

REPORT ON  
MARINE BORERS AND FOULING ORGANISMS  
IN 56 IMPORTANT HARBORS  
AND  
TABULAR SUMMARIES OF MARINE BORER DATA  
FROM 160 WIDESPREAD LOCATIONS



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BUREAU OF YARDS AND DOCKS  
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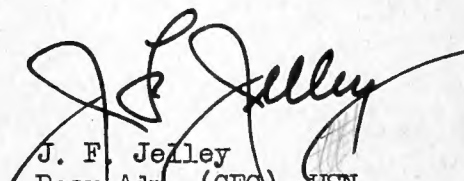


From painstaking research, such as is summarized in this report, we have learned in recent times that most of the world's coastal waters are infested more or less with destructive marine borers. Some costly marine structures built in the last decade without due appreciation of the marine borer menace have been totally destroyed by their attacks. In other cases, structures of a relatively temporary nature have required extensive repairs after only two or three years of service.

Detailed knowledge of the biological conditions in a given harbor is indispensable to those who are concerned with any type of marine structure containing timber.

Before a marine structure is designed or constructed, it is extremely important that the degree and type of local infestation be accurately determined and that specifications be established which will assure its resistance to borer attacks. After it is erected, it is equally important to maintain regular, thorough inspections and tests if borer damage is to be averted.

It is the belief of the Bureau that the information in this report will be of value not only to those officers of the Civil Engineer Corps who have cognizance over harbor installations, but also to all others who are concerned with shoreside construction and the maintenance of timber marine structures and/or the relatively safe berthing of wooden vessels.

  
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Rear Adm. (CEC), USN  
Chief of Bureau of Yards and Docks





## FOREWORD

Every year millions of dollars' worth of marine structures are damaged by marine borers of various kinds. They bore into and may eventually destroy not only timber, but also low-grade concrete, soft stone, and other nonmetallic materials in salt water. No salt-water port in the world is entirely safe from their depredations, except perhaps where the water is extremely diluted with fresh water or is heavily polluted with acids, oils, or other industrial wastes. Even heavily creosoted wood is not immune from Limnoria, the most widely distributed genus of crustacean borer.

Since about 1920, various types of marine borer traps and test boards have been designed and systematically submerged in harbors all over the world for the purpose of determining the type and extent of marine borer attack to which shoreside structures may be subjected. Examining these indicators at regular intervals led to the accumulation of much valuable data concerning the density of borer attack, rate of destruction, breeding seasons, distribution of the various species, length of life, rate of growth, and other significant factors relative to marine borer activity and destructiveness.

Test board data are now considered indispensable in the design of marine structures. When kept up to date, these data serve as continuous warnings against sudden borer invasions or a large increase in the borer population. They are of basic value in the preparation of wharf specifications and in the study of the fouling of intake tunnels, ships' bottoms, and ships' service pipe lines. They form the basis for accurate decisions as to the borer resistance of various woods, and the relative effectiveness of various treatments of piling and structural timbers subject to borer attack.

The extensive program of research now under way is an outgrowth of the initial investigations by the National Research Council in 1922 and 1923. These studies proved of such economic value that they were later organized on a continuing basis, and the present program conducted by the William F. Clapp Laboratories is being carried on at more than 500 locations along the United States coasts.

From 1942 to 1947, the Bureau of Yards and Docks of the United States Navy sponsored marine borer studies at 56 important harbors. The results are summarized in Sections 2 to 57 in PART A of this report, which comprises a narrative analysis of the data from each of the 56 harbors. These locations are widely distributed along our Atlantic and Gulf coasts; in Canada and Alaska; in various Caribbean islands; in Brazil, North Africa, Sicily, and Italy; and in the Pacific as far as Australia and New Zealand. Each analysis identifies the marine borers which attacked the test boards at a given station, summarizes the intensity of borer attack, and describes the kind and number of fouling organisms present. The depth of the test board and various hydrographic data also are reported. Additional data for 1948 and 1949, where available, are summarized under the heading "Recent Addenda."

PART B is a tabular summary of test board data recorded during 1934-1942 at several hundred locations. The majority of these locations are in the Middle Atlantic harbors; the others are scattered along the South Atlantic and Gulf ports in the Caribbean islands; in Venezuela and Brazil; in Italy; along the Pacific coast southerly from Adak, Alaska; and in the Hawaiian and other Pacific islands, Australia, and New Zealand.

Additional information on this subject may be found in the introduction to "Harbor Reports on Marine Borer Activities," NavDocks P-43, recently published by this Bureau, and in other publications listed in the References at the end of Section 1.

The test data were compiled from daily reports prepared by the biological staff of the William F. Clapp Laboratories. Much of the more recent test-board-panel analytical and evaluation work was done by Mrs. Dorothy Brown and Miss Irene Damon of that staff, and the assembly of the resulting information into its present form was accomplished by Dr. Arthur Rhoads, also of the Clapp Laboratories. Dr. Rhoads also prepared charts of each of the surveyed harbors, showing the location of each test board. These charts are available for reference in the files of the Research Division of the Bureau of Yards and Docks, Navy Department, Washington, D. C., and in the Clapp Laboratories at Duxbury, Mass.

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PART A  
ANALYSIS OF TEST BOARD RESULTS

Section 1 - GENERAL

Al.01 Prevalence and Destructiveness of Marine Borers

Test board data indicate that destructive marine borers are very widely distributed. Various species of borers have been found in most coastal waters, and it is probable that no port in any part of the world is entirely free from borer attack.

Recent studies have brought to light the great influence of local conditions on borer activities, although sufficient data are not available to evaluate the particular effects of local factors, such as currents, depth of water, degree of salinity, temperature, and pollution. Thus it has been thought that in the tropics marine borers are not only more numerous but are more destructive, because it is a fact that they grow and breed more rapidly in warm waters. But recent studies in northern harbors show that the maximum possible rate of borer destruction in timber piling may occur in Newfoundland and Alaska as well as in locations near the equator.

For example, sections of piles 12 inches to 15 inches in diameter have been totally destroyed by marine borers in six months or less in such widely separated areas as Alaska; Newfoundland; Nova Scotia; Fire Island, N. Y.; Mayport, Fla.; Puerto Rico; and San Francisco, Calif.

Lack of knowledge of the presence of destructive marine organisms in a given area, or failure to anticipate the extensive damage that such borers can cause, doubtless accounts for many costly repairs which have been required on shipyard docks, launchways, ramps, piers, and various other structures. In some cases, wartime structures, hastily built and perhaps designed for only occasional or limited use, have been severely damaged by borers in only two or three years of service.

In still other cases, large and costly structures built around 1941 for naval and other governmental uses, in this country and abroad, have been entirely destroyed by borer activities. The losses thus incurred run into many millions of dollars.

The accumulation of data from the test board research program will, therefore, be of great economic as well as scientific value.

## Al.02 Destructive Species of Marine Borers

1. Definition. For centuries the terms "shipworm" and "pileworm" have been applied to various marine boring organisms, especially Teredo, which have been observed boring into wood submerged in salt water. In this report, the generic term "marine borer" is used to designate any of the several hundred species of marine invertebrates which bore into timber, low-grade concrete, soft stone, or other nonmetallic materials in salt water.

All of the important species of marine borers belong to one of two families: the mollusca, a phylum of the animal kingdom which includes the limpets, snails, oysters, clams, and cuttlefish; and the crustacean family, which includes crabs, lobsters, and shrimps. Adult borers considered in this report range in size from the minute to those approximately one inch in diameter and several feet in length.

2. The Molluscan Borers. The two important species of destructive mollusca are the Teredinidae, the most widely distributed and most destructive, including the well-known Teredo and important genera such as Bankia and Lyrodus; and the Pholadidae, a family of bivalve borers which includes some very destructive clam-like borers. Mollusca not so well-known are the Martesia, Xylophaga, Lithodomus, Zirphae, and Petricola.

a. The Teredinidae are generally found boring into timber, but have been observed working into asphalt, bakelite, neoprene, manila, sisal, and various plastics. In their larval stage, Teredo navalis and kindred marine forms are free-swimming. This stage lasts, in the case of T. navalis, only one or two days, since they are expelled by the parent as fully developed embryos; whereas Bankia, spawned as minute eggs, roll around in the water from two to four weeks before their larval stage is over. During this period, the animal appears to be not too different from other bivalve larvae. At the end of this period, the larvae, now perhaps 1/4 mm in length, which lodge on suitable surfaces, develop into a quite different form and begin to burrow into the material. The body elongates into a worm-like shape of which only the head is covered by the hinged shells; the latter, edged with rows of microscopic denticles, now constitute the boring tool.

The borer's tail is securely attached to the wall of the tunnel it is boring, close to the entrance. As the tunnel goes deeper into the material, the shells and body of the borer become longer and grow rapidly in diameter, some species attaining a diameter of 1/2 inch or more. Teredo longer than four feet have been reported; many two-foot specimens have been recently found. As boring progresses, the entrance hole does not increase much in size, a situation which imprisons the borer in its tunnel, as the tunnel becomes partially lined with a lime deposit.

Two fleshy siphons at the tail end of the borer, which permit it to take in and expel water, may be extended as much as an inch from the entrance to the tunnel; or the borer may plug the tunnel at will with a pair of calcareous tail members called pallets. Thus the tunnel may be sealed, enabling the borer to withstand for some time the unfavorable conditions attendant upon removal to fresh water or into the open air. Thus the outside appearance of a piece of wood infested by marine borers is often deceptive: a piece that appears to be merely dotted with tiny entrance holes may in reality contain so many tunnels that only a web of wood remains.

b. The Pholadidae. The Pholads are a family of bivalve borers of which two genera, Martesia and Hiata, have been frequently found in wooden marine structures. Quite different from the Teredinidae, these small, flat, clam-like borers do not drill into wood much farther than the length of their shell, which is usually not over two inches. They make larger entrance holes than do the Teredinidae, however. As they burrow they, too, grow larger and imprison themselves in their own tunnels. Although found around the entire world, Pholads are prevalent in fewer numbers than are Teredinidae and Limnoria and are consequently responsible for much less damage, even though their attack is more difficult to prevent. In this last connection, for example, it might be noted that wood heavily impregnated with creosote has frequently been found badly damaged by Pholads although practically untouched by Teredinidae.

3. The Crustacean Borers. The crustacean borers, which are almost always found in tunnels in wood, include Sphaeroma, Chelura, and Limnoria. By far the most widely distributed and most destructive of these is Limnoria, which are numerous in almost all harbors, and are found in arctic as well as tropical waters.

a. Sphaeroma, also widely distributed, is only occasionally responsible for the destruction of timber.

b. Chelura, until recently, has been considered at least as destructive in wood as Limnoria. Recent studies, however, seem to indicate that this species has been greatly overrated in its destructive abilities, possibly because Chelura are frequently discovered occupying abandoned Limnoria tunnels.

c. Limnoria, most destructive of the crustacean borers, are only about 1/8 inch long. Their burrows are generally confined to the surface of the wood, or to a depth which seldom exceeds 3/4 inch.

Although free to move about on wooden surfaces, they usually continue to burrow close to their starting point. Usually very numerous, and living on the wood substance, they soon reduce the surface of the wood to a network of interlacing burrows which are readily eroded by movement of the water, thus enabling the borers to continue drilling deeper into the wood.

There are many examples of untreated piles which are being destroyed by Limnoria, at the rate of one inch per year. Even heavily creosoted wood is not immune from attack by these ravenous animals, and it sometimes suffers serious damage. Limnoria retains its free-swimming ability throughout the adult stage, thus it is able to move, when disturbed, to a more congenial habitat. On piling, the attack is usually most intense from half tide to slightly below low tide. However, destructive attack has often occurred from the low-tide level down to the mud line, at depths that may reach 70 feet.

### Al.03 Method of Detecting and Rating Borer Attacks

1. Detection. Standard test boards, submerged at various depths and examined at regular intervals, are the most practical means thus far devised for detecting the various species of borers and/or fouling organisms which occur in a given area. The severity of borer attacks is determined in accordance with a standard rating scale which ranges from "trace" to "very heavy."

In this way valuable data have been accumulated from harbors all over the world on density of borer attack, rate of destruction, breeding seasons, distribution of the various species, length of life, rate of growth, and other significant factors relative to borer activity and destructiveness.

Standard test boards (see paragraph Al.08) are now being operated by the William F. Clapp Laboratories at more than 500 locations along United States coasts. The information thus being collected and analyzed as to the habits and life histories of boring organisms is proving valuable to designers and builders of marine structures and to those responsible for the maintenance and protection of such structures.

### 2. Ratings for Evaluating Borer Attacks on Test Boards.

a. Severity of Attack. Study of data accumulated from a large number of test boards shows clearly that a mere count of the number of borers is not a true indication of the severity of their attacks. It has been observed that many embryonic forms of species such

as Teredinidae or Pholadidae do not develop sufficiently to do much damage.

This is true in the cold waters of Newfoundland and vicinity, where large numbers of embryonic Teredo often occur, but die before they can embed themselves in the test boards. For this reason, it is concluded that in evaluating Teredinidae and Pholadidae attacks it is more useful to record the size and number of tunnels, that is, the degree of attack, than to count the exact number of borers. Thus a reading of even 500 minute pits would be recorded only as a "trace", from the standpoint of attack, if the borers which made the pits did not live to make destructive tunnels. Limnoria attacks, however, can be accurately rated by a careful count of the number of borings.

b. Scale of Ratings. This scale is used as a general guide in evaluating the degree of attack on the standard test board (nine blocks or panels, 8-month basis) by three of the most destructive species of borers.

#### Teredinidae

<u>Number of tunnels per block or panel</u>	<u>Attack Rating</u>
Up to 5	Trace
6 to 25	Slight
26 to 100, or 25% filled	Moderate
101 to 250, or 50% filled	Medium Heavy
Over 250, or 75% filled	Heavy
Filled, riddled, or destroyed	Very Heavy

#### Pholadidae

Up to 5	Trace
6 to 20	Slight
21 to 50	Moderate
51 to 100	Medium Heavy
101 to 200	Heavy
Over 200, filled, or riddled	Very Heavy

Limnoria

<u>Tunnels</u> <u>per sq in.</u>	<u>Surface Area</u> <u>(sq in.)</u>	<u>Total No.</u> <u>of Tunnels</u>	<u>Attack</u> <u>Rating</u>
1	132	132	Trace
10	132	1,320	Slight
25	132	3,300	Moderate
50	132	6,600	Medium Heavy
75	132	9,900	Heavy
*100	132	13,200	Very Heavy

\*NOTE: Ratings of around 100 per sq in. indicate the maximum density beyond which it is impossible to count.

A1.04 Illustrations of Borer Damage

Figures 1 to 11, inclusive, have been selected from a large number in the files of the Clapp Laboratories in order to show the results of heavy attacks on test boards and piles which were exposed only 4 to 18 months each. One of the latter, shown in Figures 7 and 8, although electrolytic-copper-sulphate treated, was completely destroyed in 18 months, largely by Teredo.

Figure 3 shows the results of the combined attacks during 4 months in 1947 by crustacean Limnoria and molluscan Teredinidae. This attack was much more severe than that on a similar panel submerged in the same harbor at Pensacola, Florida, during 8 months in 1945; at that time Teredo attacks riddled the board, but there was very little evidence of Limnoria.



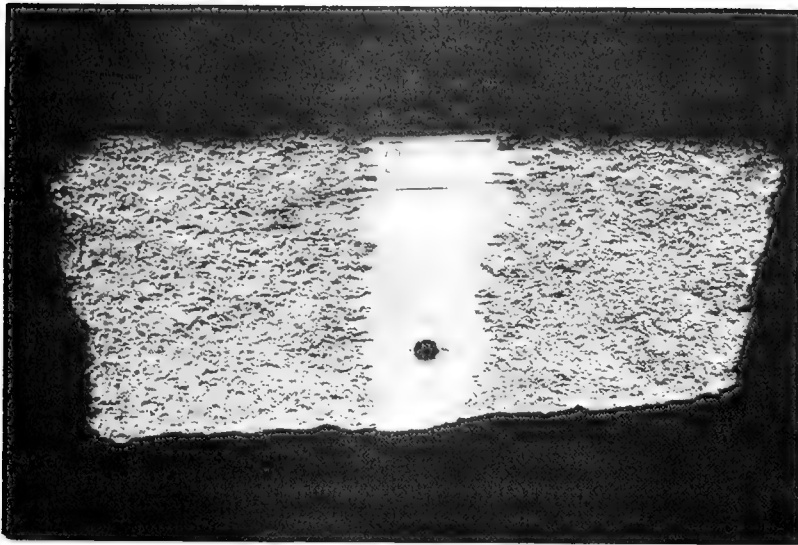


Figure 1

A panel, grossly riddled by Limnoria, taken from a test board submerged for 8 months during 1946 near Pier No. 9 in Boston Harbor.

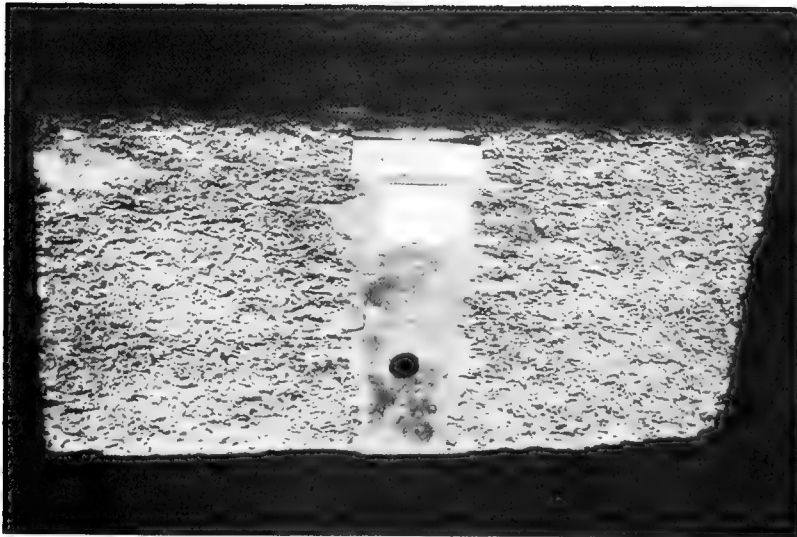


Figure 2

Another panel from a test board submerged in Boston Harbor for 8 months, this time in 1947. This panel also shows heavy infestation by Limnoria. There is no evidence whatever of Teredo.

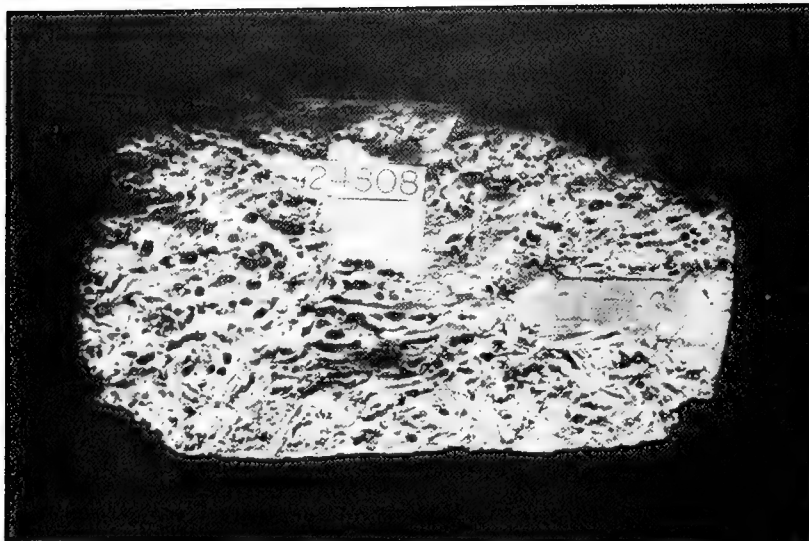


Figure 3

A badly damaged panel from a test board submerged for only 4 months in 1947 near Palafox St. Ferry Slip, Pensacola, Florida. Both Limnoria and Teredinidae have been busy here. A comparison with the panel of Figure 4 will show that the attack in 4 months in 1947 in this harbor was worse than that of 8 months in 1945.

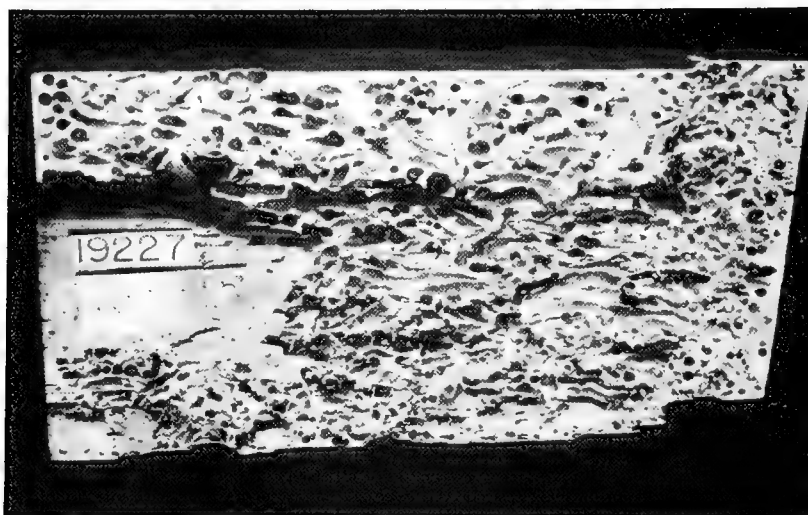


Figure 4

A panel removed from a test board submerged in the vicinity of the Railroad Trestle, N.A.S. Pensacola, Florida, after 8 months' submergence in 1945. The damage was caused, in the main, by Teredo, there being little or no evidence of Limnoria.

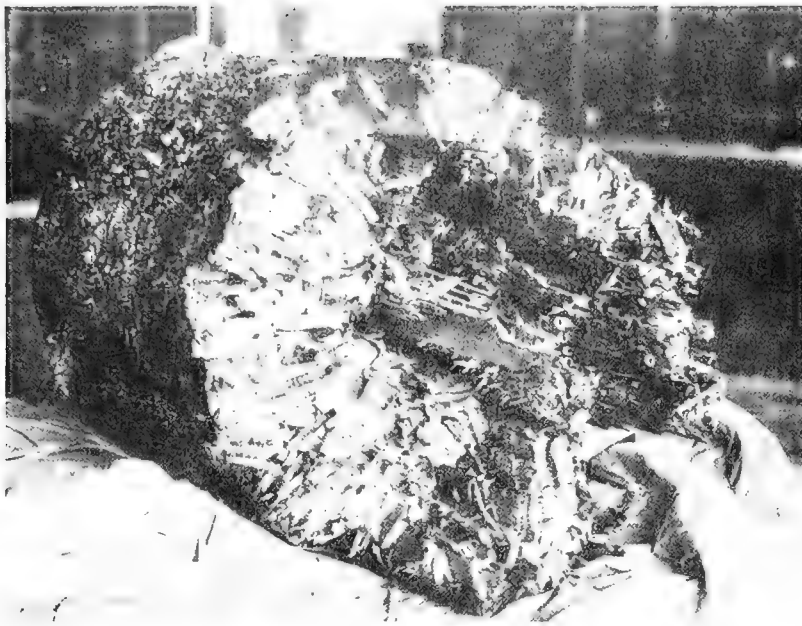


Figure 5

Portion of an untreated pile from the Tugboat Dock, N.O.B. Womens Bay, Kodiak, Alaska. This portion was taken from near the mud line. A heavy attack of Bankia setacea has virtually shredded it. A slight Limnoria attack on the outer circumference is also evident.

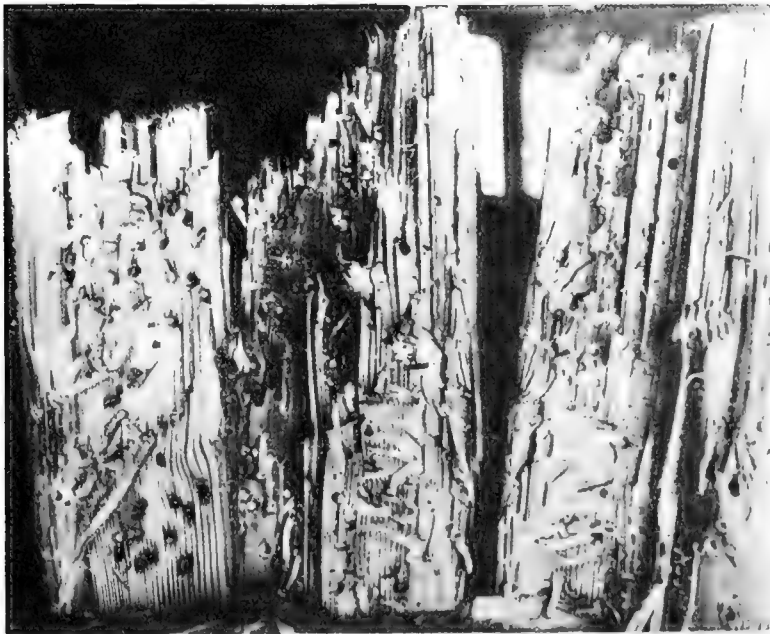


Figure 6

A split vertical section of an untreated pile from the Tugboat Dock, N.O.B. Womens Bay, Kodiak, Alaska. Pile has been ruined by a heavy attack of Teredinidae.



Figure 7

Outside portion of a completely destroyed electrolytic-copper-sulphate treated pile from U.S.N.A.S., Sitka, Alaska. Pile had been in service 18 months. Most of the visible damage was caused by Teredinidae but Limnoria is also present in numbers.



Figure 8

Typical inside portion of the pile shown in Figure 7. Note that the pile has been completely riddled, with full-grown *Teredo* in plain view.

