.n.	TOTAL	B.g.	T.f.	T.n.	TOTAL	B.g.	T.f.	T.n.	TOTAL
1	24	0	0	24	7	0	0	7	9	0	0	9
2	14	0	0	14	24	0	0	24	106	1	0	107
3	0	0	0	0	0	0	0	0	0	0	0	0
4	19	0	0	19	a	a	a	a	15	3	0	18
5	32	0	0	32	12	1	0	13	15	1	0	16
6	13	0	0	13	0	0	0	0	1	0	0	1
7	0	0	0	0	0	0	0	0	0	0	0	0
8	b	b	b	b	b	b	b	b	b	b	b	b
10	3	0	0	3	3	0	0	3	0	0	0	0
11	11	0	0	11	5	0	0	5	15	0	0	15
12	3	0	0	3	0	0	0	0	3	1	0	4
14	8	1	1	10	13	1	2	16	2	2	0	4
15	5	0	0	5	3	1	0	4	4	0	0	4
16	3	0	0	3					2	0	0	2
17	1	1 T.sp.	0	2	12	1	0	13	2	0	0	2
	136	2	1	139	79	4	2	85	174	8	0	182

[a]Panel lost.

[b]Rack containing yearly panels lost April 1977.

TABLE 9:

PERCENTAGE OF SPECIMENS IN YEARLY PANELS THAT WERE ALIVE WHEN COLLECTED

Month Retrieved	JUNE			JULY			AUGUST		
STATION	# Living Specimens	Total # Tubes Observed	% Alive	# Living Specimens	Total # Tubes Observed	% Alive	# Living Specimens	Total # Tubes Observed	% Alive
1	14	24	58	7	7	100	9	9	100
2	14	14	100	19	24	79	107	107	100
3	0	0	--	0	0	--	0	0	--
4	0	19	0	0	a	--	8	18	44
5	0	32	0	1	13	8	9	16	56
6	0	13	0	0	0	--	1	1	100
7	0	0	--	0	0	--	0	0	--
8	b	b	b	b	b	b	b	b	b
10	2	3	67	3	3	100	0	0	--
11	9	11	82	2	5	40	13	15	87
12	3	3	100	0	0	--	3	4	75
14	4	10	40	4	15	27	1	4	25
15	2	5	40	2	4	50	1	4	25
16	3	3	100	0	0	--	1	2	50
17	0	2	0	5	13	38	2	2	100
	51	139		43	84		155	182	

[a]Panel lost.

[b]Rack containing yearly panels lost April 1977.

TABLE 10:

NUMBERS OF LIVING SHIPWORMS, CUMULATIVE AND MONTHLY PANELS[a]

Date Removed	JULY 7, 1977 (Cumulative)			AUGUST 8, 1977 (Monthly)			AUGUST 8, 1977 (Cumulative)		
STATION	B.g.	Teredo sp.	TOTAL	B.g.	Teredo sp.	TOTAL	B.g.	Teredo sp.	TOTAL
1		1	1	1		1	1		1
2	4		4	21		21	113		113
3				0		0	0		0
4	1	2 (T.n.)	3	5		5	3	1	4
5				4		4	4	2	6
6				6		6	2		2
7				0		0	2		2
8				6		6	1		1
9				b		b	1		1
10				2		2	0		0
11				9		9	7		7
12				2		2	3	1	4
14		1	1	0		0	0	0	0
15				1		1	0		0
16					1	1	0		0
17				0		0	0		0
18					9[c]	9		4[c]	4
19				0		0	0		0
	5	4	9	57	10	67	137	8	145

TABLE 10: CONTINUED

[a]Cumulative series began May 27, 1977.
No shipworm specimens were found in any June panels or July monthly panels.

[b]No panel.

[c]Many Larvae beginning to enter the panel. All appear to be *T. navalis*.

TABLE 11:

NUMBERS OF LIVING SHIPWORMS PLUS EMPTY TUBES, CUMULATIVE AND MONTHLY PANELS[a]

Date Removed	JULY 7, 1977			AUGUST 8, 1977 (Monthly)			AUGUST 8, 1977 (Cumulative)		
STATION	B.g.	Teredo sp.	TOTAL	B.g.	Teredo sp.	TOTAL	B.g.	Teredo sp.	TOTAL
1		1	1	1		1	1		1
2	4		4	21		21	119		119*
3				0		0	0		0
4	1	2	3	9		9*	3	1	4
5				5		5*	4	2	6
6				6		6	2		2
7				0		0	2		2
8				6		6	2		2*
9				b		b	1		1
10				2		2	0		0
11				10		10*	7		7
12				2		2	3	1	4
14		1	1	0		0	0		0
15				1		1	0		0
16					1	1	0		0
17				0		0	0		0
18					9[c]	9		4[c]	4
19				0		0	0		0
	5	4	9	63	10	73	144	8	152

TABLE 11: CONTINUED

[a]Cumulative series began May 27, 1977.
No specimens were found in any June panels or July monthly panels. Stars represent panels with mortality.

[b]No panel.

[c]Many larvae beginning to enter the panel.

TABLE 12:

PERCENTAGE OF SPECIMENS IN CUMULATIVE AND MONTHLY PANELS THAT WERE ALIVE WHEN COLLECTED

Date Removed	JULY (Cumulative)			AUGUST (Monthly)			AUGUST (Cumulative)		
STATION	# Living Specimens	Total # Tubes Observed	% Alive	# Living Specimens	Total # Tubes Observed	% Alive	# Living Specimens	Total # Tubes Observed	% Alive
1	1	1	100	1	1	100	1	1	100
2	4	4	100	21	21	100	113	119	95
3	0	0	--	0	0	--	0	0	--
4	3	3	100	5	9	56	4	4	100
5	0	0	--	4	5	80	6	6	100
6	0	0	--	6	6	100	2	2	100
7	0	0	--	0	0	--	2	2	100
8	0	0	--	6	6	100	1	2	50
9	0	0	--	*	*	*	1	1	100
10	0	0	--	2	2	100	0	0	--
11	0	0	--	9	10	90	7	7	100
12	0	0	--	2	2	100	4	4	100
14	1	1	100	0	0	--	0	0	--
15	0	0	--	1	1	100	0	0	--
16	0	0	--	1	1	100	0	0	--
17	0	0	--	0	0	--	0	0	--
18	0	0	--	9	9	100	4	4	100
19	0	0	--	0	0	--	0	0	--
	9	9		68	73		145	152	

*No Panel.

TABLE 13:

LENGTH RANGES OF LIVING SHIPWORMS, IN MM, YEARLY PANELS

Date Removed	JUNE 6, 1977	JULY 7, 1977		AUGUST 8, 1977	
STATION	B.g.	B.g.	T.f.	B.g.	T.f.
1	46-155	150-294		5-235	
2	22- 94	31-245		3-265	56
3					
4				6- 62	63-110
5	44- 62	58		9-280	
6				5	
7					
10	250-260	199-430*			
11	90-172	260-280		3-183	
12	178-450*			5-270	
14	37-130	102-145		10	
15	105-132	144	135	4	
16	125-260			4	
17		146-243		240-290*	

Note: The largest shipworm for each month is starred.

