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Ecological Studies of Wood-Boring Bivalves in the Vicinity of the Oyster Creek Nuclear Generating Station

Progress Report
December 1980 - February 1981

Prepared by K. E. Hoagland, L. Crocket

Wetlands Institute
Lehigh University

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U.S. Nuclear Regulatory Commission

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Manuscript Completed: July 1981
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Prepared by
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Prepared for
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U.S. Nuclear Regulatory Commission
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ABSTRACT

The species composition, distribution, and population dynamics of wood-boring bivalves 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 12 stations. Physiological tolerances of 3 species are also under investigation in the laboratory. Relative destructiveness and competition among the species are being analyzed. The native species *Teredo navalis* and *Bankia gouldi* coexist with the introduced *T. bartschi* in Oyster Creek and at the mouth of Forked River. An increase in mortality occurred in January. By February, *Teredo bartschi* was found only at Bayside Beach Club and in Oyster Creek. Successful settlement of pediveligers did not occur during December-February. Salinity tolerance experiments in the laboratory using *T. bartschi* pediveligers show that the greatest activity occurs at 20-30 $^{o}/_{oo}$. Osmotic stress occurs below 10 $^{o}/_{oo}$. Adults of *T. bartschi* withdrew their siphons in circulating seawater of 28 $^{o}/_{oo}$ when the temperature was lowered gradually to 10^{o} C.

SUMMARY OF FINDINGS

The purpose of this investigation is to understand the population dynamics and competitive interactions of shipworms in the vicinity of the Oyster Creek Nuclear Generating Station (OCNGS) and at control stations outside the influence of the station. The relative importance of the introduced species Teredo bartschi in causing damage, and physiological tolerances of all species, are being assessed. On a monthly basis, wood panels are added and removed for analysis of population dynamics and to obtain live animals for the lab studies. We also record temperature, salinity, and we estimate siltation levels at each station.

1. The generating station was operating during the period of this report.

2. The ΔT was only about +2-3° C in Oyster Creek during these winter months. The salinity in Oyster Creek was essentially that of Forked River and nearby portions of Barnegat Bay. Precipitation was subnormal in December and January.

3. Teredo bartschi was found only at stations 8 (Bayside Beach Club) and 12 (Oyster Creek).

4. T. bartschi suffered very heavy mortality beginning sometime in late December or early January and continuing into February, by which time over 95% of the individuals were dead.

5. Heavy shipworm attack occurred at stations 12 (Oyster Creek), 8 (between Oyster Creek and Forked River), and 4 (the mouth of Forked River). Attack at all other stations was light.

6. No new shipworms were found to settle on the monthly panels during the winter months.

7. Teredo bartschi was the most numerous shipworm found in the panels, by an order of magnitude.

8. Teredo navalis suffered more mortality than Bankia gouldi. Nearly 50% of all T. navalis were dead when collected.

9. At 20° C, Teredo bartschi pediveligers are most active at 20-30 °/oo salinity. Hypo-osmotic stress is evident at 5 °/oo. Hyper-osmotic stress occurs at 40 °/oo.

10. At 20° C, Teredo bartschi pediveligers tend to settle on wood within 5 days at 10-15 °/oo and 30-35 °/oo. However, most remain active swimmers at 20-25 °/oo, the salinities that occur in Oyster Creek and Forked River.

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ACKNOWLEDGMENTS

We thank the many residents of Oyster Creek who have cooperated in our field work. James Selman provided technical assistance. Eugenia Böhlke of the Academy of Natural Sciences of Philadelphia served as X-ray technologist. R. D. Turner gave advice on rearing shipworms in the laboratory.

PREVIOUS REPORTS

Twelve reports have been prepared under Contract AT(49-24)-0347 during three years of funding from the U. S. Nuclear Regulatory Commission, 1976-1979, under the title:

Analysis of Populations of boring and fouling organisms in the vicinity of the Oyster Creek Nuclear Generating Station with discussion of relevant physical parameters.

Those reports with NTIS numbers are:

NUREG/CR-0223	Dec. 1, 1977-Feb. 28, 1978
NUREG/CR-0380	Mar. 1, 1978-May 31, 1978
NUREG/CR-0634	Sept. 1, 1977-Aug. 31, 1978
NUREG/CR-0812	Sept. 1, 1978-Nov. 30, 1978
NUREG/CR-0896	Dec. 1, 1978-Feb. 28, 1979
NUREG/CR-1015	Mar. 1, 1979-May 31, 1979
NUREG/CR-1209	June 1, 1979-Aug. 31, 1979

Four reports have been published in this current series:

1. Ecological studies of wood-boring bivalves in the vicinity of the Oyster Creek Nuclear Generating Station, Sept. 1, 1979-Feb. 28, 1980. NTIS # NUREG/CR-1517. 65 pp.

2. Ecological studies of wood-boring bivalves in the vicinity of the Oyster Creek Nuclear Generating Station, March 1-May 31, 1980. NTIS # NUREG/CR-1795. 31 pp.

3. Ecological studies of wood-boring bivalves in the vicinity of the Oyster Creek Nuclear Generating Station, June 1-Aug. 31, 1980. NTIS # NUREG/CR-1855. 48 pp.

4. Ecological studies of wood-boring bivalves in the vicinity of the Oyster Creek Nuclear Generating Station, September 1-November 30, 1980. NTIS # NUREG/CR-1939. 36 pp. (VOL. 1)

CORRECTION

Report #1939, September 1-November 30, 1980

Omitted from report #1939 was the discovery of two empty bore holes in the one-month panel removed from station 11 in Oyster Creek in October. The species responsible could not be identified. The size of the holes indicated a survival period of less than two weeks for the specimens.

ECOLOGICAL STUDIES OF WOOD-BORING BIVALVES

IN THE VICINITY OF THE OYSTER CREEK

NUCLEAR GENERATING STATION

December 1, 1980 - February 28, 1981

INTRODUCTION

Previous studies have shown a direct causal relationship between the effluent of the Oyster Creek Nuclear Generating Station and the proliferation of shipworms (Teredinidae) in Oyster Creek and adjacent portions of Barnegat Bay, New Jersey (Turner, 1974; Hoagland et al., 1977; Hoagland et al., 1978; Hoagland and Crocket, 1979; Hoagland and Turner, 1980, Hoagland et al., 1980). The effluent adds heat to the receiving waters, which extends the breeding season of teredinids, increases their growth rates, and reduces their winter mortality rates. It has allowed the establishment of a tropical-subtropical shipworm, Teredo bartschi, in Oyster Creek and Forked River. The design of the generating station's cooling system, taking salt water from Barnegat Bay up Forked River, through the plant, and out into Oyster Creek, has increased the salinity of these two creeks. Shipworms now can reside in these creeks, which previously were unsuitable in salinity level and constancy for the establishment of actively breeding shipworm populations.