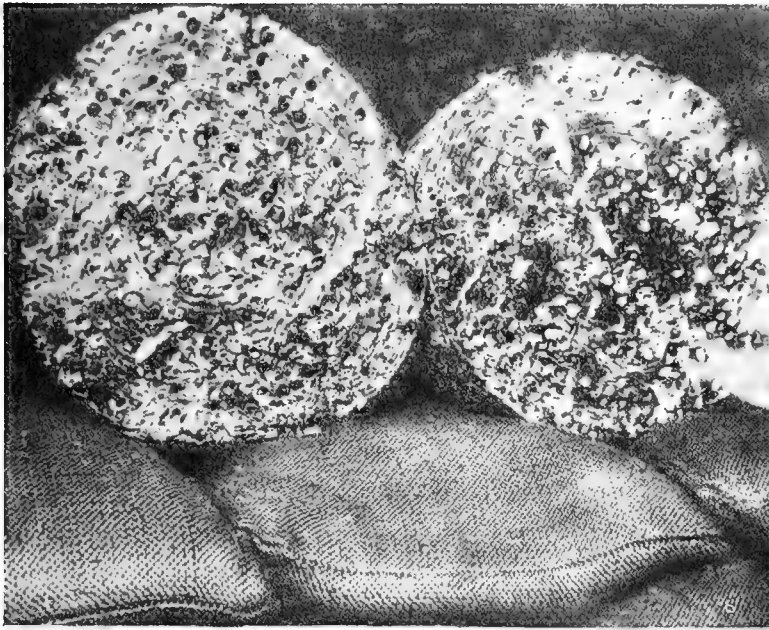


Figure 9

Sections of untreated piling from Pier No. 91, Seattle, Washington. It is plainly apparent that the pile has been ruined chiefly by Teredo, although there is evidence of a slight Limmoria attack around the outer periphery. Pile had been in service only 11 months.

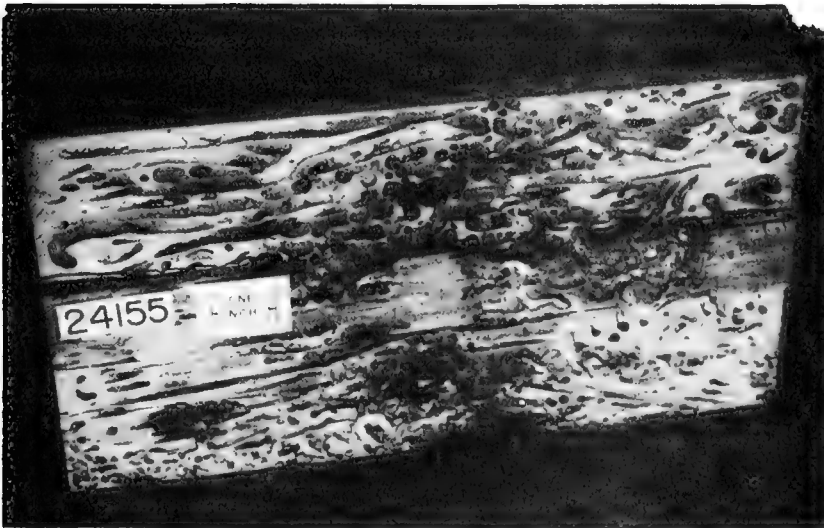


Figure 10

A panel removed from a test board at Pier No. 90, Seattle, Washington. Pile had been submerged 120 days. Most of the visible damage was done by heavy Teredo attack. A trace of Limmoria is also evident.

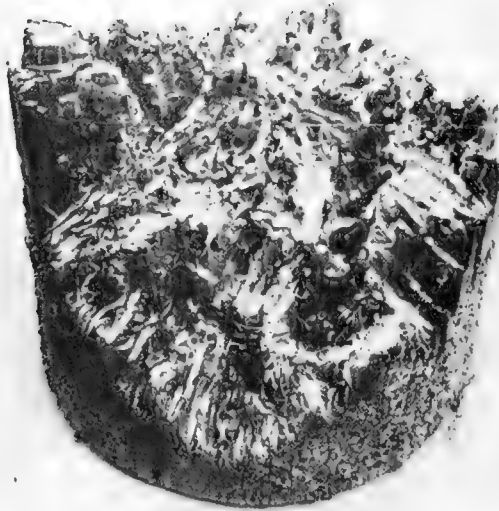


Figure 11

Section of an untreated ponderosa pile taken from the Storage Boom Dolphin, Hunter's Point, California. Pile had been in service 129 days during 1943 and failed completely before being removed. The destructiveness of Teredinidae is very well illustrated here.

## Al.05 Some Results of Test Board Research

1. Prevalence and Destructiveness. Accumulating test board data on marine borer infestation at many harbors form the basis for the following deductions regarding the effects of local conditions, the inhibiting effects of industrial pollution, and the favorable conditions found to exist in northern harbors.

a. Effects of Local Conditions. In a given area, various local conditions besides temperature of the water may strongly affect the prevalence and destructive activities of borers. The individual effects of currents, degree of salinity, depth of the submerged structure, pollution (see the following paragraph), and other factors cannot be determined at present. However, it is known that if certain species of borers are introduced into areas where they did not previously exist, and conditions prove favorable, the borers will thrive, multiply, and cause serious damage.

b. Inhibiting Effects of Pollution. It has been observed that heavy pollution seems to prevent, or at least to minimize, the activities of marine borers. For example, after the removal of sewage from an area previously immune to *Teredo* attack, a heavy onslaught of the borers was observed. On the other hand, numerous sewer outlets made of wood have been totally destroyed by *Teredo*. As a general rule the factors unfavorable for borers arise from industrial wastes--acids and oils--rather than from domestic sewage.

c. Favorable Conditions in the Arctic. As noted in paragraph Al.01, borer damage in northern harbors in Alaska, Newfoundland, and Nova Scotia may be as rapid and severe as in southern waters. In general, low temperature of the water greatly reduces the rate of destruction by *Teredinidae*, but this is not true of *Limnoria*. The latter is almost always present in the waters of many northern harbors, as, for example, at Kodiak, Alaska, where it was very active during the initial three months of a recent survey and became even more active later. Again, a trace of *Limnoria* was found in test blocks at Adak, Alaska, in each of four monthly examinations during the first part of 1948.

2. Reports on Treated and Untreated Wood. The observed results of using treated and untreated wood are summarized in a., b., and c. below for Sitka, Alaska, and Bremerton, Washington. A method for successfully repelling borer attacks on boat hulls is outlined in paragraph d.

a. Summer-cut Sitka Spruce (with bark removed) was reported to be completely destroyed by *Teredo* action at Sitka, Alaska. However, the piling of the New Navy Dock at this location, which had been treated

with arsenious trioxide, copper sulphate, and zinc sulphate, was reported to have remained sound.

b. Electrolytic, open-tank treatment of piles by the use of copper sulphate, sulphuric acid, and other chemicals proved of no value against Teredo attack at Sitka, Alaska. Figure 7 and 8 show samples of piling treated by the above method which were completely destroyed in less than two years.

c. At the Puget Sound Navy Yard, Bremerton, Washington, it was found in 1944 that test boards made of Douglas fir, western hemlock, western white pine, and cedar were similarly filled or riddled by Bankia setacea. Whether the Douglas fir panels were of heartwood or sapwood, they were riddled by Bankia setacea, and were attacked by Limnoria the same as were the other kinds of wood.

3. Protection of Wooden Hulls. In 1944 a method was developed at the U. S. Coast Guard Training Station, Mayport, Florida, to protect the hulls of wooden boats; marine borers were reported to have been eating away the keels of small boats in 12 to 18 months. The new method was to install a 1-inch worm shoe on the keel, with a layer of tar paper (commercial felt) between it and the keel. This was reported to repel marine borers for 90 to 120 days, as the borers were reluctant to penetrate felt, and instead, bored horizontally along the worm shoe.

#### Al.06 Use of the Narrative and Tabular Summaries

The following paragraphs, 1 and 2, explain the use and application of the 56 narrative summaries which constitute PART A of this report, and of the tabular summaries at 160 world-wide locations which comprise PART B. It should be noted that the chief limitation in the use of the tabular summaries arises from the fluctuations which may occur from time to time in the degree of attack by various borers at a given locality, depending upon various conditions which favor or retard the development of the organisms.

1. Narrative Summaries. The narrative summary at a given location, as given in PART A of this report, conveys the best picture of the general trend of borer activity for the years reported. Some information given in the narrative summary cannot be shown in the tabular summary. Thus the narrative summary may indicate slight chance of attack by certain borers, while in other cases attack by Teredinidae, Limnoria, or other borers may be consistently more severe, or less severe. Fluctuations in attack, over a period of years, also are indicated, as are the local variations in attack at different parts of a given harbor, where salinity or other local conditions vary.



2. Tabulated Summaries. The tabulated summaries of PART B do not convey such detailed information. They are useful, however, in giving reliable, over-all data in convenient, tabulated form. The data cover upward of 330 test board locations at approximately 160 different harbors, mainly on the U. S. Atlantic coast, the Caribbean, and the Texas coast; some South American harbors (Venezuela and Brazil); the Mediterranean; the U. S. Pacific coast from Adak, Alaska, to the Canal Zone; some Pacific islands, Australia, and New Zealand.

3. Other Comprehensive Narrative Summaries. Further summaries of marine borer research results in many parts of the world will be found in Harbor Reports on Marine Borer Activity, a publication of the Bureau of Yards and Docks.

#### Al.07 Applications of Continuous Research Program

Some practical applications of the marine borer research program now under way are summarized below.

1. Test board data have proved to be extremely valuable to writers of specifications for wharf construction in various Atlantic and Pacific harbors.

2. These data have been very useful in studying the fouling of intake tunnels, service pipe lines on government vessels, and ships' bottoms.

3. In harbors where hydrographic conditions and associated organisms are favorable for borers, test board data serve to warn the builders of marine installations that structural materials must be selected with great care.

4. Continuous research data have proved to be of inestimable value in the maintenance of marine structures. Thus a sudden borer invasion, or the probability of an increase in their destructiveness, can be quickly determined by studying recent test panels or traps. Heavy losses may be averted by making thorough inspections of marine structures at intervals; test board data should be utilized as warning signals between such inspections.

5. In a given structure, the mere presence of marine borers of some kind does not necessarily prove that the structure is headed for complete destruction. More significant information is required, that is, a complete understanding of the true relationship of the borers present to borers in general. This can only be achieved by identifying and classifying the borers in the structure under investigation.

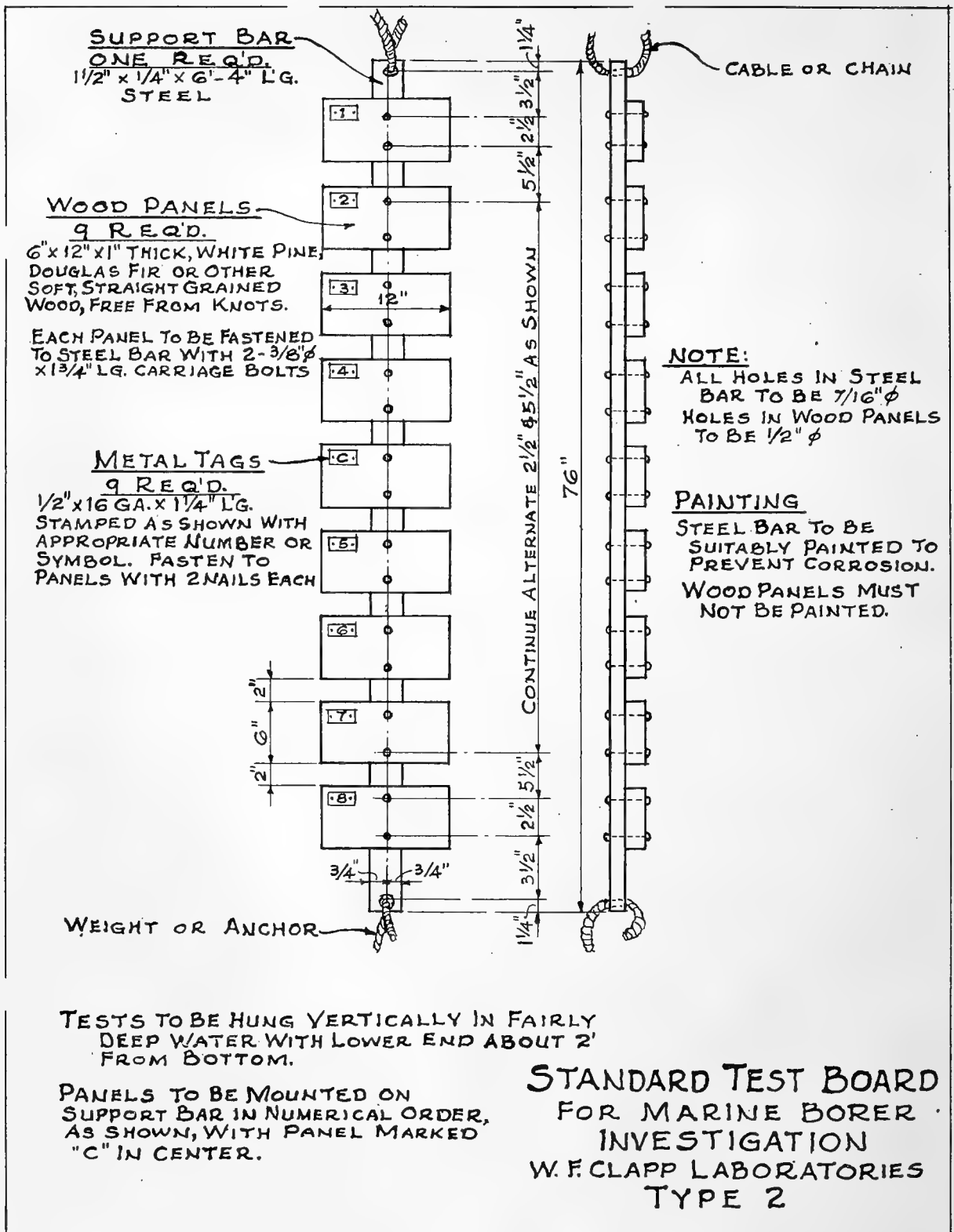


Figure 12

6. In summary, it may be said that at present there is only one sure method of determining in advance whether the timber structures in a given harbor may be attacked by destructive borers; this method is to expose test boards and to examine them monthly with great care. Thus the test board is a kind of radar system, warning us (a) when borer attack is imminent, or (b) when borer attack is increasing or diminishing. In addition, it presents a sampling of the fouling organisms present. A continuous program of study, involving the use of successive panels of test boards, becomes a form of insurance against heavy losses in marine structures.

#### Al.08 Method of Operating Standard Test Boards

The following description of standard test boards, and the succeeding specifications, paragraph Al.09, were furnished by the W. F. Clapp Laboratories.

1. A standard test board consists of a set of nine blocks or panels spaced two inches apart and bolted, screwed, or otherwise secured to a 2-in. supporting back strip of wood or to a metal bar (Figure 12). The specifications call for the blocks to be 6 in. square by 4 in. thick, while those for the panels prescribe them to be 6 in. by 12 in. by 1 in. thick. These "boards" are hung vertically in the water with the bottom suspended 2 feet above the mud line. They are usually suspended from some object fast in place (such as a wharf or pier), with a weight fastened to the bottom to minimize the movement which may be caused by tides or currents. The four top panels, which are "test panels", are numbered 1, 2, 3, and 4. The fifth, or control panel, is not numbered. Below this in the series are four test panels numbered 5, 6, 7, and 8.

2. At the end of the first month's exposure of the board, the No. 1 test panel and the control panel are removed for submission to the Laboratory; and a new No. 1 panel and control panel are installed. At the end of the second month the No. 2 test panel, which has been submerged two months, and the control panel, which has been submerged one month, are removed and forwarded to the Laboratory; and a new No. 2 panel and control panel are installed. At the end of each succeeding month's exposure each successively numbered panel and the corresponding control panel are removed and new panels installed in their places, until the entire eight numbered panels have been removed and replaced, whereupon the cycle is repeated, beginning with the No. 1 panel. Thus, at the end of 8 months and at the end of each month thereafter, the numbered panel removed will have been submerged eight months and each control panel for only one month. By this method of removal and replacement of the test and control panels the test may be carried on for as long a period as desired. The control panels, which have been submerged for one month each, are of particular value since the

information derived from their examination makes it possible to determine the breeding season and the rate of growth of the various marine borers and other organisms which are active.

3. In some places where the marine borer attack has been unusually destructive it has been found impossible to leave the panels submerged as long as 8 months, as they are frequently more or less completely destroyed within this period of time or less. Increasing the thickness of the panels from one to two, and even to four, inches has been tried. However, it was soon found that this did not increase their length of life since the thicker the wood used, the greater was the number of borers in the panels, so that the infestation was just as severe proportionately in the thicker panels as in the thin ones. Recourse was then had to using a board holding only 4 test panels and the control panel. By using this board, the period of submergence can be reduced from eight to four months. In a few locations, however, as at Mayport, Florida, it was found necessary to reduce the period of submergence to 3 months in order to have panels to remove that would not be completely destroyed.

Al.09 Specifications and Procedure for Construction and Operation of Standard Test Boards for Marine Borer Investigation

1. A "Test Board" shall consist of an assembly of nine "test panels" mounted on a metal support bar as shown on accompanying sketch, Figure 12, entitled

STANDARD TEST BOARD  
FOR MARINE BORER  
INVESTIGATION  
W. F. Clapp Laboratories  
TYPE 2

2. The support bar shall preferably be a  $1\frac{1}{2}$ " x  $\frac{1}{4}$ " x 6'-4" long steel bar, although a steel pipe or any other suitable section will serve equally well if a bar is not available. Wood shall not be used for the support bar.

3. Test panels shall be 6" x 12" x  $\frac{7}{8}$ " or 1" thick S.4.S, of comparatively light, soft wood, preferably pine, and shall be straight-grained and free from knots.

4. Each panel shall be numbered in a manner which will be permanent. A metal tag, stamped with the appropriate number or symbol, and fastened to the panel by means of 2 nails, shall be used. If metal

tags are of copper, they shall be fastened to the panels with copper nails.

5. The support bar shall be suitably painted to prevent corrosion. The wood test panels must not be painted nor treated with any other coating or preservative.

6. A suitable anchor shall be suspended from the lower end of support bar to hold the test board in place.

7. Panels shall be arranged on the support bar in numerical order beginning at the top with panel number one, except that panel marked "C" shall be placed between panels number 4 and 5.

8. Test boards shall be placed in protected locations where they will not be subjected to damage by vessels, or exposed to theft. They shall be submerged with the lower end approximately 2 feet above the mud line.

9. At the end of the first month after panels are submerged, the set shall be taken from the water and Panel No. 1 and the "Control Panel" marked "C" shall be removed. A new panel marked No. 1 shall be fastened to the support bar in the same position as that occupied by the original No. 1 panel, likewise a new control panel marked "C" shall take the place of the control panel "C" which had been removed.

10. The test boards shall be kept out of the water the minimum time practicable for the removal and replacing of panels, in order that marine organisms on the panels may not be damaged or killed by long exposure to air.

11. The foregoing procedure shall be followed at regular monthly intervals by removing and replacing the "C" panel and the numbered panels in successive order; i.e., No. 1 at the end of the first month, No. 2 at the end of the second month, etc. The test shall not stop with the eighth panel, but shall continue until notice to discontinue is received.

12. Panels removed in accordance with paragraph 9 shall not be cleaned, but shall be wrapped in several thicknesses of heavy paper and properly packaged for shipment or mailing. In each package a penciled note shall be included giving location of test and date when panels were removed.

13. Panels shall be forwarded, prepaid, to:

W. F. Clapp Laboratories  
Duxbury, Massachusetts

14. When a test board is first installed at any given location, the following information shall be forwarded to the Clapp Laboratories and a carbon copy of letter sent to the Office of Naval Research, and one to the cognizant Bureau or Agency.

- (a) Date when installed.
- (b) Depth of water.
- (c) Range of tide.
- (d) Statement regarding degree of pollution.
- (e) Temperature of water.
- (f) Strength of current if it is known or can readily be determined.

15. When any changes in above data occur, they shall be noted in subsequent letters of transmittal accompanying panels sent to laboratories.

16. A copy of the letter of transmittal to Clapp Laboratories shall be forwarded to the Bureau each time panels are sent to the Laboratory.

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## Section 2

### ARGENTIA, NEWFOUNDLAND -- U. S. NAVAL OPERATING BASE

#### A2.01 Location of Test Station and Test Board

A test board of the panel type was installed on July 1, 1944, at the U. S. Naval Operating Base, Argentia, Newfoundland. The results obtained from this test board, the operation of which is still being continued, have been summarized to the end of 1947. The board was installed at the south end of the Fleet Dock at Argentia in south-eastern Newfoundland.

#### A2.02 Hydrographic Data

The depth of water where the test board was installed was 15.4 ft at mean low water; the tidal range was 5 ft; the velocity of the current did not exceed one knot. The temperature of the water at the time of installation was 52° F. The water temperatures for 1945, which are considered typical of the past 3 years, were as follows:

Jan	36°	May	38°	Sept	59°
Feb	32°	June	46°	Oct	53°
Mar	31°	July	50°	Nov	48°
Apr	34°	Aug	58°	Dec	41°

The salinity of the water was determined to be: Chlorides, 1.4 grains per gal; total, 2.8 grains per gal.

The degree of pollution was determined in two ways. The total bacterial colony count (nutrient agar medium) was found to be 1,160 per cc. A test on Dominick Lauter medium was rated "positive for coli-aerogenes with approximately 140 organisms per 100 cc in 24 hours at 37°."

#### A2.03 Marine Borers

1. Teredinidae. The only evidence of Teredinidae at this location was a minute pit recorded in each of 2 test panels, and even one of these was questionable.

2. Limnoria. Limnoria occurred with great regularity but never in any large numbers. In the control panels they were recorded in only



6 of the 41 panels exposed, the greatest number in any one panel being 15. Most of these occurred in panels submerged during May and June of 1945 and 1946, and only one occurred in each of 2 panels submerged during October 1946 and August 1947, respectively. Limnoria occurred in every one of the test panels except the first 2, the attack attaining peaks (1,500) with low moderate ratings in panels removed October 1, 1945, and December 1, 1946, after having been submerged for 8 months. During practically all of 1947, however, the attack only rated a trace.

#### A2.04 Fouling Agents

1. Silt. Silt occurred as traces to occasionally light deposits on all but one of the 41 control panels, and as traces to light or occasionally moderate deposits on all the 41 test panels.

2. Algae. Traces of green algae appeared on only 8 of the control panels, having developed only on those removed from June 1 to October 1 after having been submerged for 8 months.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 8 of the control panels and as traces to light growths on all but 3 of the 41 test panels. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa were not present on the control panels but developed in small numbers on 12 of the 41 test panels. Electra crustulenta and Tegella unicornis were identified. Filamentous Bryozoa also were lacking on the control panels but developed more or less abundantly on 4 of the 41 test panels. Bugula flabellata was identified on 2 panels.

c. Arthropoda (crustaceans). Balanus (barnacles) were absent on the control panels and occurred on only 2 of the test panels removed July 1 in 1945 and 1946, respectively. The first of these panels had about 50 specimens ranging from embryonic to 2 mm in diameter, while the second had only 3 juvenile specimens.

d. Mollusca (nonboring mollusks). A few specimens of Mytilus (mussels) occurred on a single control panel removed October 1, 1944. Embryonic or minute specimens were numerous on 4 test panels removed from September 1 to December 1, 1944, after having been submerged for 2, 3, 4, and 5 months, respectively. Four other specimens with a maximum length of 1.5 mm were on the last panel removed December 1, 1947. Anomia (jingle-shells) was absent on the control panels but occurred sporadically on 8 of the test panels, ranging in number from a few to numerous and being mostly minute in size.

e. Chordata (tunicates). Tunicates were absent on the control panels and occurred on only 3 of the test panels. Botryllus schlosseri was the only form identified.

## A2.05 Summary and Conclusions

1. Installation. A test board of the panel type, installed at the U. S. Naval Operating Base at Argentia, Newfoundland, on July 1, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

### 2. Test Results.

a. Borers. Teredinidae were almost nonexistent at this location, only 2 minute pits having been recorded, one of which was questionable. Limnoria occurred with great regularity throughout the period covered by the test except during the first 2 months, but they never appeared in any large numbers. Late in 1945 and 1946 the maximum attacks did not exceed moderate ratings, but the attacks rated only a trace during practically all of 1947.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 5 phyla contributed to the fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, barnacles, nonboring mollusks, and tunicates. Silt occurred on all except one of the test panels. Hydroids also occurred on nearly all the test panels. Encrusting Bryozoa occurred at irregular periods on some of the test panels, and the occurrence of barnacles, nonboring mollusks, and tunicates was purely sporadic or occasional. The control panels were nearly all free of marine organisms. In fact, with the exception of hydroids, there was a very poor development of these organisms even on the test panels, the reason for which is not apparent.

3. Recent Addenda. There was no Teredinidae attack at this station in either 1948 or 1949. In 1948 the Limnoria attack rated a trace, while in 1949 it attained a rating of slight.

## Section 3

### BAR HARBOR, MAINE -- U. S. NAVAL SECTION BASE

#### A3.01 Location of Test Station and Test Board

A test board of the panel type was installed at the U. S. Naval Section Base at Bar Harbor, Mt. Desert Island, Maine, on June 12, 1944, and operated until September 12, 1944. No further panels were removed after the latter date, and the operation of the test board was discontinued on October 4, 1944, because of the termination of naval activities at this base. No information was available as to the exact location of this test board (designated by the symbol USNBH-1).

#### A3.02 Hydrographic Data

The depth of water where the test board was installed was 16 ft; the tidal range was 10.5 ft; the current velocity was negligible. The temperature of the water at the time of installation was 48° F. The degree of pollution was not determined, but the nearest sewage outlet was 345 ft from the site of the test board.

#### A3.03 Marine Borers

1. Teredinidae. No Teredinidae were recorded in any panel of either the control or test series at any time during the 3-month period for which the test board was operated.

2. Limnoria. Limnoria were recorded in small numbers on the control panels removed on July 11 and August 11. Limnoria were also found on the single test panels removed in August and September after they had been submerged for 2 and 3 months, respectively. The attack never rated more than a trace.

#### A3.04 Fouling Agents

1. Silt. Silt occurred on both the control and the test panels. The deposits rated as traces on the control panels and mostly light on the test panels.

2. Algae. No algae were present.

### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on all the control panels and on the first test panel removed after one month's submergence. They were recorded as light growths on the test panels removed in August and September after submergence of 2 and 3 months, respectively. Tubularia was the only form identified.

b. Bryozoa (encrusting). Encrusting Bryozoa did not occur on any of the 3 control panels nor on the first test panel removed after submergence of one month. Numerous small colonies of Callipora craticula and Lichenopora verrucaria occurred on the test panels removed in August and September after submergence of 2 and 3 months, respectively.

c. Annelida (annelid worms). A few serpulid worms were recorded on the test panels removed in September after a submergence of 3 months. No worms were recorded on the control panels.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on all the control panels and on the test panels removed in July and August after submergence of 2 and 3 months, respectively. Few barnacles were recorded, and the diameter of the largest of them was only 6 mm.

e. Mollusca (nonboring mollusks). Mytilus (mussels) were found only on the test panels removed in August and September after submergence of 2 and 3 months, respectively. The mussels were abundant and mostly juvenile, but some on the latter panel had attained lengths of 10 mm.

f. Chordata (tunicates). Two colonies of tunicates of the genus Molgula were recorded on the test panel removed in September after submergence of 3 months.