FIGURE 2

SHIPWORM DENSITY VERSUS

MEAN LENGTHS OF B. GOULDI

TAKEN FROM YEARLY PANELS

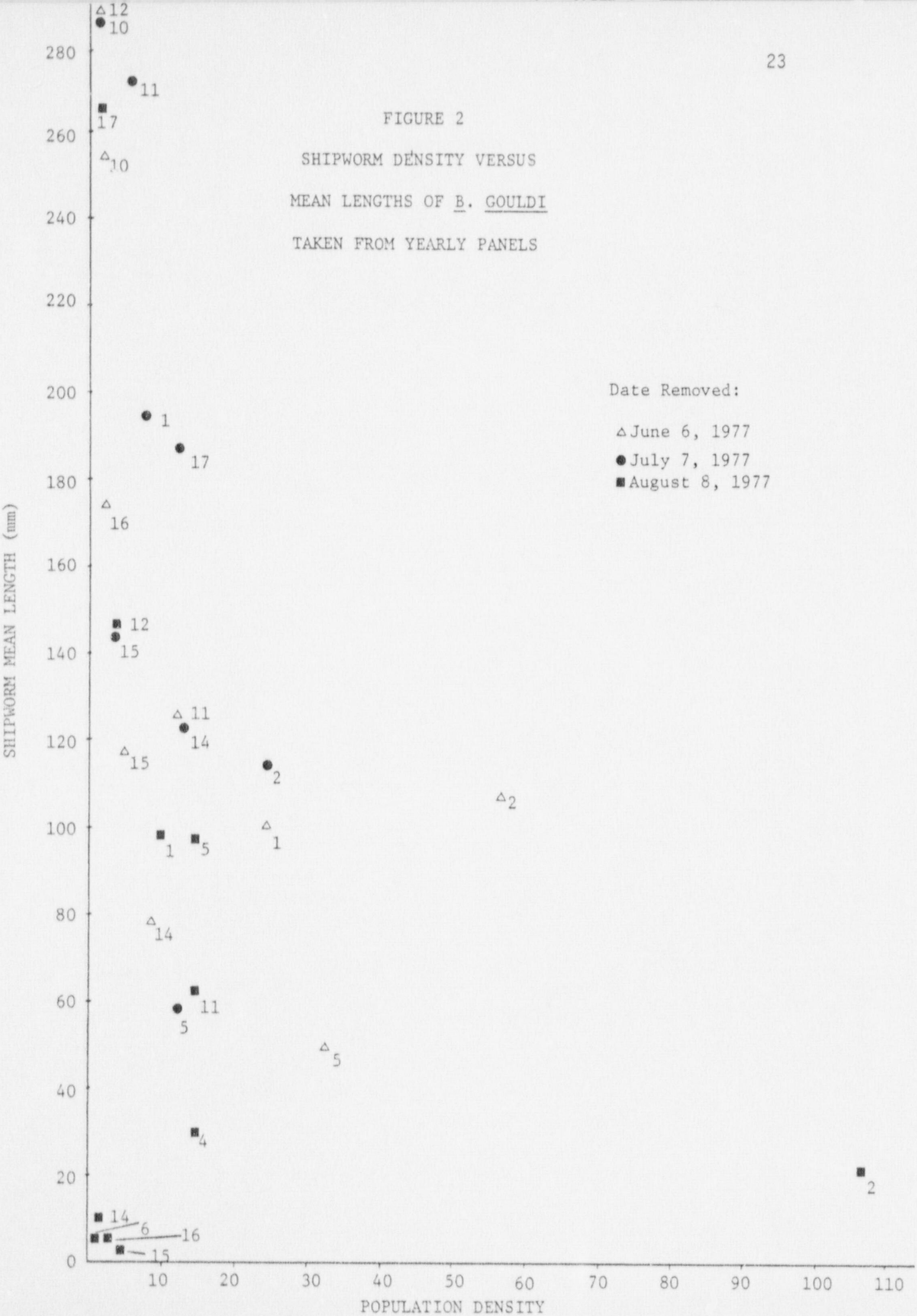


TABLE 14:

LENGTH RANGES OF LIVING SHIPWORMS, IN MM, CUMULATIVE AND MONTHLY PANELS*

Date Removed	JULY 7 (Cumulative)		AUGUST 8 (Monthly)		AUGUST 8 (Cumulative)	
STATION	B.g.	Teredo sp.	B.g.	Teredo sp.	B.g.	Teredo sp.
1		6	6		40	
2	1-5		1 -18		2-75	
3						
4	1	12-15	2 -27		4-11	14
5			4 - 9		2-32	30-75
6			1.5- 5		1-49	
7					33-41	
8			1 -10		25	
9					40	
10			4 - 7			
11			2 -11		4-65	
12			5 -21		5-43	32
14		15				
15			10			
16				15		
17						
18				2- 6		4- 6
19						

*Cumulative series began May 27, 1977.
No shipworm specimens were found in any June panels or July monthly panels.

TABLE 15:

MEAN LENGTHS, IN MM, OF SHIPWORMS FROM CUMULATIVE AND MONTHLY PANELS

Date Removed	JULY 7, 1977 (Cumulative)		AUGUST 8, 1977 (Monthly)		AUGUST 8, 1977 (Cumulative)	
STATION	B.g.	Teredo sp.	B.g.	Teredo sp.	B.g.	Teredo sp.
1	-	6[a]	6[a]	-	40[a]	-
2	2	-	6.67	-	29.7	-
3	-	-	-	-	-	-
4	1[a]	13.5[b]	8	-	8.3	14[a]
5	-	-	6.75	-	16.25	52.5[b]
6	-	-	1.67	-	25[b]	-
7	-	-	-	-	37[b]	-
8	-	-	6.2	-	25[a]	-
9	-	-	*	*	40[a]	-
10	-	-	5.5[b]	-	-	-
11	-	-	5.4	-	30.7	-
12	-	-	13[b]	-	17.7	32[a]
14	-	15[a]	-	-	-	-
15	-	-	10[a]	-	-	-
16	-	-	-	15[a]	-	-
17	-	-	-	-	-	-
18	-	-	-	4.2	-	5
19	-	-	-	-	-	-

[a]n = 1 - = none

[b]n = 2 *No Panel.