The populations of Teredo bartschi compared with the native species in Oyster Creek and Forked River are the focus of current studies. This report summarizes an ongoing collection of data on physical parameters of Barnegat Bay, as well as species composition, distribution, growth, mortality, and reproduction of teredinids. We assess the degree of shipworm damage occurring at each station. We also report on physiological studies comparing the native and introduced shipworms with regard to temperature and salinity tolerances.

METHODS

Stations

Over the first three years of our study, 20 stations were established in Barnegat Bay to monitor boring and fouling organisms. In September, 1979, the number was reduced to 12. The stations are shown in Hoagland and Turner, 1980, and are listed in the appendix. The station numbers are not contiguous because some have been discontinued.

Station 1 is a northern control station on Barnegat Bay outside the influence of the heated effluent. Some shipworms, primarily Bankia gouldi, are traditionally found there. Station 3 is a control station in a tidal creek outside the influence of the effluent. Shipworms are rarely found there. Stations 4, 5, and 6 are in Forked River, influenced by the plant's water intake system. There is some recirculation of heated water that affects these stations, but the main influence is that the salinity is essentially that of the bay. Station 6 is sampled on a reduced schedule, only 4 times a year.

Station 8 is on the bay between Oyster Creek and Forked River. Stations 10-12 are in Oyster Creek, influenced directly by heat, increased (and constant) salinity, and other components of the effluent (heavy metals, silt, increased flow rate, etc.). Since JCP & L calculates average values of heavy metal input per month, exact data necessary to characterize the effluent completely are not available.

Stations 14 and 15 are at or near the southern limit of the thermal plume, on Barnegat Bay. Station 15, like Station 6, is being sampled on a reduced schedule. Station 18 on Long Beach Island is being used only as a reliable source of Teredo navalis for laboratory experiments.

Field Work

Once each month, the water temperature and salinity are measured at each station. Air temperature and time of day are also recorded. The amount of silt settling on wood panels submerged for one month is estimated as trace, light, moderate, or heavy. At stations 1, 5, 11, and 14, records of temperature and salinity are kept by means of constant recording instruments that are serviced once a month.

White pine panels, approximately 3/4" x 4" x 8", are used to obtain shipworms for study. There are three panel series: 1) Each month, a panel that has been in the water for 1 month is removed and replaced. In this way data on monthly settlement and early growth of borers are obtained. 2) Each month, a panel that has been in the water for 12 months is removed and replaced. It provides data on timing of reproduction, species and age structure of established borer communities, and other population data. 3) Each May, a series of 12 panels is deployed. These panels are removed one per month. They provide information on the cumulative growth and maturation of individual borers as well as development of the boring and fouling communities. The cumulative monthly amount of wood destruction can be evaluated. These three panel series are called M, Y, and C, respectively. The Y and C series are replicated at some stations, as indicated in the data tables to follow. Replication is not possible at all stations because of limited space where the water is deep enough to submerge a series of shipworm panels.

Panels are presoaked for 2 weeks, then set on aluminum frame racks against bulkheading or off finger docks. They rest about 6" above the water-sediment interface.

Laboratory Work

Panels are examined for pediveliger shipworm larvae and boring isopods, scraped, and X-rayed to locate the shipworms and provide a permanent record of damage. It is possible to count and often to identify shipworms from the X-rays in uncrowded panels, but X-rays do not provide quantitative data in most cases. Therefore, using the X-rays as guides, the panels are dissected. All the shipworms are removed, identified, examined for larvae in the gills, and measured (length only). They are preserved in 75% buffered alcohol. Identifications are first made by technicians, but all *Teredo* spp. are checked by one of the senior investigators.

Wood fragments from the dissected panels are saved. Calcareous tubes and other debris left by the shipworms are removed with $HC\ell$. The wood is washed in fresh water, then dried to constant weight, allowed to cool to room temperature, and weighed. The panels are also weighed before going into the water. The weight difference is a measure of wood destruction due to boring organisms.

During dissection of the wood panels, we estimate the percentage of empty tubes, which indicate mortality. If pallets are still present in the empty tubes, we can record the species of the dead shipworm.

Shipworms from the replicate 12-month panels are not preserved but are kept alive and allowed to spawn in tanks containing filtered sea water (22% salinity) and new pine panels. In this way, we have established pure laboratory populations of *Teredo bartschi*. Individuals of *B. gouldi* and *T. navalis* from the field are being maintained in the laboratory. These stocks are used for temperature and salinity tolerance experiments. Attempts are underway to establish breeding colonies of *Teredo navalis*.

Physiological Ecology

Pediveliger larvae released from animals that had themselves been raised in the laboratory were collected from an aquarium maintained at about 18° C. Ten pediveligers were placed in each of 6 finger bowls containing artificial seawater at 20-22° C and salinities of 5 °/₀₀, 10 °/₀₀, 20 °/₀₀, 30 °/₀₀, 40 °/₀₀, and 50 °/₀₀. A sliver of presoaked white pine was placed in each bowl. Observations were made on the motility of the pediveligers every 20 minutes for 4 hours, using a dissecting microscope on a universal stand. The categories of behavior were: swimming actively, swimming near the bottom, trapped in surface film, crawling on wood, crawling on glass, and open on bottom.

Finally, ten pediveligers of Teredo bartschi and a sliver of presoaked white pine were placed in finger bowls containing water at the following salinities: 5, 10, 15, 20, 25, 30, and 35 °/₀₀. The behavior of the pediveligers was observed three times daily: 9:00, 12:00, and 16:00 E.S.T. The behavioral categories included actively swimming with velum extended, actively crawling on wood with foot extended, attached to surface film, probing the wood as if to begin burrowing, crawling on the glass bottom, swimming slowly with foot extended near the bottom, lying open on the bottom, and lying closed on the bottom. The temperature was kept at 20-21.5° C.