#### A3.05 Summary and Conclusion

1. Installation. A test board of the panel type was operated at the U. S. Naval Section Base at Bar Harbor, Mt. Desert Isle, Maine, from June 12, 1944, until its discontinuance September 12, 1944.

#### 2. Test Results.

a. Borers. During this brief period there was no evidence of Teredinidae and only traces of Limnoria.

b. Fouling Organisms. Silt and invertebrate animals belonging to 6 phyla contributed to the fouling of the panels. The latter comprised hydroids, encrusting Bryozoa, annelid worms, barnacles, mussels, and tunicates. Of these organisms, the hydroids occurred most frequently.

The 3-month period the test board was in operation was entirely too short for conclusive results. However, the general trend at this location is clearly indicated.

## Section 4

### SOUTHWEST HARBOR, MAINE -- U. S. COAST GUARD DEPOT.

#### A4.01 Location of Test Station and Test Board

A test board of the panel type was installed December 2, 1944, at the U. S. Coast Guard Depot at Southwest Harbor, Mt. Desert Isle, Maine. The Depot is located on the southern end of Clark Point on the northern side of the harbor. The test board, designated as USNSM-1, was installed under the northwest corner of a dock quite close to untreated wood piling. The operation of this test board continues, and results of the test have been summarized to the end of 1947.

#### A4.02 Hydrographic Data

The depth of water at the location where the test board was installed was 14 ft; the tidal range was 10.3 ft; the velocity of the current was negligible. The temperature of the water at the time of installation was 42° F. The water was reported to be clear, with negligible pollution.

#### A4.03 Marine Borers

1. Teredinidae. Teredinidae were not recorded in any of the panels during the 3-year period covered by the test.

2. Limnoria. Limnoria were active throughout most of the test period but were never particularly destructive. Limnoria occurred in small numbers on 17 of the 38 control panels but were confined to those submerged during the warmer months from April through August, October, and September of 1945, 1946, and 1947, respectively. From these data it would appear that Limnoria cease migration at this location during the winter season. Limnoria were present on 35 of the 38 test panels, occurring in all submerged after April 10, 1945. All except 4 of these latter panels had been submerged 8 months. The attack rated from a trace to slight throughout the 3-year period covered by the test except once in 1946, when a peak rating of moderate was attained.

#### A4.04 Fouling Agents

1. Silt. Silt occurred on all the panels. The deposits ranged from traces to slight or occasionally moderate on the control panels, and from traces to moderate or rarely heavy on the test panels.

2. Algae. Green algae occurred sporadically. A trace was recorded on only one of the 36 control panels, and growths ranging from traces to light were recorded on 8 of 36 test panels.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 16 of the 36 control panels, and as traces to light or rarely moderate growths on 30 of 36 test panels. Tubularia was the only form identified.

b. Arthropoda (crustaceans). Balanus (barnacles) occurred more or less abundantly on 10 of the 36 control panels; their development on these panels was limited to the warmer months. One panel was 40% covered. The maximum diameter of the barnacles recorded was 3 mm. They occurred in greater abundance on 27 of the 36 test panels. The maximum diameter recorded on test panels submerged for 8 months was 17 mm. Of these panels, 15 were from 50% to 100% covered. Amphipods (mostly Corophium) occurred on 4 consecutive test panels removed at monthly intervals from October 2, 1945, to February 4, 1946, after having been submerged for 8 months. The largest number of Corophium recorded on one panel was 100.

c. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred sporadically on occasional panels. Mytilus (mussels) occurred on 4 of the test panels, the maximum number on any panel being 15, and the maximum length recorded being 8 mm. A single specimen of Anomia (jingle-shells), 4 mm in diameter, was recorded on the last one of the test panels. A few specimens of Saxicava were recorded on 2 of the test panels and on one control panel, the maximum number on any panel being 8.

A4.05 . Summary and Conclusions

1. Installation. A test board of the panel type installed at the U. S. Coast Guard Depot at Southwest Harbor, Mt. Desert Isle, Maine, on December 2, 1944, is still being operated. The results of the test have been summarized to the end of 1947.

2. Test Results.

a. Borers. No evidence of Teredinidae was recorded at this location. Limnoria occurred with considerable regularity on the control panels exposed during the warmer months of each year, but only in small numbers. Limnoria occurred on all the test panels submerged after April 10, 1945, but the attack rated only from a trace to slight throughout the 3-year period covered by the test except once in 1946, when a peak rating of moderate was attained.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 3 phyla contributed to the fouling of the panels. The invertebrates comprised hydroids, barnacles and amphipods, and non-boring mollusks, which included mussels, jingle-shells, and Saxicava. The hydroids and barnacles occurred most frequently and consistently, whereas the occurrence of the other invertebrates was sporadic.

3. Recent Addenda. There was no evidence of Teredinidae at this station in either 1948 or 1949. The Limnoria attack rated medium heavy in both years.



## Section 5

### PORTLAND, MAINE -- U. S. NAVAL STATION

#### A5.01 Location of Test Station and Test Board

A test board of the panel type was installed on June 2, 1944, at what was then the U. S. Naval Frontier Base but later the U. S. Naval Station at Portland, Maine. This board was operated at the Naval Supply Pier in Casco Bay until July 1946, when the board was lost. A new test board was installed September 26, 1946, in the center of Pier No. 1 at South Portland, approximately 15 ft from the outboard end. The new board was relocated because of a change in a sewer at 404 Commercial Street. The operation of this board was discontinued after March 27, 1947, because of the disestablishment of this U. S. Naval Station and the loss of the board

#### A5.02 Hydrographic Data

The first board installed June 2, 1944, was placed in water 14 ft deep where the tidal range was from 8 to 11 ft and the current negligible. The temperature of the water at the time of installation was 54° F. The water was subject to pollution from a sewer outlet approximately 500 ft from the installation. The sewage was reported to enter the tide water approximately 100 ft from the installation.

The second board was installed September 26, 1946, and was placed in water 30 ft deep at mean low water where the current was negligible. The range of tide at this point was 8 to 11 ft, the normal range being 8.9 ft. The temperature of the water at the time of installation was 59° F. The water was subject to pollution from a sewer outlet approximately 700 ft from the installation.

#### A5.03 Marine Borers

1. Teredinidae. There was no evidence of Teredinidae during the approximately 34-month period over which this test was conducted.

2. Limnoria. Limnoria were active throughout this period, and occurred in variable numbers in the control panels almost every month each year except during the winter months. In the panels submerged between December 4, 1944 and April 10, 1945, and between October 2, 1945 and March 6, 1946, Limnoria were completely lacking. During the third winter season a total of only 20 Limnoria was recorded on the control panels

submerged between September 26, 1946 and March 27, 1947, when the test was discontinued; there was only one Limmoria during December 1946 and none during January and February 1947. It thus appears that at this location the migration of Limmoria ceases, or practically ceases, during the winter season.

Limmoria occurred on every one of the 30 test panels. From the time the first board was installed there was, in general, a gradual increase in the population until a peak rating of medium heavy was attained in the panels removed about the first of December and January, after having been submerged for 9 months. A peak rating of medium heavy was attained again in 1946. At the location where the second board was installed in September 1946 there was a gradual increase in the Limmoria population, but it did not exceed a trace even in panels submerged up to 6 months.

#### A5.04 Fouling Agents

1. Silt. Silt occurred as traces or occasionally as light deposits on each of the 30 control panels. It also occurred as traces, and more frequently as light or sometimes heavy deposits, on each of the same number of test panels.

#### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 14 of the 30 control panels. In general, their development was confined almost entirely to the late summer, fall, and early winter months. They also occurred as traces, or occasionally as light growths, on all except 4 of the 30 test panels. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred only sporadically and were generally few in number. Bryozoa were recorded on a single control panel and on 9 of the 30 test panels; they developed most consistently in test panels removed from November 1946 to March 1947, after 2 to 6 months' submergence. Tegella unicornis and Electra were the only forms identified.

c. Annelida (annelid worms). A few specimens of Serpula occurred on a single test panel.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on only 4 of the 30 control panels. The barnacles occurred intermittently for some periods on 17 of the 30 test panels and were absent for other periods between times. They appeared to occur most frequently on panels that were submerged during the warmer portion of the year. These barnacles in the control panels were either minute or juvenile. A maximum size of 10 mm was recorded on the test panels submerged for 4, 9, and 14 months. Four of the latter panels were from 20% to 100% covered. Corophium amphipods were recorded as occurring sporadically on 3 of the control panels and on 2 of the test panels. The maximum number found on any panel was 25.

e. Mollusca (nonboring mollusks). A single specimen of embryonic Mytilus (mussels) was recorded on one of the control panels. Mussels occurred on 15 of the 30 test panels, the maximum number on any one panel being 50. Lengths up to 8 and 9 mm were recorded on panels submerged for 3 and 5 months, respectively, while the maximum length recorded was 18 mm on a panel that had inadvertently been left submerged for 14 months. A few specimens of Anomia (jingle-shells) were recorded on 6 of the test panels, and a few specimens of Saxicava were recorded on one other panel.

f. Chordata (tunicates). Tunicates occurred on 4 of the 30 control panels and on 15 of the 30 test panels. The greatest number of colonies recorded on any panel was 150. Botryllus schlosseri, Molgula, and Ciona were each identified a number of times.

#### A5.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Station at Portland, Maine, from June 2, 1944, until its discontinuance on March 27, 1947, to determine the identity and prevalence of marine borers and fouling organisms at this location.

#### 2. Test Results.

a. Borers. There was no evidence whatever of the activity of Teredinidae during the nearly 3-year period covered by this test. Limmoria, however, were active in the test panels throughout the period of the test, attaining a peak rating of moderately heavy at the end of 1945 and again in 1946.

b. Fouling Organisms. Silt and invertebrate animals belonging to six phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, annelid worms, barnacles and amphipods, mussels and jingle-shells, and tunicates. Of these organisms, hydroids occurred with by far the greatest frequency, barnacles and mussels occurred with less frequency, encrusting Bryozoa occurred with still less frequency, while the occurrence of the other organisms was purely sporadic or occasional.

## Section 6

### PORTSMOUTH, NEW HAMPSHIRE -- PORTSMOUTH NAVAL SHIPYARD

#### A6.01 Location of the Test Station and Test Board

Two panel-type test boards (USNNH-1 and USNNH-2) were installed at the Portsmouth Naval Shipyard, Portsmouth, New Hampshire, on June 12 and 14, 1944, the first on the outboard end of the Topeka Pier between berths 15 and 16, and the second on the southerly side of the fitting-out pier at the western end of berth 11. It was later reported that the second board had been pulled up and found floating away. It was rehung on the inboard end of berth 11 early in August 1944. Results from these test boards, still in operation, have been summarized through 1947.

#### A6.02 Hydrographic Data

1. Test Board No. 1. The water depth at this installation was 25 ft; the average tidal range was 8 ft; the velocity of the current was estimated at 2 knots. The maximum summer water temperature was reported 70° F to 72° F, and the minimum winter temperature 26° F to 27° F. The water salinity appeared to be practically that of the ocean, and the degree of pollution was reported to be slight, if any.

2. Test Board No. 2. Here the water depth was 20 ft; the average tidal range, 8 ft; the estimated current velocity, 3 knots. Temperature, salinity, and pollution data are as given for Test Board No. 1.

#### A6.03 Marine Borers

1. Teredinidae. No evidence of Teredinidae was recorded in the control panels at either location and only slight attacks in the test panels. Teredo navalis was the only form identified. At location No. 1, no borers were recorded in 1944 and 1945; the attack rated but a trace in 1946 and slight in 1947. The maximum length of specimens was 38 mm. At location No. 2, no Teredinidae were recorded in 1944; the attack rated a trace in 1945 and slight in 1946 and 1947. The maximum length attained by specimens was 45 mm. There was no evidence of breeding before May 1.

2. Limmoria. Limmoria were present in small numbers in the control panels at both locations but occurred only in those panels exposed during the months from March through October. In the test panels, Limmoria were present practically throughout the period covered by the test at each location, the attacks mostly rating

from traces to slight, but attaining a maximum rating of moderate at location No. 1 late in 1945 and at location No. 2 in 1946.

#### A6.04 Fouling Agents

1. Silt. Silt, ranging from traces to light, occurred on all the control panels. Silt, ranging from light to moderate, occurred on the test panels at both locations except on one each of the control and test series at location No. 1.

2. Algae. Traces of algae, mostly green, occurred on one test panel at location No. 1 and on two each of the control and test panels at location No. 2.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on most of the control panels and on all test panels except one at both locations. The control panels showed traces; the growth on the test panels ranged from traces to light or rarely moderate. The majority of hydroids was Tubularia, but Metridium also occurred on a few test panels.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa were lacking from the control panels at both locations but occurred on 28 of the 36 location No. 1 test panels and on 25 of the 36 at location No. 2. Bryozoa found were Tegella unicornis, but Electra crustulenta, Electra sp., Callipora craticula, and Cribilina pinctata also were identified. Filamentous Bryozoa were absent from the control panels at both locations but occurred more or less abundantly on 8 of the test panels at location No. 1 and on 6 of the panels at location No. 2. Bugula flabellata and Bugula sp. occurred most frequently.

c. Annelida (marine worms). Traces of serpulid (Serpula) worms appeared on 3 test panels at location No. 1 and on one test panel at location No. 2.

d. Arthropoda (crustaceans). Balanus (barnacles), ranging from embryonic to juvenile, occurred on 4 of the control panels at location No. 1 and on 4 of the control panels at location No. 2, developing on the panels exposed during the months from April through September. They occurred more or less abundantly on 23 of the test panels at location No. 1 and on 26 of the panels at location No. 2, with a maximum diameter of 15 mm. after 8 months' submergence. Several of these panels were from 20% to 60% covered after 8 to 10 months' submergence. Amphipods (mostly Corophium) appeared on one test panel at location No. 1 and on 3 test panels at location No. 2, the greatest number on any panel being 200 Corophium. A trace of isopods was recorded on a single test panel at location No. 1.

e. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred more or less frequently on the panels at both locations. Mytilus (mussels) occurred on 14 of 36 control panels and on 35 of the 36 test panels at location No. 1, and on 14 of the 36 control panels and 33 of the 36 test panels at location No. 2. The maximum length recorded on a control panel submerged for one month was 22 mm, while that recorded on a test panel was 65 mm on one submerged for 8 months. Anomia (jingle-shells) occurred rather abundantly on 2 of the 36 control panels and on 17 of the 36 test panels at location No. 1, and on 17 of the 36 panels at location No. 2. The largest number recorded on any one panel was 60; the maximum diameter attained was 9 mm. Mya (clams) occurred as a trace on a single test panel at location No. 1, the specimens being juvenile. Saxicava occurred as a trace on a single test panel at each location.

f. Chordata (tunicates). Tunicates occurred more or less abundantly on 3 of the 36 control panels and on 26 of the 36 test panels at the location No. 1, and on 2 of the 36 control panels and 24 of the 36 test panels at location No. 2. Most of these tunicates were Botryllus schlosseri and Molgula sp.

#### A6.05 Summary and Conclusions

1. Installation. Two test boards of the panel type were installed at different locations at the Portsmouth Naval Shipyard, Portsmouth, New Hampshire, on June 12 and 14, 1944, and are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. At location No. 1, no Teredinidae were recorded in 1944 and 1945, and the attack rated only a trace in 1946 and slight in 1947. At location No. 2, no Teredinidae were recorded in 1944, and the attack rated only a trace in 1945 and slight in 1946 and 1947.

Limnoria were present at both locations practically throughout the entire test period, the attacks in general rating from traces to slight, but attaining a maximum of moderate at location No. 1 late in 1945 and at location No. 2 late in 1946.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter included hydroids, encrusting and filamentous Bryozoa, marine worms, barnacles, amphipods and isopods, and nonboring mollusks, which included mussels, jingle-shells, clams and Saxicava, and tunicates. Hydroids occurred the most frequently and consistently; encrusting Bryozoa, barnacles, and tunicates occurred somewhat less often, and mussels and jingle-shells still less often. The occurrence of the other forms mentioned was merely sporadic.

3. Recent Addenda. There were no Teredinidae at either location in 1948. In 1949, no Teredinidae were found at location No. 1, but a trace was recorded at location No. 2. The Limnoria attack at location No. 1 was moderate in 1948, and rated a trace in 1949. Location No. 2 showed a trace of Limnoria in 1948 and a slight attack in 1949.

## Section 7

### BOSTON, MASSACHUSETTS -- BOSTON NAVAL SHIPYARD

#### A7.01 Location of the Test Stations and Test Boards

Four test boards of the panel type were installed at different locations at the Boston Naval Shipyard at Boston, Massachusetts. The first, designated by the symbol USNB-1, was installed at Pier 9 at the Navy Yard on June 13, 1944. The second, designated by the symbol USNB-2, was installed at Pier No. 7 at the U. S. Naval Drydocks at the South Boston Annex on June 14, 1944. The third, designated by the symbol USNB-3, was installed at the Lockwood Basin in East Boston on June 16, 1944. Because of severe previous attacks by Limmoria in test boards maintained at the adjacent U. S. Army Base in South Boston, especially at the outer (eastern) end, an additional test board designated as USNB-4 was installed at the East Jetty, at a more easterly location than Pier No. 7 at the U. S. Naval Drydocks, on May 29, 1946. All test boards were hung inside the piers for protection against damage, and all locations were in the vicinity of untreated wood piles. On January 16, 1946, it was reported that the test board at the Lockwood Basin had broken away and, as it was not recovered, a new one was installed on March 1. The results from these test boards, the operation of which is still being continued, have been summarized to the end of 1947.

#### A7.02 Hydrographic Data

1. Test Board No. 1. The depth of water where this test board was installed was 20 ft from mean low water to the mud line, so that panel C was 15 ft below mean low water. The range of tide was given as 10 ft and the strength of current as tidal (480 ft per hr at half ebb tide surface flow). The monthly records of temperatures and salinities of the water for the duration of the test are given in tables following this section. In regard to pollution, it was stated that there was a slight film of oil on the surface and waste from berthed naval vessels at this and adjacent piers. On March 15, 1946, it was reported: "Escort carrier berthed on east side; crew of 350 men; sanitary overboard; garbage on shore; heavy slick of oil between piers."

2. Test Board No. 2. The depth of water where this test board was installed was 18.5 ft from mean low water to the mud line, so that panel C was 13.5 ft below mean low water. The tidal range was given as



10 ft, and the strength of current as tidal (840 ft per hr at half ebb tide surface flow). The monthly records of temperatures and salinities are given in the tables which follow. In regard to pollution, it was stated that there was very little surface oil; that there was waste from berthed naval vessels at this and adjacent piers; that the pier at which this test board was installed was about 500 ft (east) from the loading pier for deep-sea fishing boats. On March 15, 1946, the following conditions were reported: "Mayflower with crew of 104 men berthed on west side of pier; sanitary from Mayflower goes overboard; garbage on shore; oil slick on surface confined more or less by vessels berthed on either side."

3. Test Board No. 3. The depth of water where this test board was installed was 15 ft from mean low water to the mud line, so that panel C was 10 ft below mean low water. The range of tide was given as 10 ft, and the strength of current as tidal but, because of permanent and semipermanent berthing of various types of vessels, it was not possible to give the rate of flow under such changeable conditions. The monthly records of temperatures and salinities are presented in the tables which follow. Regarding pollution, it was stated that there was very little surface oil, and that there was waste from berthed naval vessels at this and adjacent piers. On March 15, 1946, it was reported: "Small craft tied up here, off and on; sanitary and garbage ashore; oil slick at site of test board, slight amount inboard."

4. Test Board No. 4. The depth of water at which this test board was installed was 20 ft from mean low water to the mud line, so that panel C was 14 ft below mean low water. The range of tide was given as 10 ft and the strength of current as tidal (approximately 1000 ft per hour). However, because of the nature of berthing of vessels, as at the other locations of test boards, it was impossible to obtain more than an approximation of the current strength. The monthly records of temperatures and salinities are presented in the following tables. Sources of pollution at this site were given as the sanitary disposal overboard from the crews of USS Falcon, YD No. 61, 73, and other nearby berthing areas. It also was reported that there was an oil slick on the surface, and that newly driven fender piles were coated with oil.

5. Water Temperature. The following record of the temperature of the water in degrees F, based on readings made about the middle of each month and taken at panel C on each test board, shows the range at each location.

Month	Pier No. 9 at Navy Yard, Boston				Pier No. 7 at Naval Drydocks, South Boston				Lockwood Basin, East Boston				East Jetty at Naval Drydocks, South Boston			
	1944	1945	1946	1947	1944	1945	1946	1947	1944	1945	1946	1947	1944	1945	1946	1947
January		28	37	32		30	37	32		28		31				32
February		30	30	30		28	29	29		28		31				29
March		36	34	36		35	34	37		36	35	36				37
April		51	46	42		51	45	42		49	44	43				42
May		50	51	48		49	49	47		50	50	47				47
June	56	59	56	54	58	58	56	54	53	58	57	53			56	54
July	70	62	59	63	66	61	59	62	68	62	60	62			58	62
August	72	67	67	65	72	66	66	64	72	67	67	64			66	63
September	62	67	64	62	61	66	64	62	62	66	63	63			63	62
October	58	56	56	60	57	56	56	59	58	56	56	58.5			56	58
November	47	53	51	44	47	53	50	44	46	53	51	44			51	45
December	40	38	43	42	40	39	42	41	40	38	42	41			42	40

6. Water Salinity. The following record of the salinity of the water, based on determinations made about the middle of each month and taken at panel C on each test board, shows the range at each location.

Date	Navy Yard, Boston	Naval Drydocks, South Boston	Lockwood Basin, East Boston	East Jetty at Naval Dry- docks, South Boston
	Chlorine as Cl	Chlorine as Cl	Chlorine as Cl	Chlorine as Cl
	Grains per gal	Grains per gal	Grains per gal	Grains per' gal
<u>1944</u>				
June	1,010	1,010	1,005	
July	945	930	945	
August	1,015	1,010	1,010	
September	1,022	1,022	1,025	
October	1,000	1,008	996	
November	1,006	1,013	994	
December	930	972	950	
<u>1945</u>				
January	958	978	963	
February	985	978	985	
March	950	963	950	
April	955	966	934	
May	940	953	925	
June	944	938	936	
July	946	952	940	
August	956	958	958	
September	978	980	979	
October	970	988	984	
November	962	982	966	
December	922	916	906	
<u>1946</u>				
January	910	932	--	
February	977	992	--	
March	750	880	916	
April	954	974	930	
May	958	962	960	
June	916	914	918	919
July	978	995	980	1,007
August	941	999	934	966

Date	Navy Yard, Boston	Naval Drydocks, South Boston	Lockwood Basin, East Boston	East Jetty at Naval Dry- docks, South Boston
	Chlorine as Cl	Chlorine as Cl	Chlorine as Cl	Chlorine as Cl
	Grains per gal	Grains per gal	Grains per gal	Grains per gal
<u>1946</u>				
September	952	924	937	971
October	980	981	977	984
November	1,000	982	982	1,008
December	1,001	986	987	997
<u>1947</u>				
January	990	989	1,014	1,023
February	980	975	980	986
March	934	892	918	951
April	878	924	832	968
May	913	925	968	910
June	951	827	952	891
July	982	986	986	997
August	1,012	980	994	1,000
September	993	983	973	1,000
October	1,022	1,008	1,010	1,015
November	940	931	933	969
December	992	962	980	973
<u>1948</u>				
January	1,003	1,000	996	1,020
February	1,013	1,023	1,006	1,036

## A7.03 Marine Borers

1. Teredinidae. No evidence of Teredinidae was recorded on any of the panels of the test boards at any of the four locations.

2. Limmoria. Limmoria were quite active at all four locations, but in the control panels their occurrence was virtually limited to the months from the middle of February or March to the middle of November or December, with the greatest period of activity largely occurring from the middle of March to the middle of August. It is interesting to note that at all locations the maximum number of Limmoria tunnels occurred in those control panels which were submerged from the middle of March to the middle of April. The number of tunnels recorded in these particular panels was 1,200 at the Navy Yard in 1946; 880 and 990 in 1946 and 1947, respectively, at Pier No. 7 at the Naval Drydocks; 660 at the Lockwood Basin in 1946; and 105 at the East Jetty of the Naval Drydocks in 1946.

In the test panels, Limmoria occurred more or less abundantly at all locations throughout the period covered by the tests except in the first and third panels submerged at the Navy Yard, and in the first 4 panels submerged at Pier No. 7 at the Naval Drydocks. As in the control panels, occurrence of the peaks of high activity coincided closely at all locations, nearly all occurring from the middle of August or September to the middle of December, after submergence for 8 months. The peaks of attack during the latter part of the year rated as follows: At the Navy Yard, heavy in 1945, 1946, and 1947; at Pier No. 7 at the Naval Drydocks, heavy in 1945, medium heavy in 1946, and heavy in 1947; at the Lockwood Basin, heavy in 1945, and medium heavy in 1946 and 1947; and at the East Jetty at the Naval Drydocks, medium heavy in 1947. Figures 1 and 2 are good examples of test panels which have been subjected to heavy attack by Limmoria.

## A7.04 Fouling Agents

1. Silt. Silt occurred on all the panels at all locations except on one at the Navy Yard and one at Pier No. 7 at the Naval Drydocks. The deposits mostly ranged from traces to light on the control panels, and from traces to moderate on the test panels.

2. Algae. A trace of green algae was recorded on only a single control panel at the Navy Yard and on one at the Lockwood Basin.