FIGURE 3: HISTOGRAMS OF LENGTHS OF SHIPWORMS TAKEN FROM PANELS. A. JUNE YEARLY PANELS

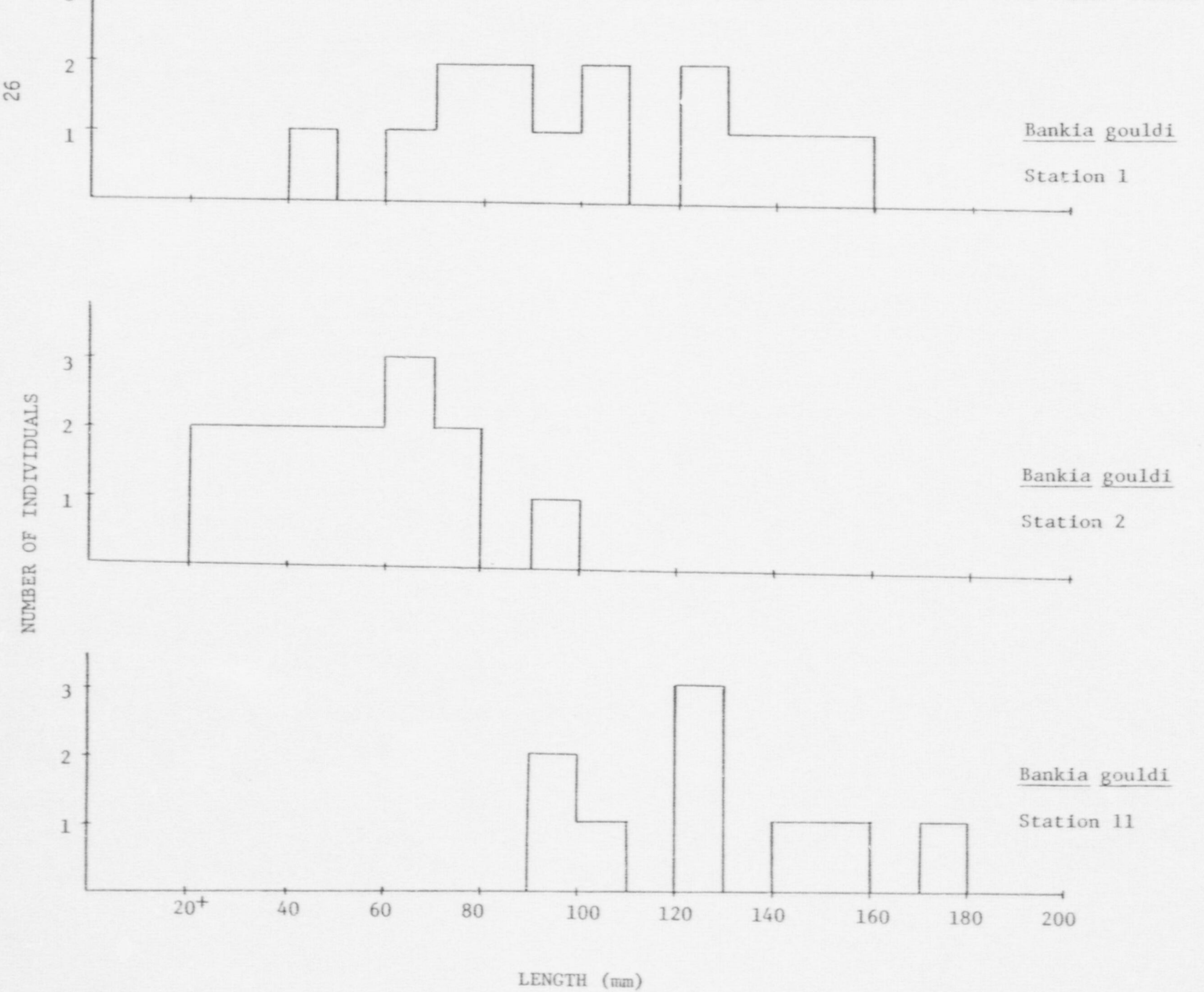


FIGURE 3, CONTINUED

B. July Yearly Panels

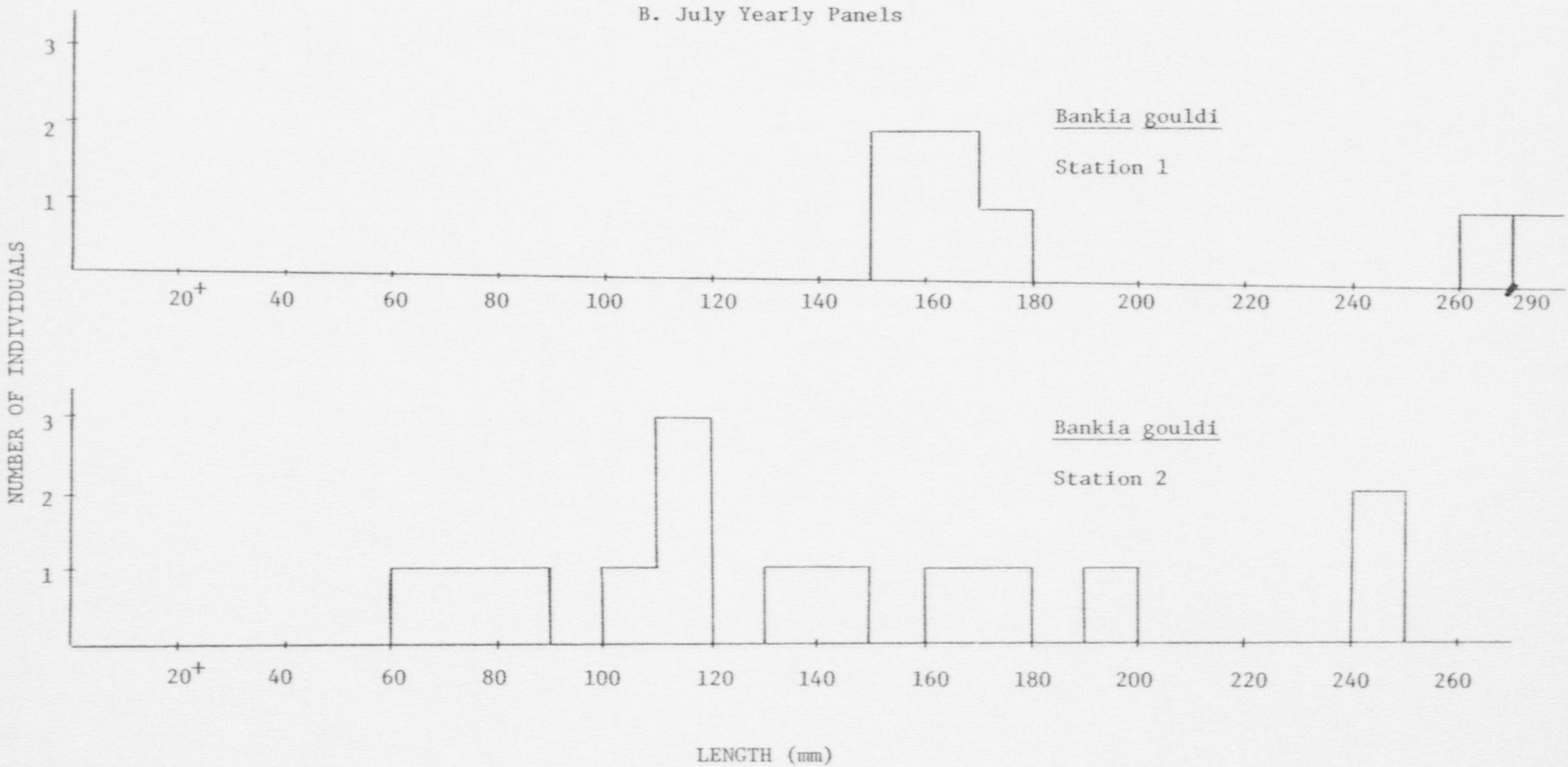
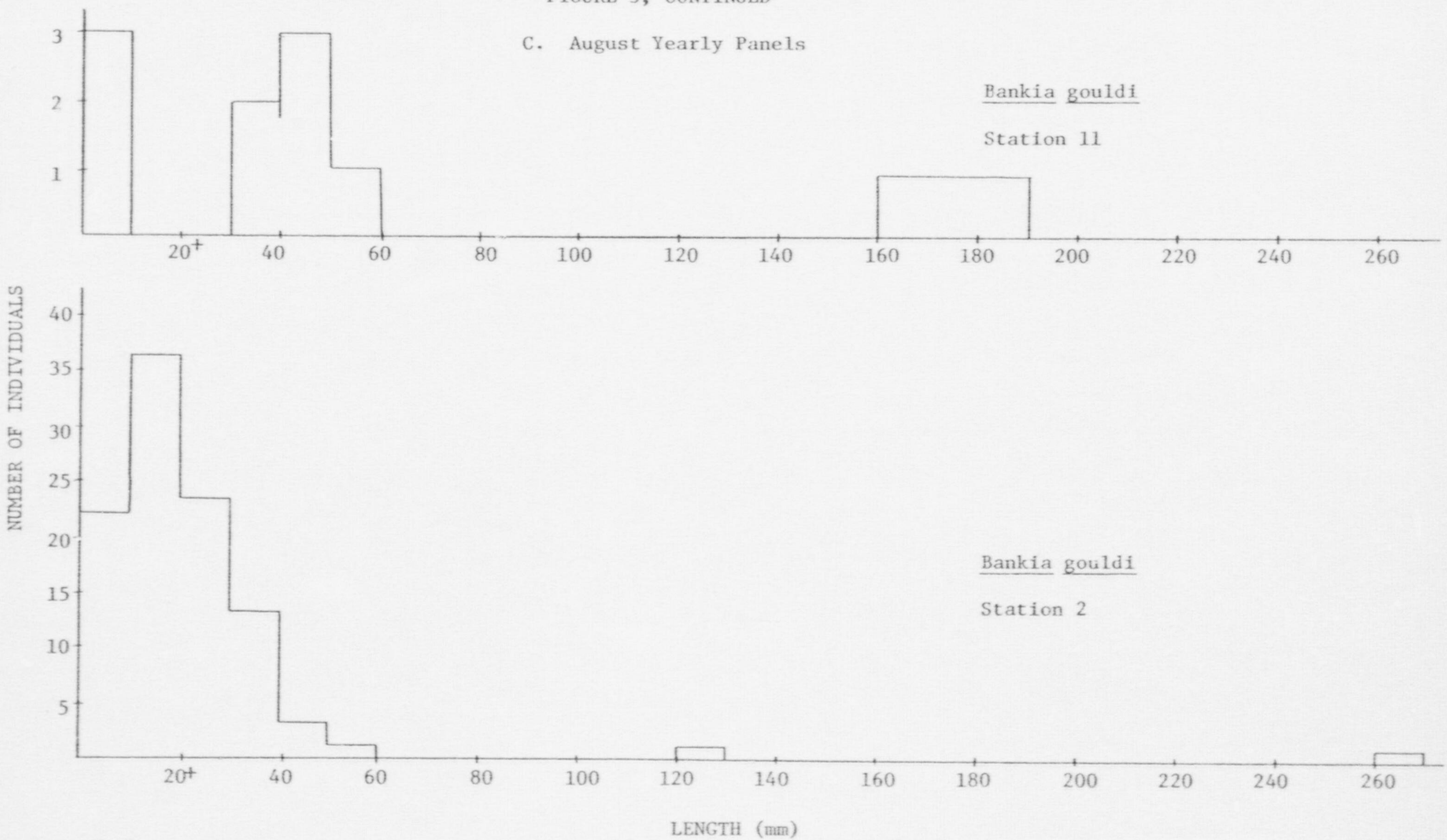