RESULTS AND DISCUSSION

Physical Factors

The temperature profile of Oyster Creek and control stations at the time of sampling (Table 1) shows that the generating station was operating during the period of this report. The ΔT on December 3 was about +3° C, while it was about +1.5° on January 8 and +2° C on February 6. There was an elevation of about 1.5° C at the Bayside Beach Club in December and February. In January and February, the temperature was low enough at all stations to nearly halt the growth and burrowing activity of all species of shipworms, and to cause mortality to Teredo bartschi. It is interesting that the temperature was lowest in early January; early February is usually colder. The temperature differential among stations is greater when the ambient temperature is higher.

The continuous temperature recorder data for the same period are in Table 2. In December, the greatest ΔT was 7.0° C and the average ΔT was 4.6° C between stations 1 and 11. The temperature was over 10° C in Oyster Creek, warm enough for metabolic activity of shipworms. The average ΔT for the month was 4.4° C in January and 3.7° C in February. The temperature at station 5 in Forked River was considerably greater than ambient in January, indicating recirculation of the thermal effluent.

The salinity profiles (Table 3) show an abnormally low salinity at station 1 in January, probably due to freshwater runoff. Otherwise the variation in salinity, both among months and among stations, was low. The salinity in Forked River was essentially the same as it was in Oyster Creek, except for the month of February, when Oyster Creek had slightly lower salinity (about 3 ‰ lower). The continuous salinity records in Table 4 agree with the findings in Table 3, except that average salinities in January do not conform with the low value recorded in January at station 1.

The outages of the Oyster Creek generating station were minimal during December-February (Table 5). Both circulation and dilution flow remained at high levels, explaining the similar salinities in Oyster Creek, Forked River, and Bayside Beach Club. The general weather pattern (Table 6) for the same period shows that the sub-average air temperatures in January were reflected in the water temperatures that we reported in Tables 1 and 2. The sub-average precipitation discussed in previous reports continued in December and January.

Table 1

Temperature Profiles in ° C
Dec. 3, 1980 - Feb. 6, 1981

Station	Dec. 3	Jan. 8	Feb. 6	Differential among months
1	6.5	-.[c]	2.0	7.0
3	6.0	c	c	-
4	6.5	-1.5	2.5	8.0
5	6.0	-1.5	1.5	7.5
8	7.0	-1.5	3.0	8.5
10	9.5[a]	0.5[a]	4.5[a]	9.0
11	8.5	0.0	4.0	8.5
12	8.0	-1.0	4.0	9.0
14	5.0[b]	-2.0[b]	1.0[b]	7.0
Differential among stations	4.5	2.5	3.5	

[a] highest monthly value
[b] lowest monthly value
[c] station frozen in ice

Table 2

Continuous Temperature Recorder Data (°C) for Dec. 3, 1980 to Feb. 6, 1981

Stations 1, 5, 11, 14

I. Temperature at 1 P.M.

	Dec.3,1980-Jan.8, 1981				Jan.8,1981-Feb.6,1981				Feb.6,1981-Mar.9,1981		
	1	5[a]	11	14[b]	1	5	11	14[b]	5	11	14
Mean Daily Temp.at 1PM	0.8		5.4		0.4	1.6	4.8		5.7	9.4	6.3
Standard deviation	1.7		2.5		0.8	2.0	2.2		2.8	2.4	2.6
Highest value of Temp. at 1PM	5.0		10.3		2.4	7.6	10.3		10.6	13.5	10.4
Lowest value of Temp. at 1PM	-1.5		1.7		-1.0	<-1.3	1.5		<-1.3	5.3	0.8
Monthly Temp. Range at 1PM	6.5		8.6		3.4	>8.9	8.8		>11.9	8.2	9.6

II. Maximum Daily Temperatures

	1	5[a]	11	1	5	11	5	11	14
Mean value of Max. Daily Temp.	1.2		5.8	0.9	2.1	5.3	6.8	10.2	6.9
Standard deviation	1.6		2.4	0.8	2.1	2.4	2.6	2.4	2.6
Highest value of Max. Daily Temp.	5.0	7.1	10.3	2.6	7.7	10.3	11.0	14.2	10.6
Lowest value of Max. Daily Temp.	-1.3		1.9	-0.4	-0.8	1.8	1.6	5.8	1.1
Monthly Range of Max. Daily Temp.	6.3		8.4	3.0	8.5	8.5	9.4	8.4	9.5

Table 2, continued

III. Minimum Daily Temperature

	Dec.3,1980-Jan.8, 1981		Jan.8,1981-Feb.6,1981			Feb.6,1981-Mar.9,1981		
	1	11	1	5[a]	11	5[a]	11	14
Mean value of Min. Daily Temp.	0.0	5.8	-0.2		3.5		9.1	5.4
Standard deviation	1.3	2.4	0.6		2.0		2.6	2.8
Highest Min. Daily Temp.	3.3	10.3	1.2	3.6	8.0	9.2	12.7	9.9
Lowest value of Min. Daily Temp.	-1.7	1.9	-1.2	<-1.3	0.0	<-1.3	4.0	0.2
Monthly Range of Min.Daily Temp.	5.0	8.4	2.4	>4.9	8.0	>10.5	8.7	9.7

IV. Daily Temperature Range

	1	11	1	5[a]	11	5[a]	11	14
Mean Daily ΔT	1.2	1.7	1.1		1.9		2.1	1.5
Standard deviation	0.6	1.0	0.4		0.8		1.2	0.8
Largest Daily ΔT for one Month	3.1	5.2	2.0	7.0	3.4	>1.6	5.6	2.8
Smallest Daily ΔT for one Month	0.3	0.2	0.3	0.2	0.3	0.6	0.3	0.4

[a] The temperature at station 5 was too low to record all data properly.

[b] The recorder did not record properly in December and January.

[c] The recorder did not record properly in February.

Table 3

Salinity Profiles in °/₀₀
Dec. 3, 1980 - Feb. 6, 1981

Station	Dec. 3	Jan. 8	Feb. 6	Differential within stations, among months
1	20[b]	[illegible][b]	22	14
3	22	c	c	-
4	25	27	25	2
5	24	27	26[a]	3
8	26[a]	27	26[a]	1
10	24	25	22	3
11	26[a]	28[a]	24	4
12	24	26	24	2
14	26[a]	28[a]	18[b]	10
Differential among stations	6	20	8	

[a] highest salinity value
[b] lowest salinity value
c station frozen in ice

Table 4

Continuous Recording Salinometer Data
(12:00 Noon, EST)
in parts per thousand, Dec. 3, 1980-Feb. 6, 1981

Dates	Statistic	Sta. 1	Sta. 5	Sta. 11	Sta. 14
Nov.7, 1980- Dec.3, 1980	N	a	13	6	a
	$\bar{x}$		21.6	25.2	
	S_x		1.3	4.3	
Dec.3, 1980- Jan.8, 1981	N	a	9	b	a
	$\bar{x}$		20.4		
	S_x		1.0		
Jan.8, 1981- Feb.6, 1981	N	12	15	b	13
	$\bar{x}$	22.2	20.9		27.7
	S_x	2.5	0.6		0.7

N Number of days recorded indicates extent of missing data

$\bar{x}$ Mean

S_x Standard deviation

a Instruments not in service due to cold weather and ice. Instruments were deployed on Jan. 21, 1981.

b Problem with micropositioner could not be corrected by the factory during this period.