### 3. Invertebrate animal phyla.

a. Porifera (sponges). One specimen of a sponge was recorded on a single test panel at Pier No. 7 at the Naval Drydocks.

b. Coelenterata (hydroids). Hydroids occurred with great frequency on the test boards at all four locations. At the Navy Yard they occurred on 24 of the 43 control panels, and on all except one of 43 test panels. At Pier No. 7 at the Naval Drydock, they occurred on 31 of the 43 control panels and on all 43 of the test panels. At the Lockwood Basin, they occurred on 22 of the 41 control panels and on all except 2 of the same number of test panels. At the East Jetty at the Naval Drydocks, there were hydroids on 13 of the 20 control panels and on all 20 of the test panels. The growths generally ranged from traces to light on the panels of the control series and from traces to moderate on panels of the test series. Tubularia occurred with great frequency.

c. Bryozoa (encrusting and filamentous). A single colony of Electra crustulenta was recorded on each of 2 of the control panels at Pier No. 7 at the Naval Drydocks. Filamentous Bryozoa were recorded on 2 control panels at the Lockwood Basin, and on a single control panel and 3 of the test panels at the East Jetty at the Naval Drydocks. They ranged in numbers from traces to several colonies.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred with great frequency on the panels of the test boards at all four locations. At the Navy Yard, they occurred on 8 of the 43 control panels and on 36 of the 43 test panels. At Pier No. 7 of the Naval Drydocks, they occurred on 13 of the 43 control panels and on 33 of the same number of test panels. At the Lockwood Basin, they occurred on 14 of the 41 control panels and on 36 of the 41 test panels. At the East Jetty at the Naval Drydocks, they occurred on 9 of the 20 control panels and on 17 of the same number of test panels. The barnacles occurred most abundantly at the Lockwood Basin, where 15 of the panels were from 50% to 100% covered, and at the East Jetty at the Naval Drydocks, where 10 of the test panels were from 50% to 100% covered, after 8 months' submergence. Maximum diameters of 7, 7, 10, and 7 mm were recorded on the control panels, and of 14, 12, 11, and 13 mm, respectively, on the test panels at the Navy Yard, Pier No. 7 at the Naval Drydocks, Lockwood Basin, and East Jetty at the Naval Drydocks. Amphipods (nearly all Corophium) occurred sporadically on the panels of the test boards at all four locations. At the Navy Yard, they occurred on 7 control panels and on 11 test panels. At Pier No. 7 at the Naval Drydocks, they occurred on 4 control panels and on 13 test panels. At the Lockwood Basin, they occurred on a single control panel and on 14 of the test panels. At the East Jetty at the Naval Drydocks, they occurred on a single control panel and on 2 test panels.

e. Mollusca (nonboring mollusks). Mytilus (mussels) occurred more or less abundantly on the panels of the test boards at all four locations. At the Navy Yard, they occurred on a single control panel and on 8 test panels. At Pier No. 7 at the Naval Drydocks, there were mussels on 10 of the test panels. At the Lockwood Basin, they occurred on 3 control

panels and on 28 test panels. At the East Jetty at the Naval Drydocks, mussels occurred on 8 control panels and on 16 test panels. On the control panels, maximum lengths of 9, 23, and 35 mm were recorded at the Navy Yard, Lockwood Basin, and East Jetty at the Naval Drydocks, respectively. On the test panels, maximum lengths of 25, 20, 47, and 68 mm were recorded at the Navy Yard, Pier No. 7 at the Naval Drydocks, Lockwood Basin, and East Jetty at the Naval Drydocks, respectively. Traces of other mollusks were recorded on occasional test panels, as follows: Onchidoris bilamellata occurred on one panel at both the Lockwood Basin and the East Jetty at the Naval Drydocks; Saxicava occurred on one at Pier No. 7 and on one at the East Jetty at the Naval Drydocks.

f. Chordata (tunicates). Tunicates occurred in considerable abundance on the panels of the test boards at all four locations. At the Navy Yard, tunicates appeared on 7 of the 43 control panels and on 33 of the same number of test panels. At Pier No. 7 at Naval Drydocks, they occurred on 11 of the 43 control panels and on all but one of the 43 test panels. At the Lockwood Basin, they occurred on 9 of the 41 control panels and on 28 of the 41 test panels. At the East Jetty at the Naval Drydocks, there were tunicates on 4 of the 20 control panels and on 15 of the same number of test panels. Test panels were from 50% to 80% covered in seven cases at Pier No. 7 at the Naval Drydocks, and in four cases at the Lockwood Basin. Botryllus schlosseri and Molgula occurred commonly at all four locations. Ciona was recorded only at the Navy Yard.

#### A7.05 Summary and Conclusions

1. Installation. Four test boards of the panel type installed at different locations at the Boston Naval Shipyard, including points at Boston, East Boston, and South Boston (three on June 13, 14 and 16, 1944, respectively, and one on May 29, 1946), are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. No evidence of Teredinidae was recorded on any of the panels of the test boards at any of the four locations. Limnoria were quite active at all four locations, but their occurrence on the control panels was virtually limited to the months from the middle of February or March to the middle of November or December, with the maximum number of tunnels occurring in the panels submerged from the middle of March to the middle of April. In the test panels, the peaks of high activity also coincided closely at all locations, with almost all attacks occurring from the middle of August or September to the middle of December on panels which had been submerged for 8 months. The maximum attacks rated heavy at the Navy Yard, Pier No. 7 at the Naval Drydocks, and at the Lockwood Basin; and, contrary to expectations, only medium heavy at the East Jetty at the Naval Drydocks.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter comprised sponges, hydroids, encrusting and filamentous Bryozoa, barnacles and amphipods, miscellaneous nonboring mollusks, and tunicates. The hydroids, barnacles, and tunicates occurred with considerable frequency at all four locations and were the most important fouling organisms. Mussels also occurred quite frequently at all four locations. The occurrence of the other invertebrate animals was purely sporadic or occasional. Green algae occurred on only one test panel at each of two locations.

3. Recent Addenda. In 1948 and 1949 there was no evidence of Teredinidae at any of the four locations at this station. The Limnoria attack was medium heavy at the first two locations each year, slight at location No. 3, and moderate at location No. 4 both years.



## NEW LONDON, CONNECTICUT -- U. S. NAVAL SUBMARINE BASE

A8.01 Location of the Test Station and Test Board

A test board of the panel type was installed at the U. S. Naval Submarine Base at New London, Connecticut, on June 10, 1944, in the Thames River north of the Base proper and adjacent to the 1800-ton wooden floating drydock. The results from this test board, the operation of which is still being continued, have been summarized to the end of 1947. In November 1945, after 15 panels had been sent in to the laboratory, the test board was lost because of dredging operations and a new one was installed; on the latter test board, exposure of the panels was reduced from 8 to 4 months on account of the severity of the Teredo attack at this location. This test board was located at the end of Pier 1 at the south end of the Base.

A8.02 Hydrographic Data

The depth of water where the test board originally was installed was given as 40 ft, but the depth of water where the replacement board was installed on November 20, 1945, was given as 33 ft. The tidal range was 3 ft; the strength of the current was reported to be weak, irregular, and unpredictable. The mean temperature of the water was given as 60° F and the salinity (total solids) as 12.70 grams per kilogram. The specific gravity of the water was given as 1.0105 and the chlorinity (determined as chloride ion) as 7.47 grams per kilogram. The river was reported to be moderately polluted with sewage and oil.

A8.03 Marine Borers

1. Teredinidae. Teredinidae (Teredo navalis) occurred sporadically each year on the control panels, the breeding season being limited to the warmer months from the middle of July to the middle of October. During 1944 and 1945, the specimens ranged from embryonic up to 4 mm in length and from 300 to 600 per panel. During 1946 and 1947, only one to 13 minute pits per panel were recorded. Teredinidae were recorded in 21 of a total of 40 test panels; 7 of these panels were riddled, some panels in as short a period as 4 months. Specimens up to 185 mm in length were recorded in 4 months in these riddled panels. Panels were riddled in 1944, 1945, and 1947, the attack rating very heavy in these years but being less severe in 1946.

2. Limmoria. A small number of Limmoria occurred in 14 of the 40 control panels but only in those panels submerged between April 19 and December 19. The number in any one panel ranged from one to 23. Limmoria occurred in 28 of the 40 test panels. The attack, however, never rated more than a trace except late in 1947, when it rose to slight.

#### A8.04 Fouling Agents

1. Silt. Silt occurred on all except 2 of the 40 control panels and on all except one of the same number of the test panels. The deposits ranged from traces to light on the control panels and from traces to moderate on the test panels, they were even heavy and oily on one of each removed September 10, 1945.

2. Algae. A trace of green algae was recorded on a single panel each of the control and test series removed on June 19, 1947, after one and 4 months' submergence, respectively.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 29 of the 40 control panels and on all except one of the same number of test panels, the growths ranging from traces to light on the controls and from traces to moderate on the test panels. The forms identified comprised Tubularia most frequently, and also Pennaria tiarella.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on 3 control panels and on 8 test panels. The forms identified included Cryptosula pallasiana and Schizoporella unicornis. Filamentous Bryozoa occurred, mostly in fairly small numbers, on 3 control panels and on 4 test panels. Bugula sp. was the only form identified.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred on 6 control panels, where diameters up to 6 mm were recorded, and on 22 test panels, where diameters up to 17 mm were recorded after submergence for 4 months. One of the control panels was 25% covered, and 4 consecutive test panels removed at monthly intervals from August 19 to November 19, 1946, after having been submerged for 4 months, were from 25% to 50% covered. Amphipods (Corophium) occurred on 2 control panels and on 6 test panels, the number on the latter ranging from 25 to 250.

d. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred sporadically on occasional panels. Ten specimens of Anomia (jingle-shells) up to 6 mm in diameter occurred on a single test panel submerged for 3 months. A few specimens of Mytilus (mussels) occurred on 2 of the test panels, with lengths up to 18 mm recorded after submergence of 4 months.

e. Chordata (tunicates). Tunicates occurred sporadically in small numbers on the panels. Ascidians were recorded on a single panel each of the control and test series, a total of 50 being recorded on the test panel. Ciona occurred in small numbers on 2 panels each of the control and test series, a total of 50 being recorded on one of the latter. Other tunicates (mostly Botryllus schlosseri) occurred on 2 of the control panels and 6 of the test panels, the number of colonies on individual panels ranging from 2 to 20.

#### A8.05 Summary and Conclusions

1. Installation. A test board of the panel type installed at the U. S. Submarine Base at New London, Connecticut, on June 10, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. The attack by Teredinidae at this location was rated as very heavy in 1944, 1945, and 1947, with panels becoming riddled in as brief a period as 4 months. The Teredo attack in 1946 was less severe. During all the years, the breeding season was limited to the warmer months from the middle of July to the middle of October. Limnoria were present, mostly in small numbers, for a large part of the time covered by the test, but the attack never rated more than a trace except late in 1947, when the rating rose to slight.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, barnacles and amphipods, miscellaneous nonboring mollusks, and tunicates. Hydroids occurred with considerable frequency and regularity, and barnacles somewhat less so, while the occurrence of the other organisms was merely sporadic.

3. Recent Addenda. The Teredinidae attack rated very heavy at this station in both 1948 and 1949. There was a slight attack of Limnoria both years.

## Section 9

### BROOKLYN, NEW YORK -- U. S. NAVAL MAGAZINE AT FORT LAFAYETTE

#### A9.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the U. S. Naval Magazine at Fort Lafayette, Brooklyn, New York, from May 31, 1944, to October 2, 1946. No further panels have been received since the latter date, and no reason has been given for the discontinuance of this test board. The Fort is located on the east side of The Narrows where upper New York Bay connects with the Atlantic Ocean. The test board was suspended under the dock at the northwest corner of the Fort and was exposed to the free movement of water under the dock.

#### A9.02 Hydrographic Data

The depth of water where the test board was installed was approximately 15 ft at low tide and 20 ft at high tide. The lower end of the board was about 7 ft from the bottom. The mean range of tide at Fort Hamilton was given as 4.7 ft and the spring range as 5.6 ft. The standard current tables give the average velocity of the current as one knot, with a spring velocity of 1.2 knots. Local observations have indicated a maximum speed of ebbing tide as 4.5 knots and a maximum of rising tide as 3.5 knots. It was noted, however, that the standard tables for The Narrows to the west of the Island indicate a maximum velocity of flood tide of 2.6 knots, with a maximum ebb of 2.7 knots. The temperature of the water at the time of installation was 62° F. The standard of salinity of sea water, taken 200 miles east of New York Harbor and averaged from 1914 to 1945, was 32.5 parts of the salt per 1,000. In The Narrows, in the vicinity of Fort Lafayette during this same period, salinity varied from 21.5 to 26.5 parts of salt per 1,000. Three sewers were reported to empty into The Narrows within a radius of one mile of Fort Lafayette.

#### A9.03 Marine Borers

1. Teredinidae. No evidence whatever of Teredinidae was recorded during the test.

2. Limnoria. No evidence of Limnoria was recorded in any of the control panels, and only from 2 to 20 tunnels were recorded in 3 test panels removed on August 1, October 1, and November 1, 1945, after having been submerged for 8 months. While only the barest trace of Limnoria was recorded during the test, damage by this crustacean borer led to the removal of a considerable number of piling at this location in 1934, as evidenced by a series of photographs on file.

## A9.04 Fouling Agents.

1. Silt. Silt occurred on all control and test panels, the deposits ranging from traces to moderate; they were often oily.

### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 18 of the 25 control panels and on 27 of the 28 test panels. They ranged from traces to light or occasionally moderate growths. Tubularia was the only form identified.

b. Bryozoa (encrusting). A trace of encrusting Bryozoa was recorded on 2 of the test panels. Cryptosula pallasiana and Electra sp. were identified.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred on 8 of the 25 control panels and on 22 of the 28 test panels. Five control panels, and the first of the test panels submerged for periods of one month each during June and July, were from 20% to 100% covered, the maximum size recorded being 5 mm in diameter. A maximum diameter of 20 mm was recorded on 3 test panels removed November 2, 1944, and January 1 and February 1, 1945, after having been submerged for 5, 6, and 7 months, respectively. Barnacles at this location appear to develop in greatest numbers and make their most rapid growth during the months of June, July, and August. Amphipods (Corophium) occurred more or less abundantly on 2 of the test panels removed December 1, 1944, and January 1, 1945, after having been submerged for 5 and 6 months, respectively.

d. Mollusca (nonboring mollusks). Mytilus (mussels) were more or less abundant on 2 control panels, where a maximum length of 8 mm was recorded, and on 8 test panels, where a maximum length of 30 mm was recorded on one removed January 1, 1945, after having been submerged for 6 months. Two specimens of Saxicava were recorded on a single one of the test panels.

e. Chordata (tunicates). Tunicates occurred on only the first 2 control panels and on 7 test panels, a maximum of 20 colonies being recorded on any panel. Botryllus schlosseri and Molgula sp. were the only forms identified.

## A9.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Magazine at Fort Lafayette, Brooklyn, New York, from May 31, 1944 until its discontinuance after October 2, 1946, to determine the identity and degree of prevalence of marine borers and fouling agents occurring at this location.

## 2. Test Results.

a. Borers. No evidence whatever of Teredinidae was recorded throughout the duration of the test. Only the barest trace of Limnoria was recorded in 1945, although damage by this crustacean borer had led to the removal of a considerable number of piling at this location in 1934.

b. Fouling Organisms. Silt and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The invertebrates comprised hydroids, encrusting Bryozoa, barnacles and amphipods, non-boring mollusks, and tunicates. Silt occurred regularly on all the panels. Hydroids also occurred with great regularity and barnacles somewhat less frequently, while the occurrence of the other organisms was merely sporadic.

## Section 10

## BROOKLYN, NEW YORK -- NEW YORK NAVAL SHIPYARD

A10.01 Location of the Test Station and Test Board

A test board of the panel type was installed July 20, 1944, at the New York Naval Shipyard, Naval Base Station, Brooklyn, New York. This test board, designated by the symbol USNMY-1, was installed at the end of Pier D in the East River. The results from this test board, the operation of which is being continued, have been summarized to the end of 1947.

A10.02 Hydrographic Data

The depth of water where this test board was installed was 24 ft at mean low water; the range of tide was 4.2 ft; the current velocity was zero. The temperature of the water at the time of installation was 71° F. The degree of pollution is stated to be heavy. The monthly data on water temperatures and analysis received from the New York Naval Shipyard are tabulated as follows:

Date	Temperature, degrees F	Specific gravity	Salinity as sodium chlor- ide: percent	Position sample taken: Depth below mean low water
4/23/46	51	1.0178	2.10	17 ft 0 in.
5/24/46	55	1.0139	1.54	17 ft 0 in.
6/19/46	59	1.0151	1.77	17 ft 0 in.
7/18/46	74	1.0159	2.23	?
8/20/46	72	1.0156	1.99	?
9/19/46	76	1.0160	2.22	?
10/22/46	62	1.0176	2.20	?
11/22/46	55	1.0189	2.22	17 ft 0 in.
12/19/46	44	1.0185	2.12	?
1/21/47	52	1.0187	2.24	17 ft 0 in.
2/21/47	36	1.0181	2.07	?
3/19/47	38	1.0155	1.60	?
4/24/47	45	1.0160	1.96	?
5/22/47	56	1.0160	1.87	?
6/27/47	65	1.0145	1.83	?
7/24/47	72	1.0154	2.04	?
8/26/47	75	1.0143	2.04	?
9/25/47	72	1.0174	2.30	17 ft 0 in.
10/23/47	66	1.0180	2.27	?
11/20/47	46	1.0185	2.10	?
12/29/47	37	1.0187	2.01	?

### A10.03 Marine Borers

1. Teredinidae. No evidence of Teredinidae was recorded on any panel in either the control or test series at this location.

2. Limnoria. The only evidence of Limnoria consisted of 5 tunnels recorded on a single test panel removed October 3, 1945, after having been submerged for 8 months. Thus the Limnoria attack at this location rated the barest trace.

### A10.04 Fouling Agents

1. Silt. Silt occurred on every one of the series of 41 control and test panels (one of the latter not received). In both types of panels the deposits ranged from traces to moderate, and were oily on several panels.

2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 6 of 41 control panels and as traces to light growths on 21 of the same number of test panels.

b. Arthropoda (crustaceans). Balanus (barnacles) occurred on 2 of the 41 control panels, and on 22 of the same number of test panels. The number on any one panel was nearly always small, but a total of 250 was recorded on one of the test panels. The maximum diameter attained on the control panels was 6 mm, while that on the test panels was 10 mm.

### A10.05 Summary and Conclusions

1. Installation. A test board of the panel type installed July 20, 1944, at the New York Naval Shipyard, Naval Base Section, at Brooklyn, New York, is still being operated. The results of this test have been summarized to the end of 1947.

2. Test Results.

a. Borers. No evidence of Teredinidae was recorded at this location, and the only evidence of Limnoria consisted of 5 tunnels on a single test panel, so that the attack by the latter rated only the barest trace.

b. Fouling Organisms. Silt and invertebrate animals belonging to 2 phyla contributed to fouling of the panels. The latter comprised hydroids and barnacles, both of which occurred with equal frequency but lightly. The heavy pollution at this location appears to be unfavorable for the development of either marine borers or of great numbers of fouling organisms.



## BAYONNE, NEW JERSEY -- BAYONNE ANNEX, NEW YORK NAVAL SHIPYARD

All.01 Location of the Test Station and Test Board

A test board of the panel type was installed July 20, 1944, at the Bayonne Annex of the New York Naval Shipyard, at Bayonne, New Jersey. This test board, which was designated by the symbol USNMY-2, was installed at the north bulkhead, New Ferry Slip north of building 102, situated on the western side of upper New York Bay. The results from this test board, the operation of which is being continued, have been summarized to the end of 1947.

On March 5, 1945, it was reported that this test board had broken its mooring and for three days had been partly covered with mud at the bottom of the channel, but had been recovered, washed off, and rehung without injury. On November 29, 1949, it was removed from the water because piles were being driven in the vicinity, and was left out for nine days (through December 7). On December 31, 1947, it was reported that panel 41 and the accompanying control had dropped into the water; these were later recovered by grappling, and these December panels are recorded as having been removed on January 12, 1948.

All.02 Hydrographic Data

The depth of water where this test board was installed was 31 ft at mean low water; the range of tide was 4.5 ft; the current velocity was given as 0.38 ft per second. The temperature of the water at the time of installation was 71° F. The degree of pollution is stated to be moderate. The following data on water temperature and analysis were received from the New York Naval Shipyard.

Date	Temperature, degrees F	Specific gravity	Salinity as sodium chloride: percent	Position sample taken: depth below mean low water
4/23/46	52	1.0175	2.22	15 ft 0 in.
5/24/46	57	1.0137	1.54	15 ft 0 in.
6/19/46	59	1.0149	1.76	15 ft 0 in.
7/18/46	74	1.0168	2.34	?
8/20/46	71	1.0164	2.12	?
9/19/46	70	1.0166	2.14	?
10/22/46	62	1.0161	2.07	?
11/22/46	53	1.0189	2.24	15 ft 0 in.
12/19/46	43	1.0188	2.16	?
1/21/47	40	1.0197	2.30	15 ft 0 in.
2/21/47	38	1.0180	2.04	?
3/19/47	39	1.0135	1.52	?
4/24/47	45	1.0148	1.69	?
5/22/47	56	1.0163	1.86	?
6/27/47	66	1.0148	1.90	?
7/24/47	72	1.0155	2.09	?
8/26/47	74	1.0125	1.97	?
9/25/47	70	1.0179	2.36	15 ft 0 in.
10/23/47	64	1.0185	2.31	?
11/20/47	44	1.0183	2.07	?
1/12/48	37	1.0205	2.24	?

#### All.03 Marine Borers

1. Teredinidae. No evidence of Teredinidae was recorded on any panels in either the control or test series at this location.

2. Limnoria. Limnoria were not recorded on any of the control panels, and were recorded on only 9 of the 41 test panels. On the latter, they occurred only during the latter half of 1945 and 1947, and the maximum number of tunnels on any one panel was 27. Thus, the Limnoria attack at this location rated only a bare trace.

#### All.04 Fouling Agents

1. Silt. Silt occurred on all except the second one each of the series of 41 control and 41 test panels. On the control panels, the deposits ranged from traces to moderate, while on the test panels they ranged from traces to moderate, or rarely heavy, and were oily on 5 panels.

2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces

on 16 of 41 control panels, as traces to light or moderate growths on 3, and heavy on one of the same number of test panels.

b. Bryozoa (encrusting). Two colonies of Electra crustulenta occurred on a single test panel.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred on 9 of 41 control panels and on 34 of the same number of test panels. Two of the control panels were each 50% covered, and 7 of the test panels were from 70% to 100% covered. The maximum diameter attained on the control panels was 8 mm, while that on the test panels was 19 mm. Amphipods (Corophium) appeared on only the first of the control panels, on which they were numerous. A few Corophium appeared on 2 of the test panels.

d. Chordata (tunicates). Tunicates occurred on the first 2 of the control panels and on 11 of the 41 test panels, ranging in number from a few to numerous. Botryllus schlosseri and Molgula occurred most frequently.

#### All.05 Summary and Conclusions

1. Installation. A test board of the panel type installed at the Bayonne Annex of the New York Naval Shipyard, at Bayonne, New Jersey, is still being operated. The results of this test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. No evidence of Teredinidae was recorded at this location, and Limnoria occurred only as bare traces on the test panels during the latter half of 1945 and of 1947.

b. Fouling Organisms. Silt and invertebrate animals belonging to 4 phyla contributed to fouling of the panels. The invertebrates were comprised of hydroids, encrusting Bryozoa, barnacles and amphipods, and tunicates. The hydroids and barnacles occurred with the greatest frequency, while the occurrence of the other organisms was merely sporadic.

3. Recent Addenda. Both Teredinidae and Limnoria appeared as traces at this station in 1948 and 1949.

## CAPE MAY, NEW JERSEY -- U. S. NAVAL AIR STATION

A12.01 Location of the Test Station and Test Board

A test board of the panel type was operated from August 4, 1944 until May 8, 1946, at the former U. S. Naval Base, which later became the U. S. Naval Air Station at Cape May, New Jersey. The exact location of the board at this Station was not given. The original board was washed away in a storm in the fall of 1945 and a new board was installed at the same place on November 7 of the same year. This test board was designated by the symbol USNNJ-1. Its operation was discontinued in May 1946, when the Naval Air Station was scheduled to be decommissioned as of June 1, 1946.

A12.02 Hydrographic Data

The depth of water at the point where the board was installed was 11 ft at mean low water; the tidal range was  $4\frac{1}{2}$  ft; the maximum current was not over 2 knots. The temperature of the water was reported to range from a minimum of  $30^{\circ}$  F in winter to a maximum of  $70^{\circ}$  F in summer. The degree of pollution was very light.

A12.03 Marine Borers

1. Teredinidae. No Teredinidae were recorded in any of the control panels, but Teredo navalis was recorded on 4 test panels removed from April 21 to July 20, 1945, after they had been submerged 8, 9, 10, and 11 months, respectively. However, no Teredo occurred either before or after this period. These data roughly indicate the extent of the breeding season at this location. The largest number of specimens in the test panels was 8, and the maximum length recorded was 170 mm in one submerged for 11 months. The attack rated very slight in 1945 and none at all occurred during the early part of 1946.

2. Limnoria. Limnoria occurred only on the first one of the control panels, which had been inadvertently left submerged for 4 months; only 11 tunnels were recorded on it. On the test panels, 37, 52, 155, and 400 tunnels, respectively, were recorded for those panels removed from April 21 to July 20, 1945, after they had been submerged for 8, 9, 10, and 11 months, respectively. Only a single tunnel was recorded for the last test panel that was removed on May 8, 1946, after it had been submerged for 6 months. The occurrence of Limnoria thus coincides almost exactly with that of Teredo navalis, both being almost limited to a single brief period. The Limnoria attack at this location rated only a trace.

## A12.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series. The deposits were mostly traces, or sometimes light on the panels of the control series, and light or moderate on the panels of the test series.

2. Algae. Green algae were recorded on 8 of the 13 control panels and on all except one of the 13 test panels. On the control panels, the growth was but a trace or sometimes light, while on the test panels, it was mostly light to occasionally moderate. The only specimen identified was Enteromorpha.

### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 5 of the 13 control panels, and on 8 of the same number of test panels. Their growth was only a trace, except on 2 of the test panels, where it rated light and moderate, respectively. Tubularia was the only form identified.

b. Bryozoa (encrusting). A few colonies of encrusting Bryozoa (Cryptosula pallasiana) were recorded on the first one of the control panels and on 2 of the test panels.

c. Annelida (annelid worms). A trace of serpulid (Serpula) tubes occurred on a single test panel.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on only the first one of the control panels and on 5 of the 13 test panels. The maximum diameter attained was 15 mm on the first of the control panels, which had been inadvertently exposed for 4 months. The maximum diameter recorded on the test panels was 12 mm on one submerged for 11 months. Thirty amphipods (Corophium) were recorded on a single test panel.

e. Mollusca (nonboring mollusks). A few specimens of Mytilus (mussels) were recorded on only a single one of the test panels, where they attained a maximum length of 13 mm.

## A12.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Station at Cape May, New Jersey, from August 5, 1944 until its discontinuance on May 8, 1946, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

## 2. Test Results.

a. Borers. Both Teredo navalis and Limnoria occurred to a limited extent, the occurrence of both being virtually restricted to the period from the middle of May through July. The attack by Teredo navalis rated very slight in 1945, and no attacks were reported during the early part of 1946. The attack by Limnoria rated only a trace.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The invertebrates comprised hydroids, encrusting Bryozoa, serpulid worms, barnacles and amphipods, and mussels. The green algae occurred with by far the greatest frequency of any fouling organisms. Of the invertebrate animals, hydroids occurred most frequently and barnacles in lesser numbers, while the occurrence of the other organisms was merely occasional.

## PHILADELPHIA, PENNSYLVANIA -- PHILADELPHIA NAVAL SHIPYARD

A13.01 Location of the Test Station and Test Board

Two test boards of the panel type were operated at different locations at the Philadelphia Naval Shipyard from July 17, 1944 until March 17, 1947, when their discontinuance was requested because they showed almost no trace of marine life. The first of these test boards, which was designated by the symbol USNPP-1, was installed 250 ft east of Point "G" along the Schuylkill River Quaywall. The second board, which was designated by the symbol USNPP-2, was installed at the east side of Pier No. 6 in the Delaware River, 11 ft inshore from the outboard end (954 ft from the Quaywall). Both of these test boards were in the vicinity of untreated wood piling.

A13.02 Hydrographic Data

1. Test Board No. 1. This test board was submerged in water 8.9 ft deep. The tidal range was 5.6 ft practically every month of the test, and this figure was reported to have been the mean range for the past 50 years. The current at ebb tide (to west) during the period of the test was generally negligible and never exceeded 0.2 mile per hour; that at flood tide (to east) also was negligible and never exceeded 0.38 mile per hour. The top of the test board was exposed at low water approximately two hours daily, as the depth of the water was only 8.9 ft at mean low tide. The temperature and salinity of the water recorded at monthly intervals during the period covered by the test are presented in the following tables. No information was given concerning pollution, but it is known from personal experience to be considerable, especially with respect to silt. The pH range of the water at this location ranged from 5.2 to 7.3.

2. Test Board No. 2. This test board was submerged in water 28.7 ft deep at mean low water. The tidal range was roughly 5.6 ft at every monthly reading during the test, and this figure was reported to have been the mean range for the past 50 years. The current at ebb tide (to west) was slight, varying from 0.4 to 1.0 mile an hour; that at flood tide (to east) also was slight, varying from 0.75 to 2.25 miles per hour. The temperature and salinity of the water recorded at monthly intervals during the period covered by the test are presented in the following tables. There was probably also considerable pollution of the water at this location. The pH reaction ranged from 4.6 to 7.3.

3. Water Temperature. Temperature records of the water in degrees F, based on readings taken at various times each month, show the general range at each location.

Month	Test Board No. 1, Schuylkill River, 250 ft east of Point "G"				Test Board No. 2, Delaware River Pier No. 6			
	1944	1945	1946	1947	1944	1945	1946	1947
January		--	40	30		--	40	30
February		30	34	30		30	34	30
March		32	--			32	--	
April		50	50			50	50	
May		58-60	58			58-60	58	
June		80	64			80	64	
July	80	--	70		78	--	70	
August	84	75	72		84	75	72	
September	72	75	72		72	75	72	
October	68	70	68		64	70	68	
November	52	55	60		52	55	60	
December	50	42	28		40	42	28	

4. Water Salinity. Salinity records of the water in ppm, compiled from readings taken at various times each month, show the general range at each location.

Month	Test Board No. 1, Schuylkill River, 250 ft east of Point "G"				Test Board No. 2, Delaware River Pier No. 6			
	1944	1945	1946	1947	1944	1945	1946	1947
January		31.0	18.3	40		22.6	15.5	30
February		36.7	25.4	--		31.0	25.4	--
March		15.5	38.1	23		25.4	32.4	23
April		19.8	20			16.9	17	
May		14.1	--			14.1	--	
June		32.4	17			33.9	14	
July	36.7	19.8	17		33.1	16.9	17	
August	75	22.6	25		85	22.6	23	
September	161	--	25		79.1	--	23	
October	100	19.7	33		139	22.6	33	
November	144	19.7	40		212	22.6	40	
December	202.0	36.6	20		183.0	28.2	43	



### A13.03 Marine Borers

Not the slightest trace of either Teredinidae or Limnoria was recorded in the test boards operated at the Philadelphia Naval Shipyard in either the Schuylkill or Delaware Rivers. Because analyses of the water at monthly intervals over the nearly three-year period covered by the test show that it is entirely fresh, neither of these groups of marine borers could possibly occur.

### A13.04 Fouling Agents

1. Silt. Silt occurred on all the control and test panels of the test boards at both locations, the deposits ranging from traces to moderate, or rarely heavy, and mostly oily.

2. Algae. Traces of green and brown algae were recorded on a single one of the test panels of Test Board No. 2 in the Delaware River, which had been submerged for 8 months.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). A trace of hydroids was recorded on a single control panel and on a single test panel of Test Board No. 1, operated in the Schuylkill River. A light growth was recorded on a single control panel and traces on 2 test panels of Test Board No. 2, operated in the Delaware River.

### A13.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Shipyard at Philadelphia, Pennsylvania, from July 17, 1944 until March 17, 1947, to determine the identity and prevalence of marine borers and fouling agents at this location.

#### 2. Test Results.

a. Borers. Not the slightest trace of either Teredinidae or Limnoria was recorded in the test boards operated in either the Schuylkill or Delaware Rivers. Since the water at both these locations is entirely fresh, neither of these groups of marine borers could possibly occur.

b. Fouling Organisms. The freshness of the water at both these locations almost completely inhibited the growth of other marine organisms. Only traces of hydroids were recorded on 2 or 3 of the panels at each location, and algae occurred only as a trace on a single panel of the board in the Delaware River. Deposits of silt, usually oily, occurred more or less abundantly on all control and test panels at both locations.

As there was nothing of value to be learned by further operation of this test board, its termination was requested.

## Section 14

PORTSMOUTH, VIRGINIA -- NORFOLK NAVAL SHIPYARD

AND

NORFOLK, VIRGINIA -- U. S. NAVAL OPERATING BASE

### A14.01 Location of the Test Stations and Test Boards

Test boards of the panel type were installed at the Norfolk Naval Shipyard at Portsmouth and at the U. S. Naval Operating Base at Norfolk, Virginia, on June 16 and July 5, 1944, respectively. The board at the Norfolk Naval Shipyard was designated as USNN-1. No details as to the location of this test board were given. Since all piling in use here is creosoted, it was not possible to locate the board in the vicinity of untreated piling. Instead, it was located near creosoted piles which were driven in 1907, and it was assumed that the value of the preservative has been greatly reduced, as marine borers have damaged the piles to a considerable extent.

The other test board, designated as USNN-2, was installed at the Navy's Convoy Escort Base on the west side of Hampton Boulevard, about one mile south of the Naval Operating Base proper. It was suspended from the outboard end of Pier No. 23, which extends into the Elizabeth River 750 ft from the bulkhead line. This location was selected because it is the only one which has water deep enough to permit completely submerging the test board and keeping it about 2 ft above the bottom; also, it was the only location at which the board could be installed reasonably near untreated wood piling. Pier No. 23 is 50 ft in width, and at each of the outboard corners are clusters or dolphins of untreated oak piles. The test board is about 11 ft from one of these clusters.

In December 1946, it was reported that panels 6, 7, and 8 of this test board (USNN-2), which were scheduled for removal in one, 2, and 3 months, respectively, were in a bad state of deterioration, and that it appeared doubtful that they would be in place on the dates scheduled for their removal. It was therefore requested that the 8-month period of submergence be reduced to 4 months. Accordingly, these panels were removed on December 16 and sent to the Laboratory; a new test board was installed on a new 4-month program on January 7, 1947.

A14.02 Hydrographic Data

1. Test Board No. 1 (USNN-1). The depth of water where this test board was installed was 22 ft 6 in. below mean low water; the tidal range was 2.8 ft; the current was not reported. The temperature of the water at the time of installation was 80° F at 18 ft below mean low water. The following determination of salinity was made from samples taken on March 8, 1946:

Chlorides (as Cl) 7,597 ppm or 444 grains per U. S. gal  
 Chlorides (as NaCl) 12,500 ppm or 732 grains per U. S. gal

The water was reported to be heavily polluted. The following record of the temperature of the water, based on readings made about the middle of each month or shortly thereafter, and presumably all made at 18 ft below mean low water, shows the general range at this location.

Water Temperature in Degrees F

Month	1944	1945	1946	1947
January		38	40	47
February		40	40	42
March		53	54	45
April		62	57	56
May		66	63	68
June	80	78	--	72
July	80	77	79	78
August	80	75	76	80
September	80	75	70	80
October	64	60	64	72
November	53	53	64	54
December	38	38	--	46

2. Test Board No. 2 (USNN-2). The depth of water where this test board was installed was 21 ft at mean low water; the tidal range was 2.7 ft; the current, tidal ebb and flow, 0.8 to 0.9 knot. The temperature of the water at the time of installations was 77° F. The salinity was not determined. A high concentration of pollution was reported. The following record of the temperature of the water in degrees F, based on readings made about the first week in each month from samples taken at 20 ft below mean water, shows the general range at this location.

Water Temperature in Degrees F

Month	1944	1945	1946	1947
January		38	44	45
February		35	41	48
March		48	44	35
April		56	48	54
May		62	57	62
June		--	68	74
July	77	78	75	78
August	82	78	75	74
September	78	75	72	82
October	69	66	68	64
November	43	58	60	62
December	41	46	46-48	44

At this location, the temperature of the water was recorded at three depths, namely at about 2, 12, and 20 ft below mean low water. As a rule, the temperature at a depth of 12 ft was but 1° cooler than that at a depth of 2 ft; at a depth of 20 ft it was the same as that at a depth of 12 ft, thus showing little vertical variation.

A14.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia gouldi and Teredo navalis, showed a moderate amount of activity in Test Board No. 1 and considerably more in Test Board No. 2.

a. Test Board No. 1. Teredinidae occurred in only 7 of the 41 control panels, ranging from minute pits or embryonic specimens to one specimen 23 mm long; breeding occurred only from the latter part of March to the middle of September. In the test panels of this board, they occurred in 31 of the 41 panels but there were never more than 75 specimens in any panel, their length ranging up to 280 mm after 9 months' submergence. The attack by Teredinidae at this location attained peak ratings of moderate in 1944 and 1945, but rated only slight in 1946 and 1947.

b. Test Board No. 2. Teredinidae occurred in 16 of the 41 control panels, ranging from minute pits or embryonic specimens to some with a length of 35 mm; breeding occurred only from March through November. In the test panels of this board, Teredinidae occurred in all except 2 of the 48, filling or riddling a large number, sometimes in as short a period as 4 months. Some specimens were recorded up to 230 mm in length after 6 months' submergence. The attack by Teredinidae rated very heavy each year at the Convoy Escort Base at Norfolk.

2. Limmoria. Limmoria did not occur in any of the panels of either the control or test series of Test Board No. 1; in Test Board No. 2 only 3 panels showed any evidence of them. There were 15 tunnels recorded in the first of the control panels, 20 in the second of the test panels, and a single one in a subsequent test panel. Thus, the Limmoria attack rated but a bare trace in 1944 and 1946, with none at all in 1945 and 1947 at the Convoy Escort Base at Norfolk.

#### A14.04 Fouling Agents

1. Silt. Silt occurred on all the control and test panels of both test boards, the deposits ranging from traces to medium on those of the control series, and from light to heavy on those of the test series.

2. Algae. A trace of brown algae occurred on a single one of the test panels of Test Board No. 1.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids and Metridium). Hydroids occurred on 19 of the 41 control panels and on 34 of the 41 test panels of Test Board No. 1; on Test Board No. 2 they occurred on 22 of the 44 control panels and on 38 of the 48 test panels. The occurrence was as traces to light growths on the panels of both series. Tubularia was the only form identified. Metridium, a member of a different group of hydroids, occurred on 3 of the 41 control panels and on 14 of the same number of test panels on Test Board No. 1. On Test Board No. 2 they occurred on a single control panel and on 24 of the 48 test panels.

b. Bryozoa (encrusting). Encrusting Bryozoa occurred on 3 of the control panels and on 5 of the test panels of Test Board No. 1, while on Test Board No. 2 they occurred on 12 of the 44 control panels and on 22 of the 48 test panels. Electra crustulenta, E. monostachys, and E. sp. were identified.

c. Annelida (marine worms). Serpulid (Serpula) tubes occurred on a single control panel and on 4 of the test panels on Test Board No. 1. On Test Board No. 2 they occurred on 9 of the 44 control panels and on 23 of the 48 test panels. They were mostly few in number, 110 being the greatest number recorded on one test panel of Test Board No. 2, the maximum length of any of these being 45 mm.

a. Arthropoda (crustaceans). Balanus (barnacles) occurred on 19 of the 41 control panels and on all except one of the 41 test panels on Test Board No. 1; on Test Board No. 2 they occurred on 20 of the 44 control panels and on 44 of the 48 test panels. The maximum

diameter recorded was 12 mm and 11 mm on the control panels of Test Boards 1 and 2, respectively, and 25 mm in 9 months and 23 mm in 4 months on the test panels of Test Boards 1 and 2, respectively. One control panel was 50% covered; 7 test panels on Test Board No. 1 were from 50% to 80% covered after 8 months' submergence, while 12 panels on Test Board No. 2 were from 50% to 100% covered, some after only 4 months' submergence. Amphipods (Corophium) occurred on a single control panel and on 3 of the test panels of Test Board No. 1, while on Test Board No. 2, they occurred on only 2 of the test panels. A maximum of 400 were recorded on a single test panel of the first board.

e. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred occasionally on the panels of both test boards. A few specimens of Mytilus (mussels) occurred on 3 of the test panels of Test Board No. 1, and on only one test panel of Test Board No. 2. A few specimens of Anomia (jingle-shells) were recorded on a single control panel and on 6 test panels of Test Board No. 2. A few specimens of Ostrea (oysters) occurred on 2 test panels of Test Board No. 1, and on 3 test panels of Test Board No. 2. A maximum diameter of 77 mm was recorded after 4 months' submergence.

f. Chordata (tunicates). Tunicates occurred more or less abundantly on 4 control panels and on 6 test panels of Test Board No. 1, also on 10 control panels and on 27 test panels of Test Board No. 2. Botryllus schlosseri was the most numerous of these tunicates, but Molgula and ascidians also were identified.

#### A14.05 Summary and Conclusions

1. Installation. Test boards of the panel type, installed June 16, 1944, at the Norfolk Naval Shipyard at Portsmouth, Virginia, and July 5, 1944, at the U. S. Naval Operating Base at Norfolk, Virginia, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. The activity of the Teredinidae differed markedly at the two locations. At the Norfolk Naval Shipyard at Portsmouth the attack attained peak ratings of moderate in 1944 and 1945, but rated only slight in 1946 and 1947. At the U. S. Naval Operating Base at Portsmouth, however, the attack rated very heavy each year. No evidence of Limmoria was recorded at the Norfolk Naval Shipyard at Portsmouth, and the attack at the U. S. Naval Operating Base at Norfolk rated only a trace in 1944 and 1946; no Limmoria appeared in 1945 and 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter comprised hydroids and Metridium, encrusting Bryozoa, serpulid worms, barnacles and amphipods, nonborer mollusks, and tunicates. Of these borers, hydroids and barnacles occurred with the greatest frequency; Metridium, encrusting Bryozoa, and serpulid worms occurred with less frequency; while the occurrence of the others, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. The Teredinidae attack was rated as slight in 1948 and very heavy in 1949, at the first location. There were no Limnoria recorded at this location either year. At location No. 2, the Teredinidae attack registered heavy in 1948 and very heavy in 1949. There were no Limnoria at the second location in 1948 and only a trace in 1949.

## Section 15

### CHARLESTON, SOUTH CAROLINA -- U. S. NAVAL BASE

#### A15.01 Location of the Test Station and Test Boards

Five test boards of the panel type were installed July 1, 1944, at three different locations at or near the Charleston Naval Base at Charleston, South Carolina. The locations and symbols used to designate these test boards are listed as follows:

<u>Symbol</u>	<u>Location</u>
USNC-1	Pier 317-C -- lower board
USNC-1U	Pier 317-C -- upper board
USNC-2	Deperming Station (Pier 320) lower board
USNC-2U	Deperming Station (Pier 320) upper board
USNC-3	Custom House Pier

As the experience in this locality indicated greater damage from marine borers in timber structures between the elevations of mean low water and mean high water than at lower depths, it was decided to install upper and lower boards at two locations. Thus, at Pier 317-C and at the Deperming Station (Pier 320), 2 sets of test boards were hung, one above the other. The upper boards, which were suspended with the top elevation at mean low water, have the letter "U" after the panel numbers and are so designated in the board symbols. The lower boards at these two locations were suspended so that the bottom of the lower panel was 2 ft above the mud line.

The depth of water at the U. S. Naval Fleet Landing being insufficient to cover the board at low tide, it was decided to make the installation of test board USNC-3 at the adjacent Custom House Pier. Permission was granted by the U. S. Engineers Office, Charleston, South Carolina, to make this installation.

The current and the corrosive action of the water caused failure of the cable supporting Test Board USNC-1 at Pier 317-C, and the board was lost after the last of the first series of panels was removed and replaced. This board was replaced by a new board on March 3, 1945. At the same time, the cables holding the other boards were renewed so as to prevent the loss of these boards. The test boards installed at the



Deperming Pier were carried away in May 1946, when a ship fouled the pier, and new boards were then installed at this point.

The results from these test boards, the operation of which is still being continued, have been summarized to the end of 1947.

#### A15.02 Hydrographic Data

The depth of water at Pier 317-C, where Test Boards USNC-1 and USNC-1U are located, was given as 28.7 ft; that at the Deperming Pier (320), where Test Boards USNC-2 and USNC-2U are located, as 37.6 ft; and that at the Custom House Pier, where Test Board USNC-3 is located, as 10.3 ft. The mean range of tide was given as 5.2 ft. The current velocity observations were made at the Charleston Shipbuilding and Drydock Co., located about one-half mile above the Custom House Pier. These observations showed velocities ranging from a maximum of 2.97 miles per hour out in the Cooper River to 0.5 mile per hour at inshore locations comparable to those velocities of the test board installations. The maximum current velocity at the Deperming Station is probably in excess of 3 miles per hour, and along the outside face of Pier 317-C it is at least 3 miles per hour, with strong eddy currents prevailing between the piles where the test board is located. The temperature of the water at the time of installation was given as approximately 82° F. Analysis of the water subsequently submitted show that the bacterial content is high in coliform organisms. This condition was expected to continue, because raw sewage and other waste matter was continually being dumped into the Cooper River by the various communities along it, including the city of Charleston. At Pier 317-C the chloride content of the water was given as 4,400 mgm per liter and the pH reading as 7.7. At the Deperming Station the chloride content was given as 6,500 mgm per liter and the pH as 7.9; at the Custom House Pier the chloride content was given as 10,700 mgm per liter and the pH as 7.9.

#### A15.03 Marine Borers

1. Teredinidae. Teredinidae occurred irregularly in the control panels at each of the five locations, but their breeding season was limited to May through September, October, or November at the different locations. Maximum lengths of 11, 11, 40, 12, and 45 mm were recorded in USNC-1, USNC-1U, USNC-2, USNC-2U, and USNC-3, respectively. One of the control panels in USNC-2 was 30% filled with Teredinidae. Teredinidae, including Bankia gouldi, Teredo navalis, and T. (Lyrodus) sp. were active at all locations except USNC-1U throughout most of the period covered by the test. In USNC-1 at Pier 317-C, several test panels were filled or riddled with specimens up to 240 mm in length. In USNC-2, which was submerged at the lower depth at the Deperming Station, the majority of the test panels were filled or riddled with specimens up to 300 mm in length.

In USNC-3, submerged at the Custom House Pier, the majority of the test panels were filled or riddled with specimens up to 240 mm in length. At all these four locations the attack by Teredinidae was rated as very heavy, especially so in the case of the lower board at the Deperming Station and the one at the Custom House Pier. In USNC-1U, with the top submerged to mean low water at Pier 317-C, the maximum attack by Teredinidae rated only slight; no panel showed more than 1 to 10 specimens, and the greatest length recorded was 185 mm.

2. Limmoria. In contrast to the Teredinidae, Limmoria in general showed little or no activity at most of the locations. In USNC-1, submerged at the lower depth at Pier 317-C, only a single specimen was recorded on a control panel submerged in June 1947, and none was recorded on any of the test panels. No evidence of Limmoria was recorded on the upper test board at this location, or on either of the 2 test boards at the Deperming Station. However, Limmoria showed more or less activity at the Custom House Pier throughout most of the period covered by the test. It occurred in 24 of the 42 control panels, but only on those panels submerged during the months from April through November. The number of tunnels recorded in the control panels ranged from 1 to 40. Limmoria occurred in all except 2 test panels submerged from July 1944 through June 1946, and again in all panels removed from March through July 1947, after having been submerged for 8 months. The attack rated from only a trace to slight most of the time, but attained a rating of moderate late in 1945.

#### A15.04 Fouling Agents

1. Silt. Silt occurred on practically all of the panels at all locations, the deposits on the control panels ranging from traces to light, or rarely moderate, and deposits on the test panels ranging from traces to moderate, with a heavy deposit on one panel.

#### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on most of the control panels at all locations and on all of the test panels except one at all locations. The growths on the control panels ranged from traces to light or rarely moderate or heavy, while the growths on the test panels ranged from traces to moderate, rarely heavy, or very heavy. Tubularia was the form identified most frequently; Pennaria tiarella also occurred. Metridium, a member of a different group of Coelenterata, also occurred.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on occasional panels at all five locations. They were recorded on 5 control panels and 7 test panels of the lower board at Pier 317-C; on 3 test panels of the upper board at Pier 317-C;

on 2 control panels and 4 test panels of the lower board at the Deperming Station; on 4 control panels and 2 test panels of the upper board at the Deperming Station; and on 10 control panels and one test panel of the test board at the Custom House Pier. Electra crustulenta and Electra sp. were the only forms identified. A trace of filamentous Bryozoa was recorded on a single control panel of the lower board at the Deperming Station.

c. Annelida (marine worms). Traces of serpulid (Serpula) worms occurred on a single test panel of the lower test board at Pier 317-C; on 3 panels of the lower test board at the Deperming Station; and on 7 test panels of the test board at the Custom House Pier. The maximum number on any one of the latter was 25 and the maximum length attained was 15 mm.

d. Arthropoda (crustaceans). Balanus (barnacles) developed profusely and with great regularity at all five locations, occurring on nearly all the control panels at each location, and on all except one of the test panels. They developed on the control panels during every calendar month of the year, attaining maximum diameters of 7, 8, 11, 8, and 8 mm, respectively, on the control panels of the five different test boards, in the order named. On the test panels they attained maximum diameters of 14, 13, 22, 18, and 23 mm on the different test boards, respectively. From 13 to 25 control panels and from 23 to 39 test panels of the 5 test boards, respectively, showed from 50% to 100% of the surface covered. Amphipods (including Corophium and Gammarus) occurred sporadically at all five locations. They occurred on 6 control panels and one test panel of the lower test board at Pier 317-C; on 3 control panels and 14 test panels of the upper test board at this Pier; on 8 control panels and 15 test panels of the lower test board at the Deperming Station; on 11 control panels and 14 test panels of the upper test board at this Station; and on 7 control panels and 9 test panels of the test board at the Custom House Pier. The greatest number recorded on any one panel was 600.

e. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred sporadically on the panels of the test boards at all five locations. Mytilus (mussels) occurred on a single control panel of the lower test board at Pier 317-C; on one each of the control and test series of the upper test board at this Pier; on 2 control panels and 14 test panels of the lower test board at the Deperming Station; on 2 control panels and 4 test panels of the upper test board at this Station; and on 10 test panels at the Custom House Pier. In most cases the numbers were few, but as many as 1,500 were recorded on a single test panel of the lower test board at the Deperming Station. Maximum lengths of 14 mm on a control panel, and of 18 mm on a test panel, were recorded.

Ostrea (oysters) occurred on 2 test panels of the lower test board at Pier 317-C; on a single test panel of the lower test board at the Deperming Station; on 2 test panels of the upper test board at this Station; and on 3 control panels and 10 test panels of the test board at the Custom House Pier. The specimens were mostly few in number; on a control panel, as many as 60 juvenile specimens were recorded on the test board at this Pier. The maximum diameter recorded on a test panel was 22 mm.

Anomia (jingle-shells) occurred on a single test panel on the lower test board at the Deperming Pier; on 3 of the test panels of the upper test board at this Pier; and on 2 of the control panels of the test board at the Custom House Pier. The greatest number on any one panel was 10. A few specimens of Astyris lunata occurred on a single panel each of the control and test series of the lower test board at the Deperming Station, and on 2 of the test panels of the test board at the Custom House Pier. Ten specimens of Cardium (cockle) and 8 unclassified specimens in the family Cardiidae were recorded on 2 of the test panels of the test board at the Custom House Pier.

f. Chordata (tunicates). A few colonies of tunicates occurred on a single panel each of the control and test series on the lower test board at the Deperming Station, and on a single control panel and 6 of the test panels at the Custom House Pier. The only forms identified were Botryllus schlosseri and Molgula sp.