FIGURE 3, CONTINUED

C. August Yearly Panels



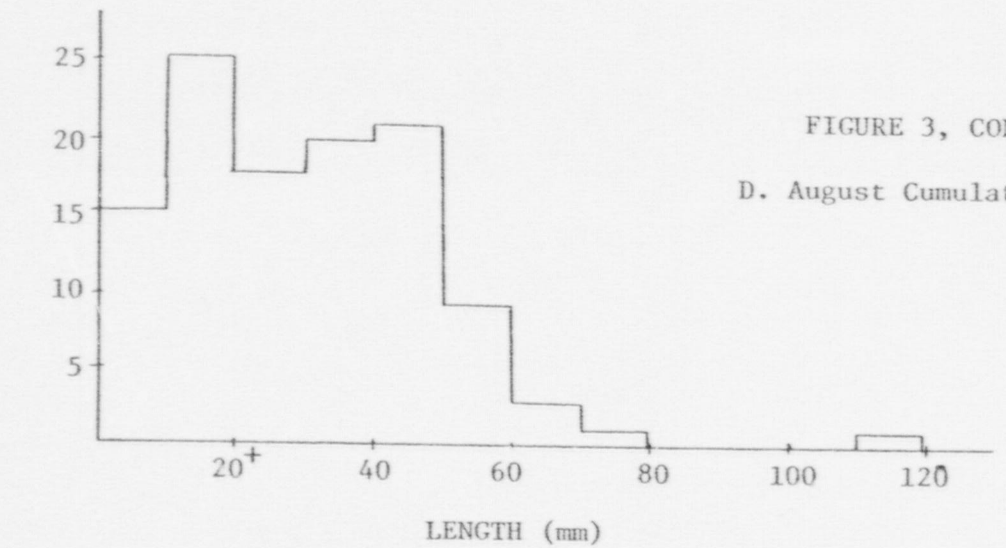
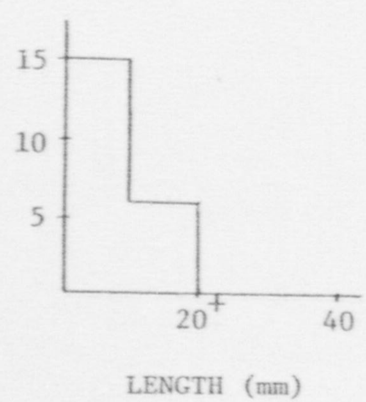


FIGURE 3, CONTINUED

D. August Cumulative Panels

<u>Bankia</u> <u>gouldi</u>

Station 2



E. August Monthly Panels

<u>Bankia</u> <u>gouldi</u>

Station 2

TABLE 16:

RANKING OF SHIPWORM PANELS ACCORDING TO THE AMOUNT OF WOOD DESTROYED

	YEARLY PANELS		CUMULATIVE PANELS		MONTHLY PANELS
RANK	JUNE 6*	AUGUST 8*	JULY 7	AUGUST 8	AUGUST 3
1	3**] > 0	3]	3]	3]	3]
2	7]	7 > 0	5	10*	7
3	17	10*]	6	14	14 > 0
4	15	6] >	7	15 > 0	17
5	10*]	16]	8	16	19]
6	12* >	15	9 > 0	17	1] >
7	16]	4] >	10*	19]	6]
8	14	14]	11*	18	5]
9	1]	11*]	12*	4	10* >
10	4 >	12* >	15	1]	18]
11	6	17]	16	6	8] >
12	11*]	1] >	17	8 >	11*]
13	5	5]	18	9]	15] >
14	2	2	19]	7] >	16]
15			1] >	12*]	4] >
16			2]	5	12*]
17			14	11*	2
18			4	2	

*From observations of x-rays. Rankings are from least to most damage. The July yearly panels were not x-rayed. Brackets indicate ties. There was no damage in any June panel or July monthly panel. Oyster Creek station numbers are starred.