Table 5

Oyster Creek Nuclear Generating Station Outages,
Circulation and Dilution Flow in gal. x 10^6
for December, 1980 - February, 1981

	Total Circulating Water Flow (gal. 10^6)	Total Dilution Flow (gal. 10^6)
December	20,327	22,634
January	20,280	23,179
February	16,929	20,950

Outages:		
	Dec. 15	94% power
	Dec. 31	89% power
	Jan.	None
	Feb.	None

Table 6

Average Temperature and Precipitation in Northern and Central New Jersey, Deviation from Normal. December, 1980-February, 1981

	Temperature (°F)	Precipitation (inches)
December	-3.0	-2.8
January	-7.1	-2.6
February	+3.7	+1.4

Shipworm Populations

No shipworm larvae were found settling on any monthly panels during December-February, 1981. This finding is consistent with the findings of the previous 4 years of the study. The majority of the shipworms found alive in cumulative panels submerged on May 3, 1980, were Teredo bartschi (Table 7). Most of them came from a single station in Oyster Creek (station 12). The only other stations to harbor T. bartschi were station 8, Bayside Beach Club, and possibly station 10 in Oyster Creek. Bankia gouldi was the most common species at Bayside Beach Club, and was more abundant than Teredo navalis in Barnegat Bay overall. There was consistency in numbers and species composition between the 2 replicate panels at stations 6, 8, and 11.

Monthly differences in the cumulative panels were small, with one exception. The living population of Teredo bartschi at station 12 was drastically reduced between Jan. 5 and Feb. 6, 1981, probably due to cold temperatures. A comparison of Table 7 with Table 8, which records living and dead shipworms, reveals that significant mortality of T. bartschi actually began in the previous month. Insignificant mortality occurred to Bankia gouldi over the three months. However, only 25 of 60 Teredo navalis were alive in panels collected in the three months covered by this report. The greater mortality of T. navalis compared with B. gouldi may be due to the heavy infestation of Minichia sp., a parasite that infests its gill tissues (Hillman, personal communication). B. gouldi is apparently not infected with Minichia. The survivorship of all species combined (Table 9) shows that significant mortality did not take place until after December 3, 1980.

The lengths of living specimens taken from the cumulative panels (Table 10) reveal some very small specimens of Teredo bartschi at station 12. The specimens of length less than 1 mm have not grown since they settled. The largest specimens of T. bartschi, 75 mm in length, have grown larger in their approximately 6 months' time in Oyster Creek than our laboratory specimens of similar age, which rarely exceed 50 mm. The sizes of the smallest Bankia gouldi and Teredo navalis collected between December and February, 61 mm and 50 mm respectively, clearly demonstrate that there has been no recent settlement of those species.

The pattern of species composition and abundance of shipworms in the yearly panels was similar to that found for the cumulative panels. There was very little attack at the stations north of Forked River, and Bankia gouldi was the most abundant species in Forked River (Tables 7 and 11). Stations 8 at Bayside Beach Club and 12 in Oyster Creek were the only stations to harbor all three species of shipworms. The only place where living specimens of Teredo navalis were dominant was at station 14 on the bay south of Oyster Creek. T. bartschi was abundant only at station 12.

Table 7

Numbers of Living Shipworms in Cumulative Panels Submerged May 3, 1980

Date Removed:	Dec. 3, 1980				Jan. 5, 1981					Feb. 6, 1981				
Station	B.g.	T.n.	T.b.	Total	B.g.	T.n.	T.b.	Teredinid	Total	B.g.	T.n.	T.b.	T.sp.	Total
1	1	1	0	2	2	1	0	0	3	1	4	0	0	5
3	0	1	0	1	0	0	0	0	0	0	0	0	0	0
4	2	2	0	4	3	0	0	0	3	6	0	0	0	6
5	1	0	0	1	1	0	0	0	1	1	1	0	0	2
8	4	1	0	5	11	1	0	0	12	5	0	0	0	5
10	1	0	0	1	3	0	0	1*	4	2	0	0	0	2
11	3	1	0	4	0	0	0	0	0	2	1	0	0	3
12	4	0	556	560	0	1	652	0	653	1	0	8	0	9
14	3	0	0	3	0	1	0	0	1	1	3	0	0	4
Total	19	6	556	581	20	4	652	1	677	19	9	8	0	36
4 Rep	4	0	0	4	2	0	0	0	2	1	1	0	0	2
8 Rep	7	3	1	11	9	0	4	0	13	12	1	1	1*	15
11 Rep	4	0	0	4	3	0	0	0	3	5	1	0	0	6

* probably *T. bartschi*

Rep = replicate panel

Table 8

Numbers of Living Shipworms Plus Empty Tubes, Cumulative Panels Submerged May 3, 1980

Date Removed:	Dec. 3, 1980					Jan. 5, 1981					Feb. 6, 1981				
Station	B.g.	T.n.	T.b.	Tere-dinid	Total	B.g.	T.n.	T.b.	Tere-dinid	Total	B.g.	T.n.	T.b.	T.sp.	Total
1	1	1	0	0	2	2	1	0	0	3	1	4	0	0	5
3	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
4	2	2	0	0	4	3	1	0	0	4	6	1	0	0	7
5	1	0	0	0	1	1	1	0	0	2	1	1	0	0	2
8	4	1	0	0	5	12	2	0	0	14	5	0	1	0	6
10	1	0	0	0	1	3	0	0	1*	4	2	0	0	0	2
11	3	1	0	0	4	0	0	0	0	0	2	1	0	0	3
12	4	0	556	0	560	0	1	922	1	924	1	0	580	0	581
14	3	6	0	0	9	0	7	0	0	7	1	7	0	0	8
Total	19	12	556	0	587	21	13	922	2	95[illegible]	19	14	581	0	614
4 Rep	5	0	0	0	5	2	3	0	1	6	2	2	0	0	4
8 Rep	7	3	1	1	12	9	10	4	1	24	12	2	1	2*	17
11 Rep	4	0	0	0	4	3	0	0	0	3	5	1	0	0	6