#### A15.05 Summary and Conclusions

1. Installation. Five test boards of the panel type, installed July 1, 1944, at three different locations at or near the Charleston Naval Base, Charleston, South Carolina, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were active at all three locations throughout most of the period covered by the test. Their breeding season started in May and did not last beyond September, October, or November. The attack rated very heavy in the lower test board at Pier 317-C, in both of those at the Deperming Station, and in the one at the Custom House Pier. In fact, it was especially heavy in the lower test board at the Deperming Pier and in the board at the Custom House Pier. In the upper test board at Pier 317-C, however, the maximum attack rated only slight. In contrast to the Teredinidae, Limnoria in general showed little or no activity at most locations. In the lower test board at Pier 317-C only a single specimen of Limnoria was recorded on one of the control panels, and there was no evidence of any on either of the 2 test boards at the Deperming Station. At the Custom House Pier, however, Limnoria showed more or less activity throughout the period covered by

the test. The attack rated from a trace to slight most of the time but attained a rating of moderate late in 1945.

b. Fouling Organisms. Silt and invertebrate animals belonging to 6 phyla contributed to the fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, marine worms, barnacles and amphipods, miscellaneous nonborring mollusks, and tunicates. Of these organisms, the hydroids and barnacles occurred with great frequency and regularity, while the occurrence of the others was more or less sporadic.

3. Recent Addenda. On the lower board at Pier 317-C, there was a moderate attack by Teredinidae in 1948 but only a trace in 1949. No Limnoria were present either year. No borers of either kind were recorded during these years on the upper board at this pier.

The Teredinidae attack was very heavy in 1948 and 1949 on the lower board at the Deperming Station, but no Limnoria at all were recorded here either year. On the upper board at this location there was a moderate attack by Teredinidae each year, but again no Limnoria at all.

At the Custom House Pier the attack by Teredinidae was very heavy in both 1948 and 1949. There was a trace of Limnoria present each year also.

## Section 16

### COCKSPUR ISLAND, GEORGIA -- U. S. NAVAL RECEIVING STATION

#### A16.01 Location of the Test Station and Test Board

A test board of the panel type was installed on August 31, 1944, at the U. S. Naval Receiving Station, on Cockspur Island near the mouth of the Savannah River, about 14 miles south of Savannah, Georgia. This test board was designated by the symbol USNSG-1. No information was given as to its exact location. The operation of this test board was discontinued after the last panels were removed on June 1, 1945, because of the decommissioning of this Station.

#### A16.02 Hydrographic Data

The depth of water where the test board was installed was 30 ft; the tidal range was 7 ft; the maximum velocity at both ebb and flood tide was 5 knots. The temperature of the water at the time of installation was 65° F. The water at this point was reported to be heavily polluted.

#### A16.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia gouldi, occurred in 4 of the 8 control panels. There were 3, 10, and 200 embryonic individuals, respectively, in 3 of these 4 panels, while in the fourth there were 2,640, with lengths up to 50 mm; the latter panel, the first to be removed, had inadvertently been left submerged for 2½ months. The breeding season at this location appears to be from April through November. The 8 test panels all showed an extremely severe attack by Bankia gouldi. These panels had been submerged on August 31, 1944, and the first panel was left submerged for 2 months, instead of the usual one month. One block was removed at the end of each succeeding month, so that the last one was submerged 9 months. The test board record given in the following table shows the extreme rapidity with which this marine borer attacked and destroyed the test panels.

Months panel was submerged	Number of borers, or degree of attack	Length attained
2	817	Up to 35 mm
3	1,320	Up to 70 mm
4	well-filled	Up to 120 mm
5	riddled	Up to 85 mm
6	riddled	Up to 110 mm
7	riddled	Up to 120 mm
8	riddled	
9	completely destroyed	

The attack by Teredinidae at this Station was so severe that the use of panels 2 inches thick was recommended.

2. Limnoria. In contrast to the extremely severe attack by Teredinidae at this Station, Limnoria were almost completely lacking; only the last one of the control panels was attacked, and this panel contained only 4 tunnels.

#### A16.04 Fouling Agents

1. Silt. Silt occurred as traces or light deposits on all the control panels and as light or sometimes heavy deposits on all the test panels.

#### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids and Metridium). Hydroids occurred as traces on all the control panels, and as traces or light growths on all the test panels except the last one, where only a small piece was left. Metridium, a member of a different group of Coelenterata, occurred on 2 of the 8 control panels and on 4 of the 8 test panels.

b. Bryozoa (encrusting). Encrusting Bryozoa occurred only on the first 4 of the 8 test panels that were submerged from 2 to 5 months. Electra crustulenta and Electra sp. were identified.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred in great abundance on all the control panels and on 5 of the 8 test panels. Three of the control panels were 80%, 90%, and 100% covered, respectively, and 4 of the test panels were completely covered.



Maximum diameters of 6 mm were attained on the control panels, while on the test panels the maximum diameter recorded was only 5 mm after 8 months' submergence. Amphipods (Corophium) occurred only on the first 2 panels of both the control and test series, there being from 100 to 200 individuals on each of these panels.

d. Mollusca (nonboring mollusks). Mytilus (mussels) occurred on both the first 3 control and test panels, and also on one of the test panels removed later. The maximum growth recorded was a length of 5 mm in one month and 8 mm in 2 months.

e. Chordata (tunicates). Tunicates were found on one of the control panels and on 2 of the test panels, to the extent of 5 to 15 colonies. The only one identified was Botryllus schlosseri.

#### A16.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Receiving Station on Cockspar Island, in the Savannah River 14 miles south of Savannah, Georgia, to determine the identity and prevalence of marine borers and fouling agents occurring at this location.

#### 2. Test Results.

a. Borers. Teredinidae were very active throughout the period covered by the test and proved extremely destructive, riddling panels in as short a period as 5 months. The attack was so destructive that the use of panels 2 inches thick was recommended. In contrast to the extremely severe Teredinidae attack at this Station, Limnoria were almost completely lacking.

b. Fouling Organisms. Silt and invertebrate animals belonging to 5 phyla were found to contribute to the fouling of the panels. The latter comprised hydroids, encrusting Bryozoa, barnacles and amphipods, mussels, and tunicates. Of these organisms, hydroids and barnacles occurred most frequently; the others were rather sporadic in occurrence.



## Section 17

### MAYPORT, FLORIDA -- U. S. COAST GUARD TRAINING STATION

#### A17.01 Location of the Test Station and Test Board

A test board of the panel type was installed on June 8, 1944, at what was then the U. S. Naval Auxiliary Air Station, but is now the U. S. Coast Guard Training Station, at Mayport, Duval County, Florida. This Station is located on the south bank of the St. Johns River, near its mouth and about 22 miles from Jacksonville. The test board is submerged under the main dock at the southwest corner of a dredged turning basin, in a part of Ribault Bay that is least affected by tidal flow. It is approximately 4,000 ft from the St. Johns River proper, and approximately  $1\frac{1}{4}$  miles from the Atlantic Ocean, or about  $2\frac{1}{2}$  nautical miles from the end of the channel jetties projecting into the ocean at the mouth of the river. The turning basin is roughly rectangular in shape, approximately 2,250 ft wide by 3,000 ft long. Access to the St. Johns River is gained by an entrance channel approximately 750 ft wide by 900 ft long, situated at the northeastern corner. This channel, as well as the greater part of the turning basin, is 35 ft deep in its central portion. This test board is well protected from storms.

Because it was not practical to install the test board near untreated piling, as requested, it was suspended underneath a wooden dock, the piling of which had been submerged since December 1941, and was covered by a thin barnacle coating. Marine borers were reported to be very active at this location, and keels of boats were said to have been eaten away in a 12- to 18-month period. In 1944 the method used to protect vessels at this activity was to install a one-inch worm shoe on the keel and to insert one thickness of commercial felt (tar paper) between the worm shoe and the keel. It has been observed that this method successfully repels marine borers for a period of 90 to 120 days. The borers are reluctant to penetrate felt and will eat horizontally along the worm shoe instead of eating the felt. This method has proven highly satisfactory on all types of small boats, up to and including the 63-footers.

#### A17.02 Hydrographic Data

The depth of water at the location where the test board was installed was 19 ft at half tide; the tidal range was approximately  $6\frac{1}{2}$  ft; the velocity of the current was approximately one-half knot, caused solely by eddies from ebb and flow of tide.

1. Water Temperature. The temperature of the water in the turning basin at the time of installation was 72° F, but it was given as 80° F on June 15, 1944. Further data on the water temperatures are tabulated below. It is apparent from a study of the table that the temperature of the water within the turning basin varies within considerable limits in different months of the year, and also during the same season in different years. During the approximately 3½-year period of the test, the greatest range of water temperature was from 50° F in January to 86° F in September, October, and November of 1945.

The following record of temperature of the water in degrees F, based on readings taken at various times each month, shows the general range at this location.

Month	1944	1945	1946	1947	1948
January		50	75	63.9	64
February		55	75	50.9	64.4
March		63	68	58.4	
April		70	68	72.0	
May		75	68	74.7	
June	72-80	84	--	77.0	
July	--	84	80.6	79.9	
August	--	84	80.4	--	
September	--	86	77.8	--	
October	--	86	73.1	76	
November	--	86	63.9	68	
December	53	75	63.5	--	

2. Salinity. The salinity of the water in the turning basin varies considerably, ranging from 15 to 32 parts of dissolved salts per thousand. The maximum range is slightly lower than the reading taken from the surf, which, in June 1944, was 34 to 35 parts per thousand. The salinity of the water is affected by the tides and winds, as certain combinations of these elements will force considerable river water into the basin.

3. Pollution. The water at this location appears to be reasonably free from pollution, but an analysis shows Bacillus coli present. The two samples tested in June 1944 showed 4,800 and 3,400 colonies per cc., respectively.

#### A17.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia gouldi and Teredo sp., were very active throughout the period covered by the test. The attack at this location was so severe that it was found impossible to maintain for the usual 8-month period the 12-in. x 6-in. x 1-in. panels used in the test. In August 1944, it was requested that the original panels be removed and replaced with new ones, 2 inches thick.

This new series was started in December 1944. However, the attack continued to be as severe as before, and it appeared that even a 2-in. panel was not sufficiently thick to carry a test through 8 months. It was therefore requested on March 23, 1945, that blocks 4 inches thick be used. Increasing the thickness of the panels did not solve the problem, however, because it was soon discovered that the attack was just as destructive to the thicker blocks. The more wood present, the greater became the number of borers infesting the panels, so that the attack was just as severe proportionately in the thicker panels as in the thinner ones.

As increasing the thickness of the panels did not prolong their life, it was decided to shorten the period of submergence and infestation to which the panels had been exposed. Consequently, on November 6, 1945, it was requested that the panels be removed and replaced by a new series operated on a 4-month basis, instead of on the 8-month basis which previously obtained. This change was made later the same month. However, it was found that even after the period of submergence was reduced to 4 months, the destruction of the panels was too rapid to permit making accurate analyses; so in December 1946, this period was further reduced, following the decision that 3 months was the longest practical period of submergence.

Teredinidae occurred in 33 of the 41 control panels, ranging from minute pits or embryonic specimens to specimens up to 65 mm in length. One of these panels, submerged for only one month, was filled, and another was riddled. The breeding season extends from March 9 to December 20, but in 1946 and 1947, it continued until February 20. It is clearly apparent that the growth attained by the sets of Teredinidae that develop during the months which have warmer water temperature is much greater than the growth of those borers which develop at either limit of the breeding season.

Teredinidae occurred in all except one of the 47 test panels, the exception being a panel that was removed during a change in panel series, after having been submerged for only 6 days. Maximum lengths of 60 mm were recorded in one month, 95 mm in 2 months, and 240 in 3 months. Eight of these panels were filled; 9 were riddled; 12 were more or less completely destroyed, although few had been left submerged for more than 3 or 4 months. The attack rated very heavy each year, including 1944.

2. Limmoria. Limmoria were more or less active throughout the period covered by the test but never occurred in particularly destructive numbers. They occurred on 24 of the 41 control panels but not on any control panel prior to October 8, 1944. The largest number on any one of these panels was 250. Limmoria occurred on 22 of the 47 test panels. Their occurrence, even here, was irregular and sporadic, the attack rating from none to a trace most of the time. However, they attained a low moderate peak in a panel removed on August 11, 1945, after 8 months' submergence, and rated as slight on 4 of the panels removed from July 20 to October 20 in 1947, after 3 months' submergence.

3. Pholadidae (Hiata and Martesia). Pholadidae also were more or less active throughout much of the period covered by the test. They occurred in 7 of the 41 control panels but were only embryonic or minute except in one panel, inadvertently left submerged for 2 months, where lengths up to 10 mm were recorded. One of these panels was recorded as containing 95 to 100 minute Teredinidae and Pholadidae per sq in., 6,600 in all. In the test panels, Pholadidae occurred in 14 of the 47, the greatest length recorded being 12 mm after 3 months' submergence. The largest number recorded in any one of these panels was 75 to 100, these ranging up to 4 mm in diameter after 2 months' submergence. However, 4 panels were more or less completely destroyed, presumably by the combined attacks of Teredinidae and Pholadidae, so that it was impossible to make exact counts of the numbers of either of these organisms. The occurrence of the Pholads was irregular and sporadic in both the control and test panels. They were recorded in only one test panel from August 11, 1945 to July 20, 1947, but 7 of these panels were destroyed and could not be read. In a few of the panels where Pholads were recorded, it was difficult to evaluate their number and importance. The Pholad attack appears to have rated medium heavy in 1944 and 1947, and moderate in 1945 and 1946. It probably would have been heavier had it not been for the rapidity with which the Teredinidae destroyed the panels.

#### A17.04 Fouling Agents

1. Silt. Silt occurred on all except one of the 41 control panels and on 40 of the 47 test panels. So little was left of the other 7 panels that it was impossible to identify silt, or much else in the way of fouling organisms. The deposits ranged usually from traces to moderate on the panels of both series, becoming heavier after the middle of 1946.

#### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 27 of the 41 control panels and on 35 of the 47 test panels. The growths rated mostly as traces on the control panels, and as traces or light on the test panels. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on 15 of the 41 control panels and on 22 of the 47 test panels. Two control panels were covered; and of 6 of the test panels, 4 were 25%, 30%, 50%, and 90% covered, and 2 entirely covered. Cryptosula pallasiana, Electra sp., and Schizoporella unicornis were identified. Filamentous Bryozoa .

occurred more or less abundantly on 7 of the 41 control panels and on 10 of the 47 test panels. One of the control panels was covered. Bugula flabellata, B. neritina, and B. sp. were identified.

c. Annelida (annelid worms). Serpulid (Serpula) tubes occurred on 5 of the 41 control panels and on 10 of the 47 test panels, the maximum on any test panel being 100.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on 34 of the 41 control panels and on 43 of the 47 test panels. Maximum diameters of 12 mm were recorded on the control panels, and of 18 mm on a test panel after 3 months' submergence. Six of the control panels were from 25% to 100% covered, and 25 of the test panels were from 20% to 100% covered. Barnacles, which developed every month of the year at Mayport, may cover panels within a short period at any season of the year.

e. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally on the panels as follows: Anomia (jingle-shells) occurred on 3 of the panels of both the control and test series, the largest number on any one of the latter panels being 25; Mytilus (mussels) occurred on 2 control panels and on 3 test panels, the maximum on any one of the latter panels being 20; Ostrea (oysters) occurred on a single control panel and on 8 test panels, the largest number on any one panel being 35. A length of 38 mm was recorded on a test panel submerged for 7 months. A solitary specimen of Musculus lateralis occurred on one of the control panels.

#### A17.05 Summary and Conclusions

1. Installation. A test board of the panel type installed at the U. S. Coast Guard Training Station at Mayport, Florida, on June 2, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active and destructive throughout the period covered by the test. Increasing the thickness of the panels did not prolong their life; and in order to prevent their uninterpretable destruction, it was found necessary to reduce the period of submergence to 3 months. Even control panels submerged for a single month were sometimes filled or riddled. The attack rated very heavy each year, including 1944. Limnoria were more or less

active throughout the period covered by the test, but never occurred in particularly destructive numbers. Their occurrence was irregular and sporadic. The attack rated from zero to a trace most of the time, but it did attain a low moderate peak in 1945, and rated slight in 1947. Pholadidae, also, were more or less active throughout much of the period covered by the test, and their occurrence also was irregular and sporadic. Their attack was difficult to evaluate because of the rapid and often complete destruction of the panels by Teredinidae, but appears to have rated medium heavy in 1944 and 1947, and moderate in 1945 and 1946.

b. Fouling Organisms. Silt and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, and miscellaneous nonboring mollusks. Of these organisms, barnacles occurred with the greatest frequency and abundance. Hydroids also occurred most frequently, encrusting Bryozoa occurred less frequently, and filamentous Bryozoa and serpulid worms occurred much less frequently, while the occurrence of the other worms was merely occasional.

3. Recent Addenda. Panels removed from the board at this station in 1948 and 1949, were riddled with Teredinidae. Limnoria reached the low moderate rating in 1948 and attained a rating of medium heavy the following year.

## Section 18

### KEY WEST, FLORIDA -- U. S. NAVAL SUBMARINE BASE

#### A18.01 Location of the Test Stations and Test Boards

Two test boards of the panel type were installed June 7, 1944, at what was formerly the U. S. Naval Operating Base, but is now the U. S. Naval Submarine Base, at Key West, Florida. One board, designated as USNK-1, was placed on the inboard side of Pier "B" at the Naval Base; the other, designated as USNK-2, was placed on the outboard end of the Section Base.

It was impossible to place either test board near untreated piling, so they were placed at what were considered to be the most suitable positions. In the case of board USNK-1, the position selected along the inboard side of Pier B, just off the edge of the pier, was 6 ft from the nearest reinforced concrete pile. Board USNK-2 was placed immediately to the right of the center of the outboard (west) end of the Section Base. This position is 3 ft from some treated wood fender piling.

On November 20, 1945, a new series of panels was installed on both test boards, and the period of submergence was reduced from 8 to 4 months because of the destructiveness of marine borers at this locality. The operation of these test boards is being continued. The results have been summarized to the end of 1947.

#### A18.02 Hydrographic Data

1. Test Board No. 1 (USNK-1). The depth of water where this test board was installed was 12 ft; the tidal range (general average) was 1.80 ft; the current was approximately 0.80 knot. The surface temperature of the water at the time of installation was 86° F. The salinity was determined as chloride (milligrams per liter), 20,900; as sodium chloride, 34,500. In regard to pollution, it was stated that there is a 4-in. sanitary sewer line discharging overboard 50 ft from the test board. Five toilets, used by approximately 40 people daily, were reported to be on this sewer line.

2. Test Board No. 2 (USNK-2). The depth of water where this test board was installed was 20 ft, but the bottom breaks off quite sharply to a depth of 27 ft, approximately 15 ft off the end of the wall. The tidal range (general average), was given as 1.80 ft, and the current was approximately 1.20 knots. The surface temperature of the water at the time of installation was 86° F. The salinity was determined

as chloride (milligrams per liter), 20,900; as sodium chloride, 34,500. In regard to pollution, it was stated that along the south side of the Section Base there is a 4-in. line discharging from a septic tank. The over-all distance from this 4-in. line around the corner to the test board is approximately 175 ft.

### A18.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia sp., Teredo clappi, T. parksi, T. (Lyrodus) sp., T. (Psiloteredo) sp., and T. sp., were very active each year at both locations. They occurred in 22 of the 43 control panels of Test Board No. 1, and in 23 of the 38 of Test Board No. 2, ranging from mere pits to minute specimens. It was indicated that the breeding season was limited from March through December, or sometimes to the middle of January or February. In the test panels at both locations, they occurred in nearly all panels that were submerged for 2½ months or more, and several of these were riddled after 8 months' submergence. The maximum lengths attained by specimens in these panels were 220 mm in Test Board No. 1, and 190 mm in Test Board No. 2. The attack by Teredinidae rated as very heavy in 1945 at both locations.

2. Limnoria. Limnoria also were very active throughout the period covered by the tests and occurred in all the panels of both test boards. The severity of attack varied, with peaks occurring at intervals, but in general, the attack rated very heavy each year at both locations. Test panels removed on June 7, 1945, after 8 months' submergence, showed Limnoria counts of 21,000 and 20,000, respectively, indicating that the attack was unusually severe. The next 2 test panels removed from Test Board No. 2, which were left submerged for 12½ and 11½ months, respectively, were destroyed by the combined attacks of Teredinidae and Limnoria.

3. Pholadidae. No Pholadidae were recorded at either location.

### A18.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both test boards except on one control and one test panel of Test Board No. 1, and on 2 test panels of Test Board No. 2. The deposits, mostly a gray clay, ranged from traces to moderate on the control and test panels of both test boards, with occasionally heavy deposits on the test panels of Test Board No. 1.

2. Algae. Algae occurred on 31 of the 43 control panels and on 35 of the 50 test panels of Test Board No. 1, the growths generally ranging from traces to moderate on the panels of both series. On Test Board No. 2, however, they occurred on only 4 of the 38 control panels



and on 7 of the 45 test panels, the growths rating only traces on the panels of both series. Mostly green algae occurred, but red algae were found on one test panel.

### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids and Metridium). Hydroids occurred on 28 of the 43 control panels and on 45 of the 50 test panels of Test Board No. 1. On Test Board No. 2, they occurred on 33 of the 38 control panels and on 39 of the 45 test panels. The growths ranged from traces to light on the panels of both series. On practically all the infested panels, Tubularia was the only form identified. However, a few specimens of Metridium, a member of a different group of Coelenterata, occurred on a single test panel of Test Board No. 1.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on only one of the 43 control panels and on 5 of the 50 test panels of Test Board No. 1. On Test Board No. 2 they occurred on 7 of the 38 control panels and on 20 of the 45 test panels. The forms identified comprised Cryptosula pallasiana, Electra sp., and Schizoporella unicornis. Filamentous Bryozoa occurred on 5 control panels and on 4 test panels of Test Board No. 1. On Test Board No. 2 they occurred on 3 of the 38 control panels and on 6 of the 45 test panels. Bugula neritina and Bugula sp. were the only forms identified.

c. Annelida (marine worms). Serpulid (Serpula) tubes occurred on 14 of the 43 control panels and on 21 of the 50 test panels of Test Board No. 1, the maximum length recorded being 25 mm. One test panel was 35% covered and 600 specimens were recorded on another. On Test Board No. 2 they occurred on 14 of the 38 control panels and on 29 of the 45 test panels, the maximum length recorded being 35 mm. One test panel was 50% covered, and 500 specimens were recorded on another. Several hundred to several thousand minute, thread-like calcareous tubes of Salmacina occurred on 2 control panels and on 2 test panels of Test Board No. 1.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred only on occasional panels of both test boards. They were recorded on 5 control panels and on 3 test panels of Test Board No. 1, and on a single control panel and on 2 test panels of Test Board No. 2. The maximum diameter recorded was 8 mm, after 4 months' submergence. Amphipods (Corophium) occurred only a single control panel and on 2 test panels of Test Board No. 1, the maximum number recorded on any panel being 100.

e. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred occasionally on the panels of both test boards. A few specimens of Anomia (jingle-shells) were recorded on a single control panel and on 2 test panels of Test Board No. 1, the maximum diameter being 20 mm.

Five specimens of Musculus lateralis were recorded on single test panels of both test boards. A solitary specimen of the family Pterididae was recorded on a single control panel of Test Board No. 2.

f. Chordata (tunicates). Tunicates occurred quite abundantly on a number of the panels of both test boards, especially on those panels of Test Board No. 1. On this board, they occurred on 8 of the 43 control panels. On Test Board No. 2 they occurred on 4 control panels and on 6 test panels, the maximum number of colonies on any one of the latter panels being 20. Botryllus schlosseri occurred on the panels of both test boards; Ciona and Molgula were recorded only on the test panels of Test Board No. 1.

#### A18.05 Summary and Conclusions

1. Installation. Two test boards of the panel type installed June 7, 1944, at the U. S. Naval Submarine Base at Key West, Florida, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active each year at both locations, the breeding season apparently being limited to the months from March through December, or sometimes to the middle of January or February. Several of the test panels were riddled after 8 months' submergence, and the attack rated as very heavy in 1945 at both locations. Limnoria also were very active throughout the period covered by the tests, and the attack was very heavy, in fact unusually destructive, at both locations. No Pholadidae were recorded at either location.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to the fouling of the panels. The latter included hydroids and Metridium, encrusting and filamentous Bryozoa, marine worms, barnacles and amphipods, miscellaneous nonborring mollusks, and tunicates. Algae and hydroids occurred with the greatest frequency, and encrusting Bryozoa and marine worms occurred with less frequency, while the occurrence of the other organisms was merely sporadic or occasional.

3. Recent Addenda. The Teredinidae attack on Test Board No. 1 was moderate in 1948 and very heavy in 1949. In 1948, there was a slight attack by Limnoria on the panels of this board, while in 1949 the Limnoria attack rated as moderate. On Test Board No. 2 there was a moderate infestation of Teredinidae in 1948, and a medium heavy attack the following year. On this board Limnoria rated medium heavy in 1948 and heavy in 1949.

PENSACOLA, FLORIDA -- U. S. NAVAL AIR TRAINING COMMAND

A19.01 Location of the Test Station and Test Boards

Two test boards of the panel type were installed July 22, 1944, at different locations at the former U. S. Naval Air Station, now the Naval Air Training Command at Pensacola, Florida. The first of these boards, designated by the symbol USNPF-1, was installed at the Ferry Slip at the Naval Air Station. The second, designated by the symbol USNPF-2, was located at the Ferry Slip at the Palafox Street Pier in the city of Pensacola. Both of these test boards are in Pensacola Bay. It was later decided that a new test board designated by the symbol USNPF-3, located at the Navy Railroad Trestle over Bayou Grande north of the Naval Air Station, where this stream empties into Pensacola Bay, would serve the purposes of the marine borer research better, so far as this Station is concerned, than the test board located at Pensacola. The new board was installed on August 22, 1944. The operation of these test boards is being continued, and results of the tests have been summarized to the end of 1947.

A19.02 Hydrographic Data

1. USNPF-1 (Ferry Slip at Naval Air Station). The depth of water where this test board was installed was 20 ft; the tidal range was 1.4 ft; the velocity of the current was not determined. The temperature of the water at the time of installation was 80° F. The presence of coliform bacteria was demonstrated in Dominick-Lauter and lactose broth media almost every month from the start of the test to the end of 1947. Estimated counts, beginning with April 1945, showed the most probable number of bacteria of the coli-aerogenes group to range from 460 to 240,000 per 100 cc.

2. USNPF-2 (Ferry Slip at Pensacola). The data for this test board are the same as for the preceding one, except that the most probable number of bacteria of the coli-aerogenes group ranged from 600 to 700,000 per 100 cc.