**Station number

0: No damage due to shipworms

FOULING ORGANISMS

Tables 17-22 show the distributions of some common fouling organisms. The relative scarcity of Polysiphonia on the monthly panels indicates that this fouling organism settles preferentially on older wood that has been in the water longer. Balanus eburneus settled during July, especially at protected stations not on the open bay. In June and July when the power plant was not operating, Botryllus schlosseri and Hydroides dianthus settled at sites on Oyster Creek. These organisms had previously been very rare there. A change in water circulation (velocity) or a change in water quality may be among the factors responsible for the settlement.

Some species of boring and fouling organisms such as Limnoria and Hippoporina are restricted to the southern stations (14-17); others, such as gammarid amphipods, are particularly abundant at northern stations. Sponge is concentrated in Oyster Creek. Polysiphonia avoid areas of low salinity. Electra crustulenta and Botryllus schlosseri are nearly ubiquitous, except that the latter is rare in Oyster Creek.

When the shipworm panels are removed from the water each month, records are made of the relative abundances of fouling organisms on the aluminum test racks. We have analysed the ranked data using Kendall's Tau B, to determine the similarities of the test stations on the basis of the composition of the fouling community. Further analyses are planned, but at present we can draw clusters of stations which share high Tau values. Stations 10, 11, and 12 show affinities with stations 5, 6, 8, and in some months, with 3 and 7. Stations 16 & 17 do not correlate highly with any other station except 14. The northern bay stations, 1, 2, 4, 5, and 8, link together at the .7 similarity level. The most important conclusion is that the Oyster Creek fauna shares elements of the estuarine creek fauna (3, 7) as well as the bay fauna, and composition fluctuates from month to month.

TABLE 17:

DISTRIBUTION OF SOME COMMON FOULING ORGANISMS:

Electra crustulenta

	Station																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
June 6	X	X	0	X	X	X	X	-	-	XR	XR	X	0	X	X	X	-	-
July 7	X	X	0	X	X	X	X	-	-	0	X	X	0	X	X	X	-	-
Aug. 8	X	X	0	X	X	X	X	-	-	0	0	X	X	X	X	X	-	-
B. Cumulative:																		
July 7	0	0	X	0	X	0	XR	X	X	0	0	0	0	X	0	0	0	0
Aug. 8	X	X	X	0	X	0	XR	0	XR	0	0	0	0	0	0	X	X	0
C. Monthly:																		
June 6	X	X	0	0	X	X	X	-	-	X	0	XR	0	XR	XR	X	-	-
July 7	0	X	0	0	0	X	X	-	-	0	0	0	0	X	0	X	-	-
Aug. 8	X	X	0	X	X	X	X	X	-	XR	0	0	0	0	0	0	X	X
D. On rack or cement only:																		
June 6			X															
July 7																		X

-: No panel
X: Present
XR: Present but rare

Note: For June, monthly and cumulative series are the same (1 month submergence).

TABLE 18:

DISTRIBUTION OF SOME COMMON FOULING ORGANISMS:

Polysiphonia spp.

	Station																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
June 6	0	X	0	0	X	0	0	-	-	X	X	X	X	X	X	X	-	-
July 7	0	X	0	0	X	X	0	-	-	X	X	X	0	X	X	X	-	-
Aug. 8	0	0	X	0	X	0	0	-	-	X	X	0	0	0	0	X	-	-
B. Cumulative:																		
July 7	0	0	0	X	0	0	0	X	0	X	X	X	0	0	0	0	0	0
Aug. 8	0	0	X	0	0	X	0	0	0	X	X	0	0	0	0	0	0	X
C. Monthly:																		
June 6	X	X	0	X	X	X	0	-	-	X	X	X	X	X	X	X	-	-
July 7	0	X	X	X	X	X	0	-	-	0	X	X	X	X	XR	X	-	-
Aug. 8	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	X
D. On rack or cement only:																		
Aug. 8				X					X					X				

-: No panel

X: Present

XR: Present but rare

TABLE 19:

DISTRIBUTION OF SOME COMMON FOULING ORGANISMS:

Hydroides dianthus

	Station																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
June 6	X	X	0	X	X	X	0	-	-	0	0	XR	X	XR	X	X	-	-
July 7	X	X	0	X	X	X	0	-	-	0	0	X	X	X	X	X	-	-
Aug. 8	X	X	0	X	X	X	X	-	-	X	X	X	X	X	X	X	-	-
B. Cumulative:																		
July 7	X	X	X	X	X	X	0	X	X	X	X	0	X	X	X	X	XR	0
Aug. 8	X	X	X	X	X	X	0	X	0	X	X	X	X	X	X	X	X	X
C. Monthly:																		
June 6	XR	0	0	X	0	0	0	-	-	0	XR	0	X	X	X	0	-	-
July 7	X	X	0	X	X	X	0	-	-	X	X	X	X	X	X	X	-	-
Aug. 8	X	X	0	X	X	X	X	X	-	X	X	X	X	X	X	X	X	X
D. On rack or cement only:																		
June 6							X			X								
July 7																		X

-: No panel

X: Present

XR: Present but rare

TABLE 20:

DISTRIBUTION OF SOME COMMON FOULING ORGANISMS:

Botryllus schlosseri

	Station																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
June 6	0	0	0	0	X	0	0	-	-	0	0	0	X	0	0	0	-	-
July 7	X	0	0	X	X	X	0	-	-	0	X	0	X	0	0	0	-	-
Aug. 8	X	0	0	0	X	X	0	-	-	X	0	0	0	0	0	0	-	-
B. Cumulative:																		
July 7	X	0	0	X	X	X	0	X	X	X	X	XR	0	0	X	0	0	0
Aug. 8	X	X	0	0	X	X	0	X	0	0	0	X	0	0	0	0	X	X
C. Monthly:																		
June 6	X	0	0	X	X	0	0	-	-	0	0	0	X	0	X	0	-	-
July 7	X	0	0	X	X	X	0	-	-	X	X	X	X	0	X	0	-	-
Aug. 8	X	X	0	X	0	X	0	X	-	X	0	0	0	0	0	0	X	X
D. On rack or cement only:																		
June 6							X			X		X						
July 7																	X	X
Aug. 8									X									

-: No panel XR: Present but rare

X: Present

TABLE 21:

DISTRIBUTION OF SOME COMMON FOULING ORGANISMS:

Enteromorpha spp.