* probably T. bartschi

Table 9

Percentage of Specimens Alive when Collected, Cumulative Panels

Month Collected:	Dec. 3, 1980			Jan. 5, 1981			Feb. 6, 1981		
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	2	2	100	3	3	100	5	5	100
3	1	1	100	0	0	-	0	0	-
4	4	4	100	3	4	75	6	7	86
5	1	1	100	1	2	50	2	2	100
8	5	5	100	12	14	86	5	6	83
10	1	1	100	4	4	100	2	2	100
11	4	4	100	0	0	-	3	3	100
12	560	560	100	653	924	71	9	>581	< 2
14	3	9	33	1	7	14	4	8	50
Total	581	587	99	677	958	71	36	614	6
4 Rep	4	5	80	2	6	33	2	4	50
8 Rep	11	12	92	13	24	54	15	17	88
11 Rep	4	4	100	3	3	100	6	6	100

Table 10

Length Ranges of Shipworms, in mm, Cumulative Panels

Date Removed:	Dec. 3, 1980			Jan. 5, 1981			Feb. 6, 1981		
Station	B.g.	T.n.	T.b.	B.g.	T.n.	T.b.	B.g.	T.n.	T.b.
1	150	220		110-120	290*		205	130-255	
3		80							
4	280-305	70-315*		170-197	50		61-245		
5	235			203	200		160	215	
8	155-250	250		93-163	113-135		136-200		55*
10	322			210-265*			232-278		
11	250-300	315*					188-195	125	
12	110-250		0.5-90*		165	0.5-75*	220		2-50
14	230-362*				80-175		115	65-135	
4 Rep	150-260			150-170	165-270		165-175	90-285*	
8 Rep	113-300	100-151	50	100-163	125-245	8-28	125-200	115-132	45
11 Rep	175-340			175-258			155-380*	170	

* Largest specimen of each species, each month

Table 11

Numbers of Living Shipworms in Yearly Panels

Date Removed:	Dec. 3, 1980				Jan. 5, 1981				Feb. 6, 1981			
Station	B.g.	T.n.	T.b.	Total	B.g.	T.n.	T.b.	Total	B.g.	T.n.	T.b.	Total
1	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	1	3	0	4	3	0	0	3	4	0	0	4
5	0	1	0	1	2	1	0	3	1	1	0	2
8	7	1	2	10	0	0	0	0	6	1	0	7
10	1	0	0	1	0	0	0	0	0	1	0	1
11	1	2	0	3	6	2	0	8	3	0	0	3
12	2	1	618	621	0	0	22	22	2	0	2	4
14	0	3	0	3	1	5	0	6	2	4	0	6
Total	12	11	620	643	12	8	22	42	18	7	2	27
1 Rep	2	0	0	2	3	1	0	4	2	1	0	3
3 Rep	0	0	0	0	0	0	0	0	0	0	0	0
4 Rep	4	1	0	5	1	1	0	2	1	1	0	2
11 Rep	0	0	0	0	1	0	0	1	1	0	0	1
14 Rep	0	1	0	1	1	0	0	1	0	2	0	2

Table 11 does document the dramatic mortality that took place in the Teredo bartschi population in Oyster Creek sometime in late December or early January and continuing into February, when only a few specimens remained alive. As in the cumulative panels, the data for pairs of yearly replicate panels were very similar.

The survivorship of Teredo navalis was 34 out of 53 specimens found in all the yearly panels, while that of Bankia gouldi was 52 out of 52 specimens (Tables 11 and 12). The percent survival of all species together for each yearly panel is shown in Table 13. The number of empty tubes is likely to have been underestimated for station 12 because of the small size of T. bartschi.

Table 14 presents the lengths of shipworms taken from the yearly panels; some are based on measurements of empty tubes. As in the cumulative panels, there were no specimens of less than 25 mm except in Oyster Creek. The size ranges are comparable in the two series of panels, except for the greater number of specimens less than 25 mm long in yearly panels. Panels submerged in the winter of 1980 would not have become infected until summer, so the cumulative and yearly panels contain the same generations of shipworms. The only difference is that the yearly panels, having been in the water longer, would possibly have been more attractive to the settling larvae and might have been attacked earlier. But neither the lengths nor the numbers of shipworms are significantly greater in the yearly panels, suggesting that the two panel series are essentially replicates at this time of year.

The percentage of wood weight lost due to borer attack is listed in Table 15 for both panel series. The differences among panels from the same station are due to the vagaries of settlement rather than to monthly growth. The amount of damage is not correlated with the length of time the panel was deployed. The greatest amount of damage occurred at station 12, followed by stations 8 and 4 in Forked River. The shipworm attack was light at all of the control stations.

Many of the specimens of Teredo bartschi found during this period contained larvae in the gills (Table 16). Even empty tubes contained some pediveliger larvae, although most appeared to have been dead when the panels were collected. The February cumulative panel from station 8 contained pediveliger larvae clinging to the shell valves of one adult specimen.

Table 12

Numbers of Living Shipworms plus Empty Tubes, Yearly Panels

Date Removed:	Dec. 3, 1980					Jan. 5, 1981					Feb. 6, 1981			
Station	B.g.	T.n.	T.b.	Teredinid	Total	B.g.	T.n.	T.b.	Teredinid	Total	B.g.	T.n.	T.b.	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	4	0	0	5	3	1	0	0	4	4	1	0	5
5	0	3	0	0	3	2	2	0	0	4	1	2	0	3
8	7	2	2	0	11	0	0	0	17	17	6	1	0	7
10	1	0	0	0	1	0	0	0	0	0	0	1	0	1
11	1	2	0	0	3	6	2	0	0	8	3	2	0	5
12	2	2	654	0	658	0	0	~85	0	~85	2	0	13	15
14	0	5	0	1	6	1	11	0	0	12	2	4	0	6
Total	12	18	656	1	687	12	16	~85	17	~130	18	11	13	42
1 Rep					a	1	3	0	0	4	2	1	0	3
3 Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4 Rep					a	1	2	0	1	4	1	1	0	2
11 Rep					a	1	1	0	0	2	1	0	0	1
14 Rep					a	1	0	0	1	2	0	2	0	2

a Panel not X-rayed. Mortality unknown.