3. USNPF-3 (Railroad Trestle at Naval Air Station). The depth of water where this test board was installed was 13 ft. The temperature of the water at the time of installation was 84° F. The other data for this test board are the same as for the first one, except that the most probable number of bacteria of the coli-aerogenes group ranged from 450 to 700,000 per 100 cc.

As the monthly temperature records given for the three locations are almost identical, only one representative set of figures is given. The following table records the temperature of the water in degrees F, based on readings taken at various times each month, showing the general range throughout the year.

Month	1944	1945	1946	1947
January		58	58.5	68
February		56	54	64
March		61	61	65
April		70	66	68
May		71	75	71
June		79	77	80
July		83	81	84
August	84	84	84	85
September	83	83	82	86
October	75	77	80	80
November	68	--	75	76
December	59	56	69	62

#### A19.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia gouldi, Teredo (Psiloteredo), and Teredo sp., were very active at all three locations throughout the period covered by the tests. In November 1944, because of the severity of the attack, it was requested that the panels on the test boards be removed and replaced by panels 2 inches thick. This was done, but it was soon found that increasing the thickness of the panels did not prolong their life, since the attack was just as severe proportionately in the 2-inch panels as it had been in the one-inch panels. In November 1945, it was requested that all panels on the test boards be removed and that a new series be installed and operated on a 4-month basis instead of being employed on the 8-month basis. The detailed figures on the occurrence of Teredinidae at each of these locations are summarized as follows:

a. USNPF-1 (Ferry Slip at Naval Air Station). Teredinidae occurred in 27 of the 32 control panels, ranging from minute pits or embryonic specimens to specimens up to 40 mm in length. The breeding season at this location generally extended from the middle of March to the middle of the following February, but it was continuous from

\* March 20, 1946 to February 25, 1948. The attack was especially heavy from April 19, 1946 to the end of 1947, during which time 5 of the panels were filled. In the test panels, Teredinidae occurred in 44 of the 47, attaining a maximum length of 150 mm on 2 panels, both of which had been submerged for 4 months. Twenty of these panels were filled or riddled, although most of them had been submerged for only 4 months. The panels sometimes became filled or riddled in as short a period as one or 2 months. The attack at this location rated very heavy each year, including 1944.

b. USNPF-2 (Ferry Slip at Pensacola). Teredinidae occurred in 24 of the 41 control panels, ranging from minute pits or embryonic specimens to specimens up to 65 mm in length. The breeding season at this location extended from the middle of March through December. Teredinidae occurred in 38 of the 47 test panels, attaining a maximum length of 200 mm in one panel submerged for 4 months. Twenty-five of these panels were filled or riddled, although most of the panels were submerged for only 4 months. They sometimes became filled or riddled in as short a period as 2 months. The attack at this location rated very heavy each year, including 1944.

c. USNPF-3 (Railroad Trestle at Naval Air Station). Teredinidae occurred in 19 of the 40 control panels, ranging from minute pits or embryonic specimens to specimens up to 25 mm in length. The breeding season at this location extended from the middle of March through December. Teredinidae occurred in 37 of the 47 test panels, attaining a maximum length of 220 mm in one panel submerged for 4 months. Twenty-one of these panels were filled or riddled, although most of the panels were submerged for only 4 months. They sometimes became well filled within 3 months. The attack at this location rated very heavy each year, including 1944.

2 Limnoria. Limnoria were more or less active at all three locations, the occurrence being summarized for each as follows:

a. USNPF-1 (Ferry Slip at Naval Air Station). Limnoria occurred on 31 of the 41 control panels, the maximum number on any one being 190 specimens. They occurred on 39 of the 47 test panels. The attacks attained peak ratings of moderate in 1945 and 1946 and of heavy in 1947

b. USNPF-2 (Ferry Slip at Pensacola). Limnoria occurred in 16 of the 41 control panels, although none appeared prior to March 22, 1945. The maximum number recorded in any of these panels was 250 forms. Limnoria occurred on 26 of the 41 test panels, although none occurred up to January 22, 1945. The attacks attained a peak rating of medium heavy in 1945, a trace in 1946, and low in the slight rating in 1947.

c. USNPF-3 (Railroad Trestle at Naval Air Station). No Limmoria occurred on any of the control panels, and only 2 of the 47 test panels were attacked. One of these panels contained only one tunnel and the other showed 5 tunnels. The first occurred in 1945 and the second in 1946. Thus the attack at this location rated only a bare trace these years, with no trace in 1947.

3. Pholadidae. Pholadidae (Martesia and Hiata) did not occur on any of the control panels at any of the locations, but occurred sporadically on the test panels at all three locations. At the Ferry Slip at the Naval Air Station, they appeared in 7 of the 47 test panels. The attacks rated a trace in 1944, moderate in 1945, zero in 1946, and medium heavy in 1947. At the Ferry Slip at Pensacola, they occurred in 4 of the 47 test panels, the attacks rating slight in 1945 and only a trace in 1947, with no traces the other years. At the Railroad Trestle at the Naval Air Station, they occurred in only 2 of the 47 test panels in 1945, the attack rating but slight.

#### A19.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series at all locations except on 3 panels at the Ferry Slip at the Naval Air Station. Only fragments of one of these panels were left, and the outer surfaces of the other 2 were destroyed. At the last-named location the deposits ranged from traces to light on the test series. At the other two locations, they ranged generally from traces to moderate on the panels of the control series, and from light to moderate on those of the test series.

2. Algae. Green algae occurred as traces or light growths on 2 control panels and on a single test panel at the Ferry Slip at Pensacola, also on 2 each of the control and test panels at the Railroad Trestle at the Naval Air Station.

#### 3. Invertebrate animal phyla.

a. Porifera (sponges). Sponges occurred on a single test panel at the Ferry Slip at Pensacola and on 3 of the test panels at the Railroad Trestle at the Naval Air Station. On the panel at the first location, 60% of the surface was covered.

b. Coelenterata (hydroids and Metridium). Hydroids occurred with great frequency on the panels at all three locations. They occurred on 20 of the 41 control panels and 30 of the 47 test panels at the Ferry Slip at the Naval Air Station, on 31 of the 41 control panels and 38 of the 47 test panels at the Ferry Slip at Pensacola, and on 28 of the 40 control panels and 41 of the 47 test panels at the Railroad Trestle at the Naval Air Station. The growths

ranged generally from traces to light (rarely) on the control panels, and from traces to light, or moderate, (rarely) on the test panels, particularly at the last location. Tubularia was the only specimen identified. Metridium, a member of another group of Coelenterata, occurred on 2 of the test panels at the Ferry Slip at the Naval Air Station.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on the panels at all three locations. They were found on 10 of the 41 control panels and 15 of the 47 test panels at the Ferry Slip at the Naval Air Station, on 11 of the 41 control panels and 23 of the 47 test panels at the Ferry Slip at Pensacola, and on 8 of the 40 control panels and 17 of the 47 test panels at the Railroad Trestle at the Naval Air Station. At the first-named location, 7 of the test panels were from 25% to 80% covered, and at the second location, 9 of the test panels were from 10% to 90% covered. Cryptosula pallasiana, Electra sp., Gemelliporida magniporosa, and Schizoporella unicornis were identified. Filamentous Bryozoa occurred on 5 of the 41 control panels and on 16 of the 47 test panels at the Ferry Slip at the Naval Air Station. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Annelida (annelid worms). Serpulid (Serpula) tubes occurred on 8 of the 41 control panels and 29 of the 47 test panels at the Ferry Slip at the Naval Air Station, on 7 of the 41 control panels and 14 of the 47 test panels at the Ferry Slip at Pensacola, and on 2 of the 40 control panels and 15 of the 47 test panels at the Railroad Trestle at the Naval Air Station.

e. Arthropoda (crustaceans). Barnacles occurred with great frequency on the panels at all three locations and in considerable abundance at the last two locations. At the Ferry Slip at the Naval Air Station, they were found on 25 of the 41 control panels and on 41 of the 47 test panels, on 33 of the 41 control panels and 46 test panels at the Ferry Slip at Pensacola, and on 31 of the 40 control panels and 45 of the 47 test panels at the Railroad Trestle at the Naval Air Station. On the control panels, maximum diameters of 9, 8, and 11 mm were recorded at the respective locations in the order in which they are listed. On the test panels maximum diameters of 15, 21, and 27 mm were attained in 4, 6, and 8 months, respectively. At the Ferry Slip at Pensacola, 14 of the control panels were from 10% to 100% covered, and 36 of the test panels were from 5% to 100% covered. At the Railroad Trestle at the Naval Air Station, 14 of the control panels were from 25% to 100% covered, and 24 of the test panels were from 5% to 100% covered.

f. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks were recorded occasionally on the panels as follows: Anomia (jingle-shells) occurred on 4 control panels and 9 test panels at the Ferry Slip at the Naval Air Station, on a single control panel and 4 test panels at the Ferry Slip at Pensacola, and on a single control panel and 2 test panels at the Railroad Trestle at the Naval Air Station. They ranged from a trace to 150 in number. Maximum diameters recorded were 6 mm on a control panel and 40 mm on a test panel after 4 months' submergence. Traces of Ostrea (oysters) occurred on 3 control panels and 11 test panels at the Ferry Slip at the Naval Air Station, on 9 test panels at the Ferry Slip at Pensacola, and on 13 test panels at the Railroad Trestle at the Naval Air Station. Maximum diameters recorded were 30 mm on a control panel and 45 mm on a test panel after 4 months' submergence. Musculus lateralis occurred on 3 test panels at the Ferry Slip at the Naval Air Station, the maximum number being 40 on any one panel. Mytilus (mussels) occurred on a single panel each of both the control and test series at the Ferry Slip at the Naval Air Station, on 6 test panels at the Ferry Slip at Pensacola, and on 3 test panels at the Railroad Trestle at the Naval Air Station. The maximum number was 65 on any one panel.

g. Chordata (tunicates). A few colonies of tunicates occurred on 2 test panels at the Ferry Slip at the Naval Air Station, on a single panel each of the control and test series at the Ferry Slip at Pensacola, and on a single control panel at the Railroad Trestle at the Naval Air Station. Botryllus schlosseri, Ciona, and Molgula were identified.

#### A19.05 Summary and Conclusions

1. Installation. Three test boards of the panel type, installed at different locations at the Naval Air Training Base at Pensacola, Florida, on July 22 and August 22, 1944, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active each year at each of these locations. The breeding season extended from the middle of March, but may be continuous some years at the Ferry Slip at the Naval Air Station. The attack rated very heavy each year, including 1944, at each location, panels becoming filled or riddled in as short a period as one to 3 months. There was some evidence of Limnoria activity at all three locations, but the severity of attack varied from year to year and at the different locations. At the Ferry Slip at the Naval Air Station, the attacks attained peak ratings of moderate in 1945 and 1946 and heavy in 1947. At the Ferry Slip



at Pensacola, they attained a peak rating of medium heavy in 1945, merely a trace in 1946, and low in the slight rating in 1947. At the Railroad Trestle at the Naval Air Station, the attack rated the barest trace in 1945 and 1946, with no forms showing in 1947. Pholadidae occurred sporadically at all three locations. At the Ferry Slip at the Naval Air Station the attack rated a trace in 1944, moderate in 1945, none in 1946, and medium heavy in 1947. At the Ferry Slip at Pensacola they rated slight in 1945 and only a trace in 1947, with no forms the other years. At the Railroad Trestle at the Naval Air Station there was only a slight attack in 1945 and no attacks the other years.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to the fouling of the panels. The latter comprised sponges, hydroids and Metridium, encrusting and filamentous Bryozoa, annelid worms, barnacles, miscellaneous nonboring mollusks, and tunicates. Of these organisms, barnacles occurred with the greatest frequency and in the greatest abundance; hydroids also occurred with great frequency. Encrusting Bryozoa and serpulid worms occurred with considerable frequency, and filamentous Bryozoa occurred with a fair degree of frequency at one locality. Oysters and jingle-shells occurred with still less frequency, while the occurrence of the other forms, as well as the algae, was merely sporadic or occasional.

Figures 3 and 4 are illustrations of test panels which had been submerged at Pensacola. The panel shown in figure 3 has been attacked severely by Teredo and moderately by Limnoria, while the damage done to the panel shown in figure 4 was the work of Teredo alone.

3. Recent Addenda. The attack by Teredinidae rated very heavy in both 1948 and 1949 at the Naval Air Station Ferry Slip. The Limnoria attack was moderate at this location in 1948 and medium heavy the following year. Pholads also were recorded as heavy at this place in 1948, but as only a trace in 1949.

At the Pensacola Ferry Slip there was a very heavy onslaught of Teredinidae in both 1948 and 1949. The Limnoria attack was slight at this point in 1948 and was only a trace the following year. There was a slight attack by Pholads in 1948, but none appeared in 1949. At the Railroad Trestle, the Teredinidae attack rated very heavy both years, but Limnoria appeared as a trace only in 1949. There was also a trace of Pholads in 1948.

## GALVESTON, TEXAS -- U. S. NAVAL FRONTIER BASE

A20.01 Location of the Test Station and Test Board

A test board of the panel type, designated by the symbol USNGT-1, was operated at the U. S. Naval Frontier Base at Galveston, Texas, from July 21, 1944 until July 15, 1946, when it was discontinued because of termination of military activity at this base. No details were given as to the exact location of the test board.

Unfortunately, the continuity of this test was interrupted by the loss of the test board on two occasions, first about November 1944, and again in August 1945, because of winds nearing hurricane force. It was requested in November of this year that a new set of panels be installed and operated on a 4-month basis, instead of the 8-month basis previously adhered to, because of the unusual severity of the attack by marine borers at this location. Accordingly, a new set of panels was put into operation on November 15.

A20.02 Hydrographic Data

The depth of water at the location where the test board was installed was 28 ft; the tidal range was approximately 16 in.; the velocity of the current was approximately  $1\frac{1}{2}$  knots. The temperature of the water at the time of installation was  $74^{\circ}$  F. The water was reported to be generally muddy and the degree of pollution extreme.

A20.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia gouldi, B. mexicana, Teredo (Lyrodus) sp., and Teredo sp., occurred in all the control panels submerged during the warmer months of the year, but no borers were recorded in January and February of 1945, nor during the period extending from November 15, 1945 to April 16, 1946. The specimens noted were mostly embryonic or small, although a maximum length of 60 mm was recorded in the panel submerged from May 21 to June 21, 1945. A total of 6,930 minute specimens was recorded in a control panel that happened to be left submerged for  $1\frac{1}{2}$  months at the end of 1944. The breeding season at this location extended from March through December.

Teredinidae occurred in all the test panels throughout the duration of the test, except in one panel submerged from November 15, 1945 to January 16, 1946. At the beginning of the test in

July 1944 there was a rapid increase in the number of Teredinidae, and the attack soon attained a peak rating which was maintained until the loss of the test board during a storm in August 1945. During this period, all the panels that were submerged for 5 or more months were more or less riddled, and the last one was one-third destroyed. The attack in panels that were submerged subsequently appeared less severe, although none of these panels were left submerged longer than 4 months. The next to the last panel of this series was well filled with specimens up to 95 mm in length after 4 months' submergence. It is apparent that the attack by Teredinidae rated very heavy.

2. Limnoria. Throughout the period of the test Limnoria were active, but only occurred in small numbers. In 15 of the 18 control panels, 70 Limnoria was the largest number found on any panel. Limnoria occurred in 14 of the 19 test panels, 200 forms being the largest number found in any of these panels. The attack was low in the slight rating in 1945 and only a trace in 1946.

3. Pholadidae. Only 2 Pholadidae were recorded on the test panels that was submerged for a single month, and the genus was not identified.

#### A20.04 Fouling Agents

1. Silt. Silt occurred on all the panels, both control and test, the deposits ranging from traces to light on the control, and from traces to light or occasionally moderate on the test panels.

2. Algae. Traces of green algae occurred only on the first 2 of the test panels and the accompanying controls.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces to occasionally light growths throughout the period covered by the test, on all the panels, both test and control, except for a single test panel. Tubularia was the only form identified.

b. Bryozoa (encrusting). Encrusting Bryozoa occurred on the first 3 and the last 3 control panels, and on 13 of the 19 test panels. They occurred regularly on the first 7 test panels submerged on July 21, 1944, and removed after from one to 7 months, respectively, but their subsequent occurrence was very sporadic. While, as a rule, only from 2 to 50 colonies occurred on a test panel, the first 3 panels in the test were covered, and the fourth was 60% covered. Cryptosula pallasiana, Cryptosula sp., and Gemelliporida magniporosa were identified.

c. Annelida (annelid worms). Serpulid (Serpula) worms were recorded on only one test panel which showed 15 to 20 specimens up to 10 mm long.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred with great regularity and often in considerable abundance. They were recorded on 16 of the 19 control panels, and on all the test panels, and developed throughout the year. In the control panels, the maximum diameter recorded was 7 mm, and panels exposed in February and March of 1944 were 100% covered. In the test panels, the maximum diameter recorded was 22 mm, this appearing on a panel removed January 30, 1945, after having been submerged for 5 months. The rate of growth and number present appeared to vary considerably in the same month during different years.

e. Mollusca (nonboring mollusks). A trace of Ostrea (oysters) occurred on one control panel and on 4 test panels, the greatest number recorded on any panel being 5. Anomia (jingle-shells) occurred on 4 control panels (second, third, and last two), where the maximum number on any one was 55, and on 3 test panels (third and last two), where 60 was the maximum number.

f. Chordata (tunicates). A few colonies of Botryllus schlosseri occurred on only the first of the test and control panels.

## A20.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Frontier Base at Galveston, Texas, from July 21, 1944, until its discontinuance on July 15, 1946, to determine the identity and prevalence of marine borers and fouling agents at this location.

### 2. Test Results.

a. Borers. Teredinidae were more or less active throughout practically the duration of the test, the severity of the attack rating very heavy, and panels frequently becoming riddled after 5 months' exposure. The attack at this location was so severe that the period of exposure of the test panels was reduced from 8 to 4 months. The breeding season extended from March through December. Limnoria were present in small numbers throughout the test, but they never exceeded a trace most of the time, though they did become low in the rating of slight in 1945. Only a trace of Pholads was recorded at this location.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to the fouling of the panels. The latter were comprised of hydroids, encrusting Bryozoa, annelid worms, barnacles, oysters and jingle-shells, and tunicates. Silt, hydroids, and barnacles occurred with great regularity, the latter being the most important organism causing fouling. The encrusting Bryozoa occurred less frequently, while the other forms occurred only occasionally.

## CORPUS CHRISTI, TEXAS -- U. S. NAVAL AIR STATION

A21.01 Location of the Test Station and Test Board

A test board of the panel type, designated by the symbol USNCC-1, was installed June 10, 1944, at the U. S. Naval Air Station at Corpus Christi, Texas. It was installed in the yardcraft small boat basin in Corpus Christi Bay, and is attached to the south-southeast (landward) side of a cluster of three creosoted wooden pile dolphins in the operating area. The board to which the test board is attached is 292 ft from a concrete bulkhead. The operation of this test board is being continued. The results have been summarized to the end of 1947.

Inquiries were made in regard to previous records of destruction by marine borers at this location. Mr. Ridenour, of the U. S. Engineers, stated that while there has been considerable destruction by marine borers attacking the boats and piles, no data have been gathered by them on this subject. Mr. Gordon Gunter, of the Department of Marine Biology of the University of Texas, and Dr. Joel W. Hedgpeth, Marine Biologist of the Texas Game, Fish, and Oyster Commission, both stated that to their knowledge no studies of marine borer activities have ever been made in this area.

A21.02 Hydrographic Data

The depth of water where the test board was installed was given as  $12\frac{1}{2}$  ft at the start of the test in June 1944 and as approximately 23 ft in March 1946. The tidal range was said to be negligible except when high winds occur. The tidal range from mean low water was given as 1.1 ft at mean high water and as 0.6 ft at mean sea level. The current velocity was not determined, but the location is somewhat well protected from rough wave action by a pier and breakwaters. The available data on temperature and salinity of the water are presented in the following tables. The area was reported to be subject to considerable pollution from oil, grease, and paint wastes from surface craft operating in the basin. From June 1944 to January 1948 the bacterial content, determined at monthly intervals, ranged from 10 to 350,000 per cc, and the coli-aerogenes group from 0 to 60 per cc, when no visual signs of pollution were evident.

The following record of the temperature of the water in degrees F, based on monthly readings, shows the annual range and the variation from year to year.

Month	1944	1945	1946	1947	1948
January		58	62	46	62
February		60	52	54	
March		68	62	50	
April		70	72	68	
May		76	76	76	
June	82	82	78	65	
July	82	82	84	87	
August	84	85	84	85	
September	80	86	84	81	
October	79	82	78	78	
November	73	70	63	72	
December	58	75	60	--	

The following salinity determinations of the water, based on monthly readings, show the general range.

Total chlorides--parts per million

Month	1944	1945	1946	1947	1948
January		16,510	18,200	10,700	18,700
February		17,482	16,500	14,500	
March		16,300	17,500	15,053	
April		16,600	17,500	15,000	
May		17,300	17,700	15,800	
June	16,000	18,000	12,500	16,500	
July	15,100	18,000	15,300	15,200	
August	17,400	20,000	17,200	17,500	
September	16,000	19,500	18,700	18,100	
October	16,400	18,500	13,900	18,800	
November	15,054	16,300	6,500	19,800	
December	15,540	17,700	10,200	----	

## A21.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia gouldi, Teredo navalis, T. (Lyrodus) sp., T. (Psiloteredo) sp., and T. sp., were very active throughout the period of the test. The borers were so destructive that it was requested on November 6, 1945, that the panels be removed and a new series installed in which the period of submergence was to be reduced to 4 months instead of the 8-month basis previously employed. This change was made on December 3.

Teredinids occurred in 32 of the 42 control panels, the maximum breeding season apparently covering the period from February 10 to January 10, although it was shorter in some years. In these panels, the specimens ranged from minute pits or embryonic specimens to forms up to 37 mm in length. They occurred in 51 of the 56 test panels, with panels becoming filled or riddled in as short periods as 3 and 4 months. A maximum length of 325 mm was recorded on 3 panels which had been submerged for 4 months. The attack rated heavy each year.

2. Limnoria. Limnoria showed more or less activity beginning with 1945, but no forms occurred in the control panels prior to April 10, and they occurred only in small numbers in these panels subsequently. Moreover, no forms occurred in the test panels prior to June 11. While it was impossible to make an accurate count of the number of tunnels late in 1945, because of the severe riddling or destruction of the panels by Teredinidae, it appears that the Limnoria attack never rated more than moderate that year, only low in the slight rating in 1946, and merely a trace in 1947.

3. Sphaeroma. A trace of Sphaeroma occurred on 3 test panels which were removed in 1945, after having been submerged for 8 months. One, 2, and 3 specimens, respectively, were recorded on these 3 panels.

4. Pholadidae. No Pholadidae were recorded.

## A21.04 Fouling Agents

1. Silt. Deposits of silt, ranging from traces to medium, occurred on all the panels of both the control and test series.

2. Algae. Algae, mostly green, occurred on 2 control panels and on 3 test panels. The growths ranged from traces to light.

### 3. Invertebrate animal phyla.

a. Porifera (sponges). A solitary sponge occurred on a single test panel.

b. Coelenterata (hydroids). Hydroids occurred as traces or rarely light growths on 26 of the 42 control panels and on 37 of the 49 test panels.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 18 of the 42 control panels and on 30 of the 49 test panels. Four control panels were from 50% to 100% covered, and 5 test panels were from 30% to 100% covered. Cryptosula pallasiana, Cryptosula sp., Electra crustulenta, Gemelliporidra magniporosa, Schizoporella unicornis, and Schizoporella sp. were identified. Filamentous Bryozoa occurred on 12 of the 42 control panels and on 16 of the 49 test panels. One panel in both the control and test series was 50% covered. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Annelida (annelid worms). Serpulid (Serpula) tubes occurred on 9 of the 42 control panels and on 24 of the 49 test panels. Maximum lengths of 15 mm were recorded on the control panels and of 45 mm on the test panels after 5 months' submergence.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred on 35 of the 42 control panels and on 47 of the 49 test panels. Nine of the panels of the control series were from 25% to 100% covered, and 25 of the test panels were from 20% to 90% covered. A maximum diameter of 15 mm was recorded on the control panels and of 29 mm on a test panel after 5 months' submergence.

f. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally as follows: Anomia (jingle-shells) occurred on 5 of the control panels and on 7 of the test panels; the maximum number recorded on any panel was 70. Maximum diameters of 13 mm on a control panel and of 40 mm on a test panel were recorded after 8 months' submergence. Mytilus (mussels) occurred on 3 control panels and on 21 test panels; the maximum number recorded on any one of the test panels was 100 mussels. Maximum lengths of 8 mm on a control panel and of 25 mm on a test panel were recorded after 5 months' submergence. Ostrea (oysters) occurred on 4 control panels and on 26 test panels. Two-thirds of the face of one test panel submerged for 2 months was encrusted. Maximum diameters of 32 mm on a control panel and of 78 mm on a test panel were recorded after 7 months' submergence.



## A21.05 Summary and Conclusions

1. Installation. A test board of the panel type installed June 10, 1944, at the U. S. Naval Air Station at Corpus Christi, Texas, to determine the identity and prevalence of marine borers and fouling organisms, is still being operated. The results of this test have been summarized to the end of 1947.

### 2. Test Results.

a. Borers. Teredinidae were very active at this location. The maximum breeding season apparently was limited to the period from February 10 to January 10, although it was shorter in some years. The attack rated very heavy each year; some panels became filled or riddled within 3 months and others in 4 months. Limnoria also showed more or less activity, but not until April 1945. The attack appears never to have rated more than low in the slight rating in any year. No trace of Sphaeroma occurred in 1945. No Pholadidae were recorded.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to the fouling of the panels. The latter included sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, and miscellaneous nonborer mollusks. Of these organisms, barnacles occurred with by far the greatest frequency as well as in unusual abundance. Hydroids, encrusting Bryozoa, serpulid worms, oysters, filamentous Bryozoa, and mussels, arranged in the order of decreasing frequency, also were important fouling organisms. The occurrence of the other forms as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. The attack by Teredinidae was very heavy in both 1948 and 1949, and the Limnoria attack was rated as slight in both these years.