	Station																	
	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
June 6	X	X	X	X	X	X	0	-	-	0	X	0	X	X	X	X	-	-
July 7	0	0	X	X	X	X	0	-	-	0	0	0	X	X	X	0	-	-
Aug. 8	0	0	X	X	0	X	0	-	-	0	X	0	X	0	0	0	-	-
B. Cumulative:																		
July 7	0	0	0	X	X	X	0	X	X	0	X	X	X	0	X	0	X	X
Aug. 8	0	X	X	X	X	0	X	0	0	X	X	X	0	0	0	X	X	X
C. Monthly:																		
June 6	0	XR	X	X	X	X	0	-	-	XR	XR	0	X	XR	X	0	-	-
July 7	0	XR	X	0	X	X	0	-	-	0	X	0	X	X	0	0	-	-
Aug. 8	0	X	X	X	X	0	X	0	-	0	X	0	0	0	0	X	X	X
D. On rack or cement only:																		
June 6																		
July 7																		
Aug. 8								X						X	X			

-: No panel XR: Present but rare

X: Present

TABLE 22:

DISTRIBUTION OF SOME COMMON FOULING ORGANISMS:

Balanus eburneus

	Station 1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19
A. Yearly:																		
June 6	X	X	X	0	XR	X	X	-	-	X	X	X	X	X	X	X	-	-
July 7	X	X	X	X	X	X	X	-	-	X	X	X	X	X	X	X	-	-
Aug. 8	0	X	X	0	XR	X	X	-	-	X	X	X	X	0	XR	X	-	-
B. Cumulative:																		
July 7	0	0	X	0	0	X	XR	0	0	0	0	0	0	X	0	0	0	XR
Aug. 8	X	X	X	0	X	X	X	X	0	X	X	X	0	0	0	0	X	X
C. Monthly																		
June 6	X	0	X	X	XR	0	0	-	-	0	0	0	0	0	XR	0	-	-
July 7	0	0	X	0	0	X	0	-	-	0	0	0	0	0	0	0	-	-
Aug. 8	0	X	X	X	0	X	X	0	-	X	X	X	X	X	0	0	X	X
D. On rack or cement only:																		
June 6																		
July 7				X														
Aug. 8																		

-: No panel XR: Present but rare

X: Present

DISCUSSION

There were fairly dramatic changes in the density and distribution of shipworms in 1976-1977 as compared with previous years. Table 23 gives shipworm numbers for key stations over the period. Shipworm density has increased in the northern portion of our test area and has declined in Oyster Creek, while remaining the same in Forked River and at the Stout's Creek control site. Removal of untreated wood from Oyster Creek during the winter of 1975 and increased dilution pumping are factors in the decline of shipworms in Oyster Creek. Had we had more stations in Forked River prior to 1976, we may have been able to see a slight rise in shipworm attack due to recirculation of heated water (see our temperature data) and increased pumping of water up Forked River by the power plant.

Within Forked River, shipworm damage is greatest in the south fork and the region of confluence of the three forks, where the flow of water is rapid. The middle branch had little or no attack in 1976, but a few shipworms have settled there in the summer of 1977. Side lagoons where water is sluggish and organic pollution is high, such as our station 6, have lower shipworm damage. The region south of Oyster Creek represented by our station 14, shows only moderate shipworm damage and is not now receiving significant numbers of larvae from Oyster Creek. When the power plant was operating in early spring (e.g., 1972) the increase in temperature caused earlier breeding and settlement of shipworms in Oyster Creek. There was no early breeding or settlement of shipworms in the spring of 1977, when the power plant was not operating.

Species composition has changed slightly over the period of monitoring shipworms in Oyster Creek. While Bankia gouldi has remained the dominant species, Teredo furcifera has increased and Teredo navalis has decreased in numbers. Teredo bartschi made a brief appearance in 1973, but apparently did not survive the winter of 1975.

Hard winters in 1975-76 and 1976-77 decreased populations of invertebrates living in shallow water. Fouling samples in the spring and summer of 1977 suggest that many organisms produced large numbers of gametes as opposed to vegetative reproduction. Many new colonies of organisms have been found. Those species that normally settle during the fall and winter (Balanus balanoides, Botryllus schlosseri, grass shrimp) are currently minor elements of the fauna.

There is little overlap between the distributions of the wood-boring isopod Limnoria and the shipworms, but we have no evidence of competitive exclusion. Heavy growth of Botryllus schlosseri and Hydroides dianthus is correlated with low numbers of shipworms (interestingly, neither of these fouling organisms grows well in Oyster Creek). But barnacle settlement and growth does not seem to interfere with shipworms, probably because it does not cover wood surfaces completely, as may the above fouling organisms.

Property owners in the middle branch of Forked River have reported shipworm damage greater than would be indicated from our test station 7. We have inspected pilings from this area, and do find shipworm damage, as well as dry rot (above the water line). It appears that shipworm larvae reach the middle branch at irregular intervals.

We have also inspected the wooden structures in the portion of Forked River known as the Christmas Tree lagoons. The major wooden structures are creosoted and do not appear to be infested with shipworms. However, some residents have constructed wooden finger docks that are not creosoted. A wooden piece of a crab trap attached to one such dock was found to be riddled with shipworms. Therefore, shipworm larvae do reach this area and structures should be occasionally examined for damage. Residents should be cautioned to use creosoted wood materials for any marine construction.

TABLE 23:

SHIPWORM NUMBERS FOR KEY STATIONS AND REPRESENTATIVE TIME INTERVALS OVER THE PERIOD OF STUDY, 1971 - 1977

MONTHLY	HOLLY PARK	STOUT'S CREEK	OYSTER CREEK*
7/72 - 8/72	54	0	8
7/73 - 8/73	-	0	28
7/74 - 8/74	7	0	43+ (riddled)
8/74 - 9/74	0	0	riddled
9/74 - 10/74	0	0	20
10/74 - 11/74	0	0	50+
9/75 - 10/75	0	0	0
1/76 - 2/76	0	0	0
7/76 - 8/76	8	0	3
8/76 - 9/76	0	0	0
7/77 - 8/77	1	0	10
CUMULATIVE			
9/71 - 2/72	0	0	2
8/72 - 12/72	1	0	29
8/72 - 3/73	0	0	riddled
8/73 - 10/73	0	0	240
8/73 - 3/74	0	0	riddled
7/74 - 9/74	16	1	riddled
7/74 - 3/75	8	1	riddled
9/75 - 12/75	0	0	7
9/75 - 4/76	0	0	26
4/76 - 7/76	9	0	8
4/76 - 3/77	41	1	5
5/77 - 8/77	1	0	7

*Station 11, or closest station with data.

RECOMMENDATIONS

1. Residents in the south and middle branches in Forked River, and all connecting lagoons and canals, should be advised to use creosoted wood for all marine construction.

2. Spring maintenance shutdowns of the nuclear generating station are recommended to be continued, because they do not cause as severe a biological effect as do winter shutdowns, and they reduce the tendency for a lengthened shipworm breeding season.

3. Continued monitoring is necessary to know how much of the results of the last 2 years are due to changes in power plant operations and how much are due to abnormal weather.