Table 13

Percentage of Specimens that were Alive when Collected, Yearly Panels

Month Collected:	Dec. 3, 1981			Jan. 5, 1981			Feb. 6, 1981		
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	0	0	-	0	0	-	0	0	-
3	0	0	-	0	0	-	0	0	-
4	4	5	80	3	4	75	4	5	80
5	1	3	33	3	4	75	2	3	67
8	10	11	91	0	17	0	7	7	100
10	1	1	100	0	0	-	1	1	100
11	3	3	100	8	8	100	3	5	60
12	621	658	94	22	~85	<26	4	~15	< 27
14	3	6	50	6	12	50	6	6	100
Total	643	687	94	42	~130	<32	27	~42	<64
Rep 1	2	a	-	4	4	100	3	3	100
Rep 3	0	0	-	0	0	-	0	0	-
Rep 4	5	a	-	2	4	50	2	2	100
Rep 11	0	a	-	1	2	50	1	1	100
Rep 14	1	a	-	1	2	50	2	2	100

a Panel not X-rayed. No estimate given.

Table 14

Length Ranges of Shipworms, in mm, Yearly Panels

Date Removed: Station	Dec. 3, 1980 B.g.	Dec. 3, 1980 T.n.	Dec. 3, 1980 T.b.	Jan. 5, 1981 B.g.	Jan. 5, 1981 T.n.	Jan. 5, 1981 T.b.	Feb. 6, 1981 B.g.	Feb. 6, 1981 T.n.	Feb. 6, 1981 T.b.
1									
3									
4	225	120-260*		155-250*	175		140-300	250*	
5		210		153-165	195-240		195	58-95	
8	135-235	145	36-72				47-330	130	
10	19							5	
11	200	22-160		127-215	118-204		175-240	130-170	
12	160	240	0.5-82*			1-35*	330-335*		3-61*
14		140-190		182	62-146		153-175	30-55	
1 Rep	230-260*			132	205-285*		100-155	230	
3 Rep									
4 Rep	25-235	250		175	80-100		220	175	
11 Rep				210	6-90		112		
14 Rep		140		135				65-90	

* Largest specimen each month, each species.

Table 15

Percentage of Wood Weight Lost by Cumulative and Yearly Panels

A. Cumulative

Date Removed:	Dec. 3, 1980	Jan. 5, 1981	Feb. 6, 1981
Station			
1	10.4	9.1	20.7
3	7.5	0.0	0.0
4	19.5	23.9	20.1
5	11.7	10.3	9.9
8	23.6	36.0	23.6
10	16.5	17.0	20.9
11	25.5	0.0	18.7
12	38.8*	67.4*	22.5
14	23.6	11.6	10.4
4 Rep	29.3	11.5	13.5
8 Rep	32.8	45.8	33.9*
11 Rep	30.4	13.3	34.6

B. Yearly

1	0.0	0.0	0.0
3	0.0	0.0	0.0
4	20.3	25.9	20.6
5	9.8	18.1	12.0
8	29.6	0.0	26.5*
10	11.3	10.3	0.0
11	17.2	31.8*	21.4
12	47.1*	9.3	21.3
14	17.7	22.9	16.5
1 Rep	18.4	15.7	14.0
3 Rep	0.0	0.0	0.0
4 Rep	25.0	10.1	13.0
11 Rep	0.0	13.6	8.3
14 Rep	13.0	10.3	10.8

* Greatest amount of damage

Table 16

Percentages of *Terado bartschi* Carrying Larvae in the Gills

(Number of Individuals in Parentheses)

Station	Dec. 3, 1980	Jan. 5, 1981	Feb. 6, 1981
8	100 (2)	0	0
12 Cum.	48 (130)	40 (50)	0
12 Yearly	61 (122)	27 (11)	0

Physiological Ecology: Pediveliger behavior of Teredo bartschi.

The behaviors of Teredo bartschi pediveligers observed at the various salinities are recorded in Table 17. Animals at 40 and 50 °/oo salinity stayed closed up on the bottom, and are not included in Table 17.

In addition to the data in Table 17, there are several distinctions to be made. Once past the first hour, the pediveligers in 5 °/oo and 10 °/oo salinity swam more slowly than those in 20 °/oo and 30 °/oo; they also tended to move in circles rather than up and down. Movement of the larvae was more rapid at 30 °/oo than at 20 °/oo. The shells of animals in 5 °/oo salinity gaped open more widely than the others. By the end of the experiment, the pediveligers at 20 and 30 °/oo tended to be higher in the water than those kept at 5 and 10 °/oo.

The results of the 5-day experiment on behavior of Teredo bartschi under different salinities are reported in Table 18 and summarized in Table 19. At 5 °/oo, the majority of the T. bartschi pediveligers spent the first two days swimming slowly near the bottom of the finger bowl with foot extended. However, most individuals spent the last three days lying open on the bottom. At 10 °/oo, the only behaviors observed after three days were lying open on the bottom of the finger bowl, probing the wood as if to begin boring, and active swimming. The first two were most common. Early in the experiment, during days 1 and 2, swimming slowly near the bottom was a common behavior, as was lying open on the bottom.

At 15 °/oo, probing of wood was by far the most common behavior during the entire period. At 20 °/oo and 25 °/oo, behavior was quite variable, but most individuals were actively swimming. Other common behaviors were lying open on the bottom and swimming slowly with the foot extended.

At 30 °/oo and 35 °/oo, most animals were probing the wood after an initial 24-hour period of active swimming. However, many individuals remained active swimmers throughout the experiment.

These results suggest that Teredo bartschi pediveligers are not stressed between 10 and 35 °/oo, and that crawling on and probing wood as well as active swimming are the most common behaviors. Slow swimming near the bottom occurs more commonly at low salinities (5-10 °/oo).

There is some aggregate shift in behavior after the first 24 hours, somewhat independent of salinity. There is a steady increase in the number of animals found probing the wood substrate (Table 20). There is also a fairly steady increase in the number of animals lying open on the bottom. There is a strong decline in the numbers of animals swimming slowly after the second day, and in animals swimming rapidly after the fourth day.