4. Future changes in plant operations must be correlated with biological effects.

Appendix A

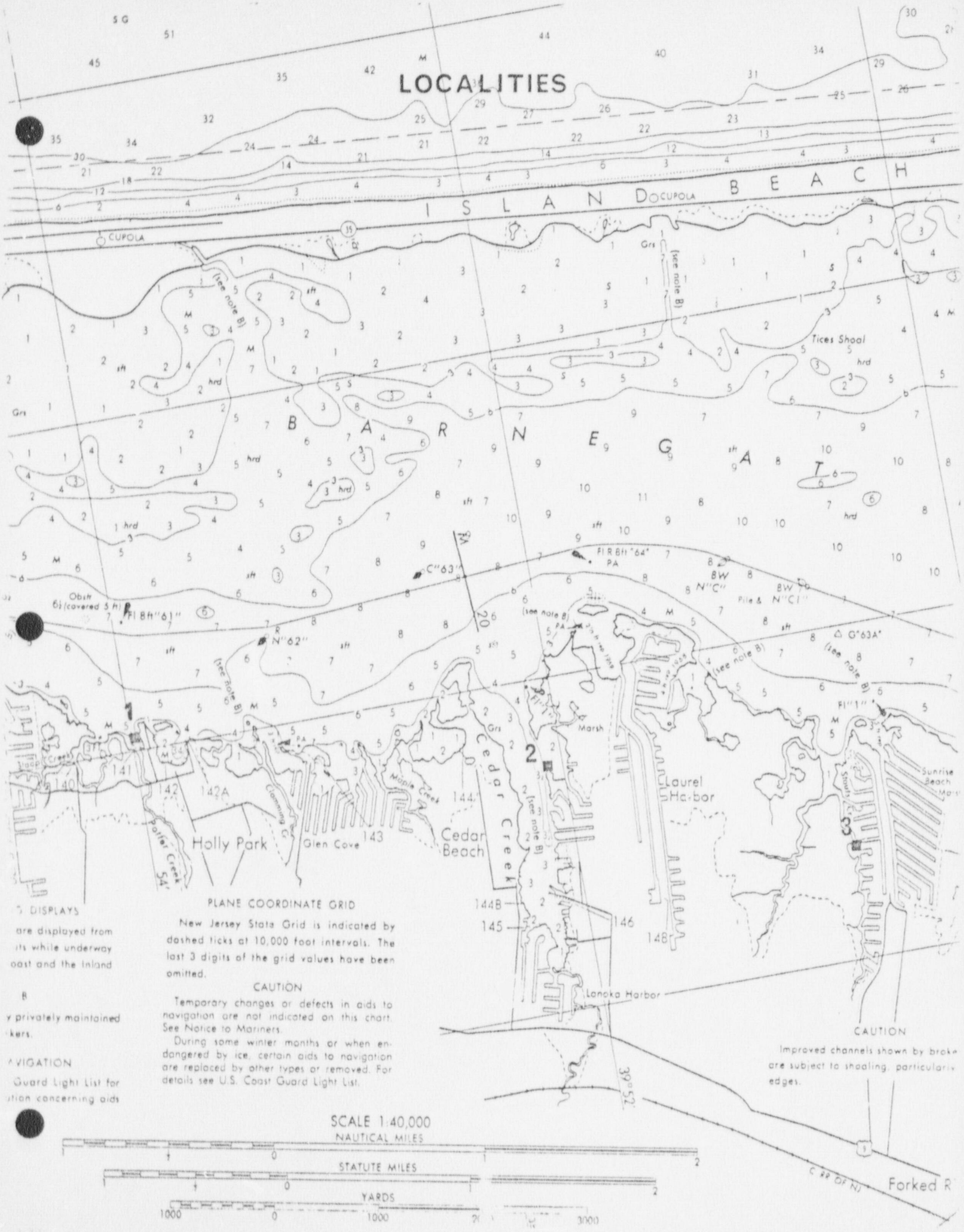
STATION NUMBER	NAME	DESCRIPTION	COORDINATES
1	Holly Park	Dick's Landing Island Drive Bayville, N.J. Bay control	Lat. 39° 54' N Lon. 74° 8.1' W
2	Cedar Creek	Last Lagoon toward mouth South Side Estuarine Control	39° 52' N 74° 8.5' W
3	Stout's Creek	End of Raleigh Drive Gustav Walters' residence Estuarine 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. ' 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	Long Beach Island	Bayview Marina	39° 17.4' N 74° 54' W
**19	Barnegat Light	Marina adjacent to Coast Guard Station	39° 15' N 74° 53' W