Table 17

Behavior of Teredo bartschi Pediveligers When Exposed to Different Salinities for Several Hours (20° C)

5 °/oo Time elapsed (min)	Swimming Vert.	Swimming near bottom	Trapped at Surface	Crawling: On wood	Crawling: On glass	Open on Bottom
20	5	0	0	0	5	0
40	10	0	0	0	0	0
60	8	0	0	0	2	0
80	4	5	0	0	0	1
100	9	0	0	0	1	0
120	8	0	1	0	1	0
140	10	0	0	0	0	0
160	7	3	0	0	0	0
180	8	2	0	0	0	0
200	10	0	0	0	0	0
220	4	4	0	0	1	1
240	0	10	0	0	0	0
10 °/oo						
20	9	0	0	0	0	1
40	9	0	0	0	0	1
60	8	0	0	0	2	0
80	3	4	0	0	0	3
100	5	0	0	0	1	4
120	9	0	0	0	1	0
140	10	0	0	0	0	0
160	5	0	0	0	1	4
180	9	1	0	0	0	0
200	7	0	0	0	0	3
220	4	3	0	0	0	3
240	0	9	0	0	1	0
20 °/oo						
20	7	0	0	0	3	0
40	8	0	0	0	2	0
60	0	7	0	0	1	2
80	6	0	0	1	0	3
100	10	0	0	0	0	0
120	6	0	0	0	3	1
140	7	0	0	0	1	2
160	5	5	0	0	0	0
180	7	0	0	0	1	2
200	8	0	0	0	2	0
220	7	2	0	0	1	0
240	8	0	0	0	1	1

Table 17 (continued)

30 °/₀₀

Time elapsed (min)	Swimming Vert.	Swimming near bottom	Trapped at Surface	Crawling: On wood	Crawling: On glass	Open, on Bottom
20	8	0	1	0	1	0
40	6	0	0	0	1	3
60	8	0	0	0	0	2
80	10	0	0	0	0	0
100	8	1	0	0	0	1
120	8	0	0	1	0	1
140	9	0	0	0	1	0
160	7	0	0	0	0	3
180	6	0	0	0	2	2
200	6	0	0	0	3	1
220	9	1	0	0	0	0
240						

Overall, the most active animals were found at 20 and 30 °/₀₀. A salinity of 40 °/₀₀ exceeds the limit for normal activity. Swelling due to osmotic stress was obvious at 5 °/₀₀; normal swimming movements were impaired at 10 °/₀₀. However, the behavior of swimming near the bottom at low salinities may be an adaptation to estuaries, increasing the possibility that the pediveligers will come in contact with wood.

The shipworms did not seem particularly attracted to wood; many more chose to crawl on glass. Crawling was most common at 20 °/₀₀, while sitting open on the bottom was most common at 10 °/₀₀.

Table 18

Behavior of *Teredo bartschi* Pediveligers when Exposed to Different Salinities for Several Days at 20°C

5 °/₀₀	Day 1 9h	Day 1 12h	Day 1 16h	Day 2 9h	Day 2 12h	Day 2 16h	Day 3 9h	Day 3 12h	Day 3 16h	Day 4 9h	Day 4 12h	Day 4 16h	Day 5 9h	Day 5 12h	Day 5 16h
1. Lying open on bottom		1	1		1		6	7	5	9	8	8	8	9	9
2. Lying closed on bottom															
3. Probing wood										1	1	2	1	1	1
4. Crawling on wood				2			1	1	1		1		1		
5. Crawling on glass	1						3	2	4						
6. Swimming slowly with foot extended near the bottom	8	9	9	8	9	10									
7. Attached to surface film															
8. Actively swimming	1														

10 °/₀₀	Day 1 9h	Day 1 12h	Day 1 16h	Day 2 9h	Day 2 12h	Day 2 16h	Day 3 9h	Day 3 12h	Day 3 16h	Day 4 9h	Day 4 12h	Day 4 16h	Day 5 9h	Day 5 12h	Day 5 16h
1. Lying open on bottom		4	1	7	5	2			2	8	4	2	4	4	3
2. Lying closed on bottom															
3. Probing wood				1				2	3	1	6	6	6	6	7
4. Crawling on wood		1	1	1			2								
5. Crawling on glass			1		1										
6. Swimming slowly near bottom	8	5	6		4	8	4		1						
7. Attached to surface film							2	1							
8. Actively swimming	2		1	1			2	7	4	1		2			

Table 18 (continued)

Behavior of <u>Teredo bartschi</u> Pediveligers when Exposed to Different Salinities for Several Days at 20° C

	Day 1			Day 2			Day 3			Day 4			Day 5		
15 °/₀₀	9h	12h	16h	9h	12h	16h	9h	12h	16h	9h	12h	16h	9h	12h	16h
1. Lying open on bottom		2		2	1	1					1	1			1
2. Lying closed on bottom															
3. Probing wood		6	6	6	8	8	8	8	8	8	8	8	8	8	9
4. Crawling on wood	1			2											
5. Crawling on glass	1	1	2								1	1			
6. Swimming slowly with foot extended near the bottom						1									
7. Attached to surface film															
8. Actively swimming	8	1	2		1		2	2	2	2			2	2	
20 °/₀₀															
1. Lying open on bottom				1	3	1				4	1	1	4	2	7
2. Lying closed on bottom		1	1												
3. Probing wood							1		1		1	1	1		2
4. Crawling on wood	3	1	1			5			1		1		3	1	
5. Crawling on glass	1	2	2	1			1				4	4	2	5	
6. Swimming slowly near bottom				7	2	4		8	1						
7. Attached to surface film															
8. Actively swimming	6	6	6	1	5		8	2	7	6	3	4		2	1

Table 18 (continued)

Behavior of Teredo bartschi Pediveligers when Exposed to Different Salinities for Several Days at 20° C

	Day 1			Day 2			Day 3			Day 4			Day 5		
25 °/₀₀	9h	12h	16h	9h	12h	16h	9h	12h	16h	9h	12h	16h	9h	12h	16h
1.Lying open on bottom				2	1	1	1	1			1		1	1	6
2.Lying closed on bottom									1				1		
3.Probing wood				1	2		2	2	1	1	2	2	3	3	3
4.Crawling on wood						1									1
5.Crawling on glass		2	2				1	1	2	1	1	1	1	1	
6.Swimming slowly with foot extended near the bottom		1	1							1					
7.Attached to surface film									2						
8.Actively swimming	10	7	7	7	7	8	6	6	4	7	6	7	4	5	
30 °/₀₀															
1.Lying open on bottom						1						1	3		1
2.Lying closed on bottom															
3.Probing wood				5	6	6	6	6	6	6	6	6	6	6	6
4.Crawling on wood	3	4	2		1			1							
5.Crawling on glass		4	6												3
6.Swimming slowly with foot extended near the bottom													1	1	
7.Attached to surface film									1						
8.Actively swimming	7	2	2	5	3	3	4	3	3	4	4	3		3	