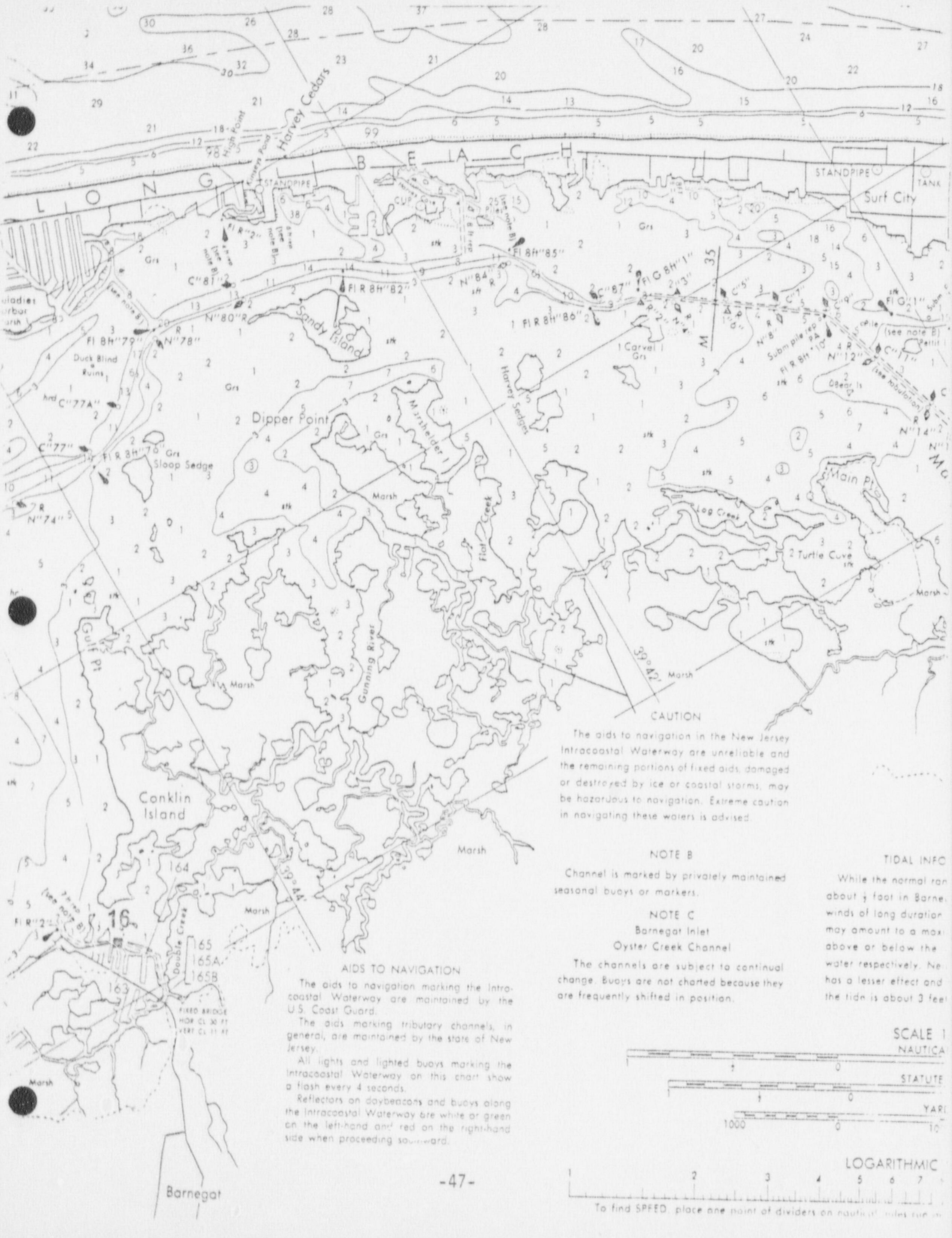
**Stations new as of May 27, 1977

LOCALITIES


LOCALITIES
ISLAND BEACH
CUPOLA
BARNEGAT
Tices Shoal
(see note B)
Fl R 8ft "64" PA
C"63"
N"62"
Fl 8ft "61"
Obstr 6ft (covered 5 ft)
BW N"C"
BW N"C1"
Pile &
G"63A"
Fl"1"
Marsh
Cedar Creek
Laurel Harbor
Holly Park
Glen Cove
Cedar Beach
Potter Creek
Clamming C
Maple Creek
Stouts Cr
Sunrise Beach
Lanoka Harbor
Forked R
C RR OF NJ
39°52'
140
141
142
142A
143
144
144B
145
146
148
PLANE COORDINATE GRID
New Jersey State Grid is indicated by dashed ticks at 10,000 foot intervals. The last 3 digits of the grid values have been omitted.
CAUTION
Temporary changes or defects in aids to navigation are not indicated on this chart. See Notice to Mariners.
During some winter months or when endangered by ice, certain aids to navigation are replaced by other types or removed. For details see U.S. Coast Guard Light List.
DISPLAYS
are displayed from
its while underway
oast and the Inland
B
privately maintained
kers.
AVIGATION
Guard Light List for
ation concerning aids
CAUTION
Improved channels shown by broke
are subject to shoaling, particularly
edges.
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
1000
0
1000
2000
3000
1
2


LOOKOUT TOWER
TOWER
Marsh
Sedge Islands
(use panel at right)
B A Y
Oyster Creek Channel
(use panel at right)
Clam I
BW N"D"
(see tabulation)
BW N"E"
Fl G 8ft "65"
Fl R"2"
N"40"
Fl 2½sec "67"
Mile 25
Fl 4sec Priv maintd
Fl"3"
Shoal rep
(see note B)
(see notes)
BW N"G"
Sunrise Beach Marsh
Forked River
Fl R"12"
Being filled
Sands Point Harbor
Oyster Creek
Fl R"2"
Stakes
Waretown
Waretown Creek
Barnegat Beach
Platforms
Sanborn Anchorage
South Branch
Middle Br
North Branch
Fl R"20"
FIXED BRIDGE
River
TANK
B
19
14
15
10
11
12
13
5
6
7
8
9
149
149A
149B
149C
150
151
151A
152A
153
155
156
158A
159
160
161
162
74°12'


Barnegat Light
CG
R Bn 322 kHz
TANK
74°06'
74°08'
74°10'
High Bar
Marsh
Fl G 4sec 30ft 6M HORN
Fl R 4sec 37ft
BARNEGAT INLET
39°46'
Barnegat Light
CG
R Bn 322 kHz
TOWER
STORM WARNINGS
Obstr rep
Cable Area
Sedge Is
Clam I
Marsh
High Bar
Vol Sedge
Loveladies
Double Creek Channel
Oyster Creek Channel (see note C)
39°48'
BARNEGAT BAY
Mile
Shoaling rep 1975
Fl R 8ft "68"
Fl 2½sec "67"
BW N"G"
Platforms
Barnegat Beach
Waretown
Sands Point Harbor
Pebble Beach
Lochiel Creek
TANK
JOINS PANEL AT RIGHT
JOINS PANEL AT LEFT


LONG BEACH
Harvey Cedars
High Point
Kinseys Pond
STANDPIPE
Surf City
TANK
Sandy Island
Duck Blind Ruins
Dipper Point
Sloop Sedge
Marshelder I
Harvey Sedges
Flat Creek
Gunning River
Log Creek
Main Pt
Turtle Cove
Gulf Pt
Conklin Island
Double Creek
Barnegat
Marsh
FIXED BRIDGE HOR CL 30 FT VERT CL 11 FT
CAUTION
The aids to navigation in the New Jersey Intracoastal Waterway are unreliable and the remaining portions of fixed aids, damaged or destroyed by ice or coastal storms, may be hazardous to navigation. Extreme caution in navigating these waters is advised.
NOTE B
Channel is marked by privately maintained seasonal buoys or markers.
NOTE C
Barnegat Inlet
Oyster Creek Channel
The channels are subject to continual change. Buoys are not charted because they are frequently shifted in position.
AIDS TO NAVIGATION
The aids to navigation marking the Intracoastal Waterway are maintained by the U.S. Coast Guard.
The aids marking tributary channels, in general, are maintained by the state of New Jersey.
All lights and lighted buoys marking the Intracoastal Waterway on this chart show a flash every 4 seconds.
Reflectors on daybeacons and buoys along the Intracoastal Waterway are white or green on the left-hand and red on the right-hand side when proceeding southward.
TIDAL INFO
While the normal ran
about ½ foot in Barne
winds of long duration
may amount to a maxi
above or below the
water respectively. Ne
has a lesser effect and
the tide is about 3 feet
SCALE 1
NAUTICA
STATUTE
YAR
LOGARITHMIC
To find SPEED, place one point of dividers on nautical miles run in

TIDAL INFORMATION

…le the normal range of the tide is only … foot in Barnegat Bay, with strong … of long duration, the change in depth …mount to a maximum of about 3 feet …e or below the normal high or low … respectively. Near the inlets the wind … lesser effect and the normal range of …ide is about 3 feet.

FISH TRAP AREAS

Boundary lines of fish trap areas are shown thus: — — — —

Caution: Submerged piling may exist in these areas.

CAUTION

Mariners are warned to stay clear of the protective riprap surrounding navigational light structures shown thus:

SCALE 1:40,000

NAUTICAL MILES 1 2

STATUTE MILES 0 1 2

YARDS 1000 2000 3000

LOGARITHMIC SPEED SCALE

5 6 7 8 9 10 15 20 25 30 40 50 60

…utical miles run and the other on minutes run. Without changing divider spread, place … 2.0 miles run in 15 minutes, the speed is 16.0 knots

NEW JERSEY INTRACOASTAL WATERWAY

CORPS OF ENGINEERS REPORT OF SEPT. 20, 1976

CONTROLLING DEPTHS FROM SEAWARD IN FEET AT MEAN LOW WATER (MLW)

NAME OF CHANNEL	DEPTH MLW (FEET)	WIDTH (FEET)	DATE OF SURVEY
N.Y. AND L.B. R.R. BRIDGE TO BAY HEAD (40°03'50"N., 74°03'02"W.)	B 5.5	A.	3-67, 10-69 11-73, 1-74
THENCE TO BARNEGAT INLET	5.5	A.	3-76
THENCE TO LITTLE EGG INLET	4.8	A.	5-76
THENCE TO ABSECON INLET	5.2	A.	5-76
THENCE TO GREAT EGG HARBOR INLET	5.2	A.	8-76
THENCE TO CORSON INLET	5.0	A.	8-76
THENCE TO TOWNSEND INLET	4.7	A.	8-76
THENCE TO RIO GRANDE BRIDGE, WILDWOOD	4.2	A.	7-74, 9-75
THENCE TO CAPE MAY INLET	10.0	A.	8-70

A. PROJECT WIDTH IS 100 FEET. DEPTHS GIVEN WERE REPORTED AVAILABLE IN THE MIDDLE 80 FEET.

B. BUOYS 3A AND 4A IN MANASQUAN RIVER MARK THE BEST WATER AND ARE NOT CHARTED.

NOTE-CONSULT THE CORPS OF ENGINEERS FOR CHANGING CONDITIONS SUBSEQUENT TO THE ABOVE

PRODUCED BY COMPUTER ASSISTED METHODS