Table 18 (continued)

Behavior of _Teredo bartschi_ Pediveligers when Exposed to Different Salinities for Several Days at 20° C

35 °/oo	Day 1			Day 2			Day 3			Day 4			Day 5		
	9h	12h	16h	9h	12h	16h	9h	12h	16h	9h	12h	16h	9h	12h	16h
1. Lying open on bottom	1									1	2	2	3		2
2. Lying closed on bottom															
3. Probing wood		1	1	1	4	4	3	6	6	6	6	6	6	6	6
4. Crawling on wood	6	3	2	2	1	1	1								1
5. Crawling on glass		1		1		1									
6. Swimming slowly with foot extended near the bottom	1								3						
7. Attached to surface film															
8. Actively swimming	2	5	7	6	5	4	6	4	1	3	2	2	1	4	1

Table 19

Behavior of Teredo bartschi Larvae Summed over 5 Days at 7 Salinities

Behavior	Salinity (°/₀₀) 5	10	15	20	25	30	35
1.Lying open on bottom	72	46	9	24	15	6	11
2.Lying closed on bottom	0	0	0	2	2	0	0
3.Probing wood	7	38	107	7	22	71	62
4.Crawling on wood	7	5	3	16	2	11	17
5.Crawling on glass	10	2	6	22	13	13	3
6.Swimming slowly with foot extended near the bottom	53	36	1	22	3	2	4
7.Attached to surface film	0	3	0	0	2	1	0
8.Actively swimming	1	20	24	57	91	46	53

Table 20

Composite Behavior of Teredo bartschi Larvae (7 salinities) for each Day of the Experiment

Behavior	Day 1	2	3	4	5
1.Lying open on bottom	10	29	21	54	68
2.Lying closed on bottom	2	0	1	0	1
3.Probing wood	14	53	69	84	95
4.Crawling on wood	32	15	8	1	7
5.Crawling on glass	24	4	13	14	12
6.Swimming slowly with foot extended near the bottom	46	53	17	1	2
7.Attached to surface film	0	0	6	0	0
8.Actively swimming	82	56	75	56	25

It can be seen that the activity level of the pediveligers decreases over time and that boring commences within 5 days at salinities of 10, 15, 30, and 35 °/oo. Oddly, most pediveligers kept at 20 and 25 °/oo, the salinity range most common to Oyster Creek (Tables 3-4), remain active swimmers over a 5-day period. If this is a general result, it means that pediveligers of Teredo bartschi have greater potential for dispersal at intermediate salinities. Further statistical analyses will be done after more replications are made.

CONCLUSIONS

Teredo bartschi is the dominant shipworm in Oyster Creek, in terms of numbers of individuals and in terms of damage to wood. Its larvae can settle normally at a temperature of 20° C as long as the salinity is above about 10 $^{\circ}/_{\circ\circ}$. The larvae can withstand salinities above those found in Oyster Creek and our other stations in the Barnegat Bay system. The larvae can swim for at least 5 days at salinities of 20-25 $^{\circ}/_{\circ\circ}$, hence dispersal out of Oyster Creek can occur.

That such dispersal does occur is shown by the presence of *Teredo bartschi* in Forked River. Its gradual spread down Oyster Creek and up Forked River that we documented in past reports is more consistent with larval transport via currents than with adult transport in wooden boats. If the latter occurred, the distribution pattern would be more irregular.

Cold winters reduce the populations of *Teredo bartschi* and *T. navalis* but not *Bankia gouldi*. There is a possibility that parasitic infection could also play a role in the winter kill of *Teredo* species, since they are more heavily infested by parasites (*Minchinia*) than are *B. gouldi* (Hillman, 1978).

Outside of Oyster Creek and Bayside Beach Club, there was no shipworm outbreak in the winter of 1980-81. The distribution of *Teredo bartschi* and its physiological tolerances indicate that its reproduction and survival in Oyster Creek and Forked River are directly related to the operation of the Oyster Creek Nuclear Generating Station.

REFERENCE

Hillman, R. E. 1978. The occurrence of Minchinia sp. (Haplosporida, Haplosporidiidae) in species of the molluscan borer, Teredo, from Barnegat Bay, New Jersey. J. Invert. Pathology 31: 265-266.

APPENDIX: STATION LOCALITIES

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' 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° 49.6' N 74° 9.8' W
5	Leilani Drive	At branch point of Forked River	39° 49.6' N 74° 10.5' 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
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
10	Kochman's Residence	End of Compass Rd. on #1 Lagoon, Oyster Creek, Waretown, N.J. Temperature, salinity, siltation increase	39° 48.5' N 74° 10.6' W

STATION NUMBER	NAME	DESCRIPTION	COORDINATES
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
14	Cottrell's Clam Factory	End of North Harbor Rd. Waretown, N.J. (Mouth of Waretown Creek) Within but near limits of reported thermal plume	39° 47.7' N 74° 10.9' W
15	Carl's Boats	Washington & Liberty Sts Waretown, N.J. (on the bay)	39° 47' N 74° 11' W
16	Barnegat Light	Marina adjacent to Coast Guard Station	39° 45.8' N 74° 6.5' W

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16. ABSTRACT (200 words or less)

The species composition, distribution, and population dynamics of wood-boring bivalves 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 12 stations. Physiological tolerances of 3 species are also under investigation in the laboratory. Relative destructiveness and competition among the species are being analyzed. The native species *Teredo navalis* and *Bankia gouldi* coexist with the introduced *T. bartschi* in Oyster Creek and at the mouth of Forked River. An increase in mortality occurred in January. By February, *Teredo bartschi* was found only at Bayside Beach Club and in Oyster Creek. Successful settlement of pediveligers did not occur during December-February. Salinity tolerance experiments in the laboratory using *T. bartschi* pediveligers show that the greatest activity occurs at 20-30 $^o/_{oo}$. Osmotic stress occurs below 10 $^o/_{oo}$. Adults of *T. bartschi* withdrew their siphons in circulating seawater of 28 $^o/_{oo}$ when the temperature was lowered gradually to 10° C.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

Thermal Effects
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17b. IDENTIFIERS/OPEN-ENDED TERMS

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