## Section 22

## BERMUDA ISLANDS, BERMUDA -- U. S. NAVAL OPERATING BASE

A22.01 Location of the Test Station and Test Board

A test board of the panel type, designated by the symbol USNHH-1, was installed February 19, 1946, at the U. S. Naval Operating Base at the southwestern end of the Bermuda Islands. The operation of this test board is being continued. The results of the test have been summarized to the end of 1947.

A22.02 Hydrographic Data

The depth of water where the test board was installed was 10 ft; the tidal range was given as mean, 2.6 ft, and spring, 3.2 ft; the current velocity was zero. The temperature of the water at the time of installation was 62° F. Additional records of the temperature of the water at this location, recorded in degrees F at monthly intervals, are given below. No pollution was reported.

Month	1946	1947	1948
January		64	62
February		64	64
March	62	62	63
April		72	
May		--	
June		--	
July		77	
August		79	
September		80	
October		78	
November		72	
December		66	

1. Teredinidae. No evidence of Teredinidae was recorded in the panels of either the control or test series until late in 1947. The test panel removed November 13, 1947, after having been submerged for 4 months, showed 8 specimens of Teredo somersi up to 40 mm long. No borers were recorded in either of the next 2 months of the test, which covered up to January 10, 1948. On the basis of these data, the attack is rated as slight in 1947, and there was none at all in 1946. While Teredinidae occurred only in small numbers in a single test panel during the brief period covered by this test, records of the William F. Clapp Laboratories show that they are very destructive at other points in Bermuda.

2. Limnoria. Limnoria were very active throughout the period covered by the test and occurred in considerable numbers in all panels of both the control and test series. Of the 19 control panels, 9 showed a thousand or more tunnels, and one panel exposed from August 22 to September 22, 1946 showed 3,300 tunnels.

In November of 1946, because of the destructiveness of Limnoria at this location, it was requested that the panels on the test board be removed and a new series installed on a 4-month basis instead of on the 8-month basis previously followed. This change was made on December 13, 1946. After the fourth of this new series of panels was removed, the test was interrupted again, for some reason that is not clear, by starting another 4-panel series on July 10, 1947.

In the test panels, the Limnoria attack at the beginning of the test increased rapidly in severity with each month's submergence. In the first set of 8 panels submerged on February 19, 1946, where a panel was removed at the end of each month, the tunnels numbered 497, 2,300, 4,600, 4,000, 5,300, 7,800 and 13,200 respectively, the last panel, which had been submerged for 8 months, being entirely destroyed except for a piece approximately  $1\frac{1}{2}$  in. square around one of the bolt holes. The next 2 panels, which were submerged from March 22 to November 19 and from April 22 to November 19, respectively, also were almost completely destroyed. The 2 succeeding panels, which were submerged for only 7 and 6 months, respectively, also were attacked with extreme severity. With the reduction of the period of submergence to 4 months, however, the attack was less severe. The Limnoria attack at this location rated as extremely severe in both 1946 and 1947.

3. Sphaeroma. Two specimens of Sphaeroma were observed on a single test panel in 1946.

4. Pholadidae. No Pholadidae were recorded at this location.

#### A22.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series. The deposits, which were mostly clay, ranged from traces to moderate on the control panels and from traces to heavy on the test panels.

2. Algae. Algae occurred on a single control panel and on 9 of the 26 test panels, the growths ranging from traces to light, even to moderate in one case. Green algae occurred most frequently, but brown and red algae also were observed.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 4 of the 19 control panels and on 15 of the 26 test panels, the growths rating as traces on the control panels and from traces to moderate on the test panels. No hydroids were identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 4 of the 19 control panels and on 14 of the 26 test panels. Schizoporella unicornis was identified on a single test panel. Filamentous Bryozoa occurred on 4 of the 19 control panels and on 8 of the 26 test panels. No forms were identified.

c. Annelida (marine worms). Serpulid (Serpula) tubes occurred on 2 of the 19 control panels and on 16 of the 26 test panels. No lengths were recorded. Five of the test panels were from 25% to 50% covered.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on a single control panel and on 5 of the 26 test panels. The barnacles on the control panels were juvenile, and 7 mm was the maximum diameter recorded on the test panels after both 2 and 6 months' submergence, respectively. Two hundred and fifty amphipods were recorded on a single control panel, and the presence of Corophium was noted on a single test panel.

e. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally as follows: Four juvenile specimens of Anomia (jingle-shells) occurred on a single control panel; a trace of juvenile Avicula occurred on 2 of the test panels; and 3 specimens of Ostrea (oysters) up to 30 mm in diameter occurred on a single test panel.

1. Installation. A test board of the panel type installed at the U. S. Naval Operating Base at Bermuda on July 19, 1946, to determine the identity and prevalence of marine borers and fouling organisms, is still being operated. The results of this test have been summarized to the end of 1947.

2. Test Results.

a. Borers. Teredinidae occurred only in small numbers late in 1947, in a single test panel where the attack was slight. While there was little evidence of their activity at this location, records of the William F. Clapp Laboratories show they are very destructive at other points in Bermuda. Limnoria were very active throughout the period covered by the test, frequently occurring in destructive numbers. Panels left exposed for 8 months were almost completely destroyed. The attack rated as extremely severe in both 1946 and 1947. A trace of Sphaeroma was observed on a single test panel in 1946. No Pholadidae were recorded at this location.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter consisted of hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles and amphipods, and miscellaneous nonborring mollusks. Of these organisms, hydroids, encrusting Bryozoa, and serpulid tubes occurred with considerable frequency; filamentous Bryozoa occurred with less frequency, while the occurrence of the other forms, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. In both 1948 and 1949 the Teredinidae attack at this station registered as very heavy. There was a slight attack of Limnoria in both these years.

## Section 23

### GUANTANAMO BAY, CUBA -- U. S. NAVAL OPERATING BASE

#### A23.01 Location of the Test Station and Test Board

A test board of the panel type was installed June 20, 1944, at the U. S. Naval Operating Base, Guantanamo Bay, Cuba, but was soon lost. A duplicate test board, designated by the symbol USNGC-1, was installed on July 15, 1944, on Pier No. 1, and the test is considered to begin from this date.

In December 1944 the Naval Operating Base advised that they were unable to send the panels for that month because the test board had been taken away by a visiting ship. A new board was installed on December 22. The operation of this test board is being continued, and the results have been summarized to the end of 1947.

It was reported that creosoted pine piles last about 3 years at this location. It also was reported that, as far as can be ascertained, the most resistant native hardwoods for piles are those locally known as "jiqui" and "jucaro negro." Jiqui piles have been known to last over 20 years, but the tree is now almost extinct, at least as far as sizable timber is concerned. Jucaro negro hardwood, which can be procured in logs about 35 to 40 feet in length, remains serviceable here for about 7 years.

#### A23.02 Hydrographic Data

The depth of water where the test board was installed was 40 ft; the tidal range was 12 in. (mean difference); the current was not appreciable. The temperature of the water at the time of installation was 82° F. The test board was located in what may be considered open bay water, with the nearest sewer outlet 1,000 ft distant. It is suspended from the side of a pier which had been built about a year previous. This pier has creosoted piles with approximately one-inch penetration, but all of the bracing is constructed of untreated timber.

#### A23.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo (Teredothyra) dominicensis, T. (Lyrodus) sp., T. (Psiloteredo) sp., and T. sp., were very active and extremely abundant throughout the period covered by the test. In November of 1944, after the test panels had been submerged for only 4 months, the attack was so severe that it became evident that the panels would be completely destroyed before the date scheduled for their removal. It was therefore requested that all the panels be removed and replaced with panels 2 inches thick. However, increasing the thickness

of the panels did not solve the problem, as it was soon discovered that the more wood present the greater became the number of borers in the panels, so that the infestation was just as severe proportionately in the 2-inch panels as it had been in the 1-inch panels. As increasing the thickness of the panels did not prolong their life, it was decided to shorten the period of submergence and infestation to which the panels had been exposed. Consequently, all panels which were on the test board were removed on November 19, and a new set, operated on a 4-month basis instead of the prevailing 8-month basis, was installed.

Teredinidae occurred in unusual abundance in all the control panels, which is conclusive evidence that the breeding season at this location is continuous. In these panels, 13 of the 40 were from 50% to 100% filled, and specimens were recorded up to 30 mm in length. All the test panels showed Teredinidae; 35 of the 47 were filled or riddled, mostly after only 4 months' submergence, and in one case, after only 2 months' submergence. Specimens were recorded up to 190 mm in length after 5 months' submergence. The attack of Teredinidae was extremely severe each year.

2. Limnoria. Limnoria were active throughout the period covered by the test and occurred in every month of the year, but never in particularly destructive numbers. They occurred in 34 of the 40 control panels, 110 tunnels being the maximum number recorded in any panel. In the test panels, they occurred in 42 of the 47, the attack rating slight in 1945 and 1946, with a peak low in the moderate rating in 1947.

3. Pholadidae. Pholadidae (Hiata and Martesia) likewise were more or less active throughout much of the period covered by the test. In the control panels, they occurred in 12 of the 40, but were only embryonic or minute. However, 2 of these panels, which had been submerged in 1946 from July 19 to August 19 and from August 19 to September 18, respectively, were half filled. They occurred in 34 of the 47 test panels, and specimens were recorded up to 17 mm in length. Three of these panels removed at monthly intervals from August 19 to October 18 in 1946, after having been submerged for 4 months, were 75%, 67% and 35% filled, respectively. The attack by Pholadidae rated heavy in 1944 and 1946 and medium heavy in 1945 and 1947.

#### A23.04 Fouling Agents

1. Silt. Silt occurred as traces to light or occasionally heavy deposits on all the panels of both the control and test series.

2. Algae. A trace of a green alga occurred on one panel each of the control and test series.

### 3. Invertebrate animal phyla.

a. Porifera (sponges). Three colonies of a sponge occurred on a single test panel.

b. Coelenterata (hydroids). Hydroids occurred as traces or (rarely) light growths on 19 of the 40 control panels and on 26 of the 47 test panels. Tubularia was the only form identified.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 4 of the 40 control panels and on 13 of the 47 test panels. Schizoporella unicornis, Schizoporella sp., and Watersipora cucullata were identified. Filamentous Bryozoa occurred on 5 of the 40 control panels and on 4 of the 47 test panels, one of the former being one-third covered. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Annelida (marine worms). Serpulid (Serpula) tubes occurred more or less abundantly on 24 of the 40 control panels and on 43 of the 47 test panels. The maximum length recorded on the test panels was 45 mm after 4 months' submergence. One of the control panels was 50% covered.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred on 29 of the 40 control panels and on 46 of the 47 test panels. The maximum diameters recorded were 8 mm on the control panels and 15 mm on the test panels after 4 months' submergence. Two of the control panels and 4 of the test panels were from 50% to 100% covered.

f. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally as follows: Anomia (jingle-shells) occurred on 22 of the 40 control panels and on 23 of the 47 test panels. They were generally few in number, the most recorded on a single test panel being 20 forms. The maximum diameter recorded was 10 mm on a control panel and 21 mm on a test panel after 4 months' submergence. Mytilus (mussels) occurred on a single control panel and on 2 of the test panels, a maximum number of 35 being on any panel of either series. Ostrea (oysters), ranging from a few to 14 specimens, occurred on six of the test panels. Two specimens of Pecten (scallops) occurred on a single control panel. A solitary specimen of Pinctada (pearl oyster) occurred on a test panel.

g. Chordata (tunicates). Tunicates occurred more or less abundantly on 3 control panels and on 5 test panels. Botryllus schlosseri occurred most frequently, and ascidians also were noted.

#### A23.05 Summary and Conclusions

1. Installation. A test board of the panel type installed July 15, 1944, at the U. S. Naval Operating Base at Guantanamo, Cuba, to determine the identity and prevalence of marine borers and fouling organisms, is still being operated. The results of this test have been summarized to the end of 1947.



## 2. Test Results.

a. Borers. Teredinidae were very active and extremely abundant throughout the period covered by the test, the breeding season being continuous. The attack was extremely severe each year. Limnoria also were active throughout the period covered by the test and occurred in every calendar month of the year, but never in particularly destructive numbers. The attack rated slight in 1945 and 1946, with a peak low in the moderate rating in 1947. Pholadidae likewise were more or less active throughout much of the period covered by the test, the attack rating heavy in 1944 and 1946 and medium heavy in 1945 and 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The latter included sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, miscellaneous nonboring mollusks, and tunicates. Of these organisms, hydroids, marine worms, barnacles, and jingle-shells occurred with great frequency, while the occurrence of the other forms, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. The attack by Teredinidae was very heavy at this station in both 1948 and 1949, while the Limnoria attack was rated as slight in both these years.

## SAN JUAN, PUERTO RICO -- U. S. NAVAL AIR STATION

A24.01 Location of the Test Station and Test Board

A test board of the panel type was installed September 21, 1944, at the U. S. Naval Air Station at San Juan, Puerto Rico. This board was located between the center supporting piles of a temporary wharf at the San Antonio Tank Farm, located on the south side of the San Antonio Channel in San Juan Harbor, which is on the northern coast of the Island. The wharf was a small structure built of untreated piles, which on August 23, 1945, was said to be 4 or 5 years old and in ruins.

On March 26, 1947, the Naval Air Station advised that the small wharf at the gasoline tank farm, under which the test board had been suspended, had ceased to be serviceable and had been removed about January 21, 1947, when the test board was relocated under the Tender Pier, on San Juan Bay proper, about 12 ft from the nearest wood pile. Sewage, water salinity, and temperature conditions at both locations are considered to be about the same.

The test board was designated by the symbol USNSJ-1. Its operation is being continued, and the results have been summarized to the end of 1947.

A24.02 Hydrographic Data

The depth of water where the test board was installed was 16 ft at low tide; the tidal range was given as 1.2 ft; there was no appreciable current. The temperature of the water at the time of installation was 80° F. The temperature of the sea water in Puerto Rico is two to three degrees lower than the temperature of the air, which is roughly between 75° F and 90° F. The temperature of the water is around 80° F most of the time. The salinity of the water at the point where the board is located is said to be the same as that of normal sea water, and there is no reason to believe that it will vary at this location more than in the open ocean; the specific gravity was 1.024 on March 25, 1946. The degree of pollution (sewage and oil) was reported to be moderate. However, there is a constant flow of fresh sea water through the east end of the channel, caused by the waves of the Atlantic Ocean pounding over a reef at the Atlantic entrance to it.

A24.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia sp., Teredo navalis, T. parksi, T. (Lyrodus) sp., and T. sp. were very active through the period of the test. The attack was so destructive that in November of 1945 it was requested that the panels be removed and a new series installed which

would be submerged for only 4 months instead of the 8 months previously employed. This change was made on November 23.

In the control panels, Teredinidae occurred on all 38, except one panel submerged from July 22 to August 25, 1947. These forms were mostly minute pits or embryonic or minute specimens, but some specimens up to 10 mm in length were recorded. Infestation occurred every month, so it is clearly evident that the breeding season at this location is continuous. One panel was filled with both Teredinidae and Pholadidae in one month, and another was filled by Teredinidae alone in about 1-1/3 months.

Teredinidae occurred in all except one of the 45 test panels. The maximum length recorded was 230 mm in one panel submerged for 4 months. Three of these panels submerged for only 4 months were riddled, with specimens having maximum lengths of 215, 200, and 150 mm, respectively, and one was well filled in a single month. The attack rated very heavy each year.

2. Limnoria. Limnoria showed some evidence of activity throughout the period of the test. They occurred in 18 of the 38 control panels, but no forms were recorded after January 28, 1947. A maximum of 200 was recorded in one of the panels submerged for about 1-1/5 months, although 43 was the most that occurred in the others. In the test panels, the attack never rated more than a trace to low in the slight rating except in the panel removed on November 23, 1945, after 8 months' submergence, where a peak rating of medium heavy was attained.

3. Pholadidae. Pholadidae (Hiata and Martesia) also were very active throughout the period of the test. They occurred in 27 of the 38 control panels, mostly ranging from pits to embryonic or minute, but up to 5 mm long in one panel. In the test panels, they occurred in 39 of the 45, attaining lengths up to 40 mm in 4 months. Some of these panels were almost completely filled in 4 months, often with Pholadidae in conjunction with Teredinidae. The attack rated very heavy in 1945 and 1946, but appeared less severe in 1947.

4. Sphaeroma. Sphaeroma also were present in 1944 and 1945, occurring on a single control panel and on 6 test panels. The number on any one panel was few, but from 45 to 50 forms were recorded on a test panel submerged for 9 months; while 75 forms were recorded on the control panel infested.

#### A24.04 Fouling Agents

1. Silt. Silt occurred as traces to moderate deposits on all the panels of both the control and test series.

2. Algae. Green algae occurred as a trace or light growth on a single panel of both the control and test series.

### 3. Invertebrate animal phyla.

a. Porifera (sponges). Four colonies of a sponge were recorded on a single test panel.

b. Côelenterata (hydroids). Hydroids occurred on 27 of the 38 control panels and on 39 of the 45 test panels. They ranged mostly from traces to occasionally light growths on the control panels, and from traces to light or occasionally moderate growths on the test panels. Tubularia occurred on several.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 7 of the 38 control panels and on 15 of the 45 test panels. Schizoporella unicornis, Schizoporella sp., and Watersipora cucullata were identified. Filamentous Bryozoa occurred on 23 of the 38 control panels and on 27 of the 45 test panels. Four of the control panels were from 25% to 50% covered, and 4 of the test panels were from 40% to 80% covered. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Annelida (annelid worms). Serpulid (Serpula) tubes occurred on 37 of the 38 control panels and on 42 of 45 test panels. On the control panels, 17 were from 25% to 100% covered; while on the test panels, 10 were from 20% to 90% covered. A maximum length of 40 mm was recorded on both control and test panels after they had been submerged for one month.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred in great abundance on 33 of the 38 control panels and on 44 of the 45 test panels. Twenty-six control panels and 36 test panels were from 25% to 100% covered. Maximum diameters of 14 mm were recorded on the control panels and of 25 mm on the test panels after 4 months' submergence.

f. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally on the panels as follows: A few specimens of Anomia (jingle-shells) occurred on 2 control panels and on 3 test panels. A trace of Mytilus (mussels) occurred on 2 test panels. A few specimens of Ostrea (oysters) occurred on 6 test panels. A solitary specimen of Musculus occurred on a single test panel.

g. Chordata (tunicates). Tunicates occurred on 5 of the 38 control panels and on 18 of the 45 test panels. One of the test panels was 75% and another 90% covered.

#### A24.05 Summary and Conclusions

1. Installation. A test board of the panel type installed September 21, 1944, at the U. S. Naval Air Station at San Juan, Puerto Rico, to determine the identity and prevalence of marine borers and fouling organisms, is still being operated. The results of this test have been summarized to the end of 1947.

## 2. Test Results.

a. Borers. Teredinidae were very active at this location, infesting panels in every month of the year, which shows that the breeding season is continuous. The attack rated very heavy each year, and the rapidity with which panels become filled or riddled indicates that Teredinidae are extremely destructive. Limnoria showed some evidence of activity throughout the period of the test, but the attack never rated more than a trace to light except in November 1945, when a peak rating of medium heavy was attained. Pholadidae also were very active throughout the period of the test. The attack rated very heavy in 1945 and 1946, but appeared less severe in 1947. The combined attacks of the Teredinidae and Pholadidae at this location are extremely destructive. Sphaeroma were present, mostly in small numbers, in 1944 and 1945.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The latter included sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, miscellaneous nonboring mollusks, and tunicates. Of these organisms, hydroids, serpulid worms, and barnacles occurred with outstanding frequency, the last two being exceptionally abundant. Filamentous Bryozoa occurred less frequently, encrusting Bryozoa and tunicates still less frequently, while the occurrence of the other forms, as well as of the algae, was merely sporadic or occasional.

3. Recent Addenda. The Teredinidae attack was very heavy at this station in 1948 but only moderate the following year. Limnoria were recorded as a trace in both 1948 and 1949.

## ST. THOMAS, VIRGIN ISLANDS -- U. S. NAVAL SUBMARINE BASE AT KRUM BAY

A25.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the U. S. Naval Submarine Base at Krum Bay on the southern side of St. Thomas, Virgin Islands, from July 1, 1944 until the end of April 1947, when it was discontinued because of the scheduled inactivation of this Base by June 30, 1947. This test board was suspended from a steel brace attached to a creosoted wood pile which was reported to be under attack by marine borers. The pile is located in a cove of Krum Bay, which is approximately 160 yds by 275 yds and is landlocked on three sides. The test board was designated by the symbol USNVI-1.

A25.02 Hydrographic Data

The depth of water where the test board was installed was 12 ft, average tidal range 0.7 ft, velocity of the current zero. The temperature of the water at the time of installation was 84° F. The salinity of the water was reported to be 34 parts per thousand. The water in the cove is subject to pollution from the effluent lines from three domestic sewage septic tanks, one on the east side and two on the west side, and from an outlet of a storm sewer on the eastern side. Further pollution of the water is caused during heavy rains when surface water runs into the bay.

A25.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo (Lyrodus) sp. and Teredo sp., were more or less active throughout much of the period of the test. In the control panels, they occurred in 14 of the 31 received (4 submerged during the latter part of 1946 were not received), but did not appear in a panel until after March 1, 1945. Teredinidae recorded were mostly minute pits or embryonic specimens up to 10 mm in length, and were observed in one panel submerged for a scant month, and up to 60 mm in a panel inadvertently left submerged for 3 months. Teredinidae occurred erratically in 24 of the 35 test panels, attaining a maximum length of 200 mm in a panel submerged for 8 months. The largest number in any one of these panels was 40 borers. The breeding season at this location appeared to be more or less continuous. The attack rated slight in 1945 and moderate in 1946 and 1947.

2. Limnoria. Limnoria were vastly more prevalent than the Teredinidae and occurred in every control and test panel received. The attack ratings in the control panels ranged up to slight. In the test panels, there was a rapid and progressive increase in the Limnoria population from the time the panels were submerged, until the attack rated

very heavy in those panels submerged for 7 and 8 months. With the exception of occasional panels in which the attack was lighter, their attack continued very heavy until the termination of the test. In several cases the panels were riddled and some were nearly destroyed. Chelura were numerous along with Limnoria in 1945 and 1946.

3. Pholadidae. No Pholadidae were recorded at this location.

#### A25.04 Fouling Agents

1. Silt. Deposits of silt, ranging from traces to light or sometimes moderate, occurred on all the panels, both control and test.

2. Algae. Traces to moderate growths of algae occurred on 5 of the 31 control panels and on 12 of the 35 test panels. The algae recorded were mostly green, sometimes red.

3. Invertebrate animal phyla.

a. Porifera (sponges). Traces of encrusting sponges occurred on a single control panel and on 5 of the 35 test panels.

b. Coelenterata (hydroids). Hydroids, ranging from traces to occasionally light growths, occurred on 25 of the 31 control panels and on 32 of the 35 test panels. Tubularia was the only form identified.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on 29 of the 31 control panels and on 28 of the 35 test panels. Cryptosula pallasiana, Cryptosula sp., Gemelliporidra aculeata, Schizoporella unicornis, Schizoporella sp., and Watersipora cucullata were identified. Filamentous Bryozoa occurred on 5 of the 31 control panels and on 2 of the 35 test panels. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Annelida (annelid worms). A few serpulid (Serpula) worms were found on 2 control panels.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred on 23 of the 31 control panels, ranging from a few to an abundance, and on 25 of the 35 test panels. On the test panels, they occurred regularly from the start of the test on July 1, 1944 until October 23, 1945, and also on the last 4 test panels, but only intermittently on those panels in between. On the control panels, the maximum diameter recorded was 12 mm on one panel submerged during December 1944. The first control panel submerged during July 1944 was the only one that was covered. On the test panels, the maximum diameter recorded was 23 mm on one panel submerged during July, August, September, and October in 1944. Only the first 3 test panels

which were submerged for one, 2, and 3 months, respectively, were covered. A few Corophium were recorded on the first test panels and the accompanying control panel.

f. Mollusca (nonboring mollusks). Ostrea (oysters) occurred on one control panel and on 12 test panels; the maximum number recorded on any panel was 25, and the maximum length recorded was 20 mm on a panel submerged for 5 months. Traces of Anomia (jingle-shells) occurred on 2 of the control panels and on one of the test panels. A trace of Pinctada radiata occurred on 2 test panels, and a single specimen of Musculus lateralis was recorded on another.

g. Chordata (tunicates). Tunicates occurred on 5 control panels and on 9 test panels. The first panel in both the control and test series was covered, but on the other panels the number of colonies ranged from one to 25 forms. Most of these tunicates were identified as Botryllus schlosseri.

## A25.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Submarine Base at Krum Bay, St. Thomas, Virgin Islands, from July 1, 1944 until its discontinuance at the end of April 1947, in order to determine the identity and prevalence of marine borers and fouling organisms at this location.

### 2. Test Results.

a. Borers. Teredinidae, while showing little activity during the last half of 1944, were active for periods of varying length and season throughout most of the period covered by the test. The breeding season at this location appears to be more or less continuous but is chiefly from March through October. No great numbers of these borers were recorded in any one panel, and the severity of the attack was rated as moderate. Limnoria occurred with great regularity throughout the test and were far more numerous and destructive than the Teredinidae. The attack soon rated very heavy in the test panels and continued to be severe until the termination of the test. Chelura were numerous, along with the Limnoria, in 1945 and 1946. No Pholadidae were recorded at this location.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The latter included encrusting sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles and Corophium, miscellaneous nonboring mollusks, and tunicates. Of the latter organisms, hydroids and encrusting Bryozoa occurred with great regularity, barnacles occurred with less regularity, while the occurrence of the others was merely sporadic or occasional.



## Section 26

## TRINIDAD, BRITISH WEST INDIES -- U. S. NAVAL OPERATING BASE

A26.01 Location of the Test Station and Test Board

A test board of the panel type was installed July 11, 1944, at the U. S. Naval Operating Base at Trinidad, British West Indies. Within a month this test board was destroyed inadvertently, and a new one was installed on August 16, 1944, so that the test starts from this later date. This test board, which was designated by the symbol USNT-1, was installed in the vicinity of untreated wood piling at Pier No. 1 (Fueling Pier).

On November 16, 1945, a new series of panels was installed on the test board, in which the period of submergence was reduced from 8 to 4 months on account of the destructiveness of the Teredinidae. In August 1947, the test board was again destroyed inadvertently but was soon replaced by another. The operation of this last test board is being continued, and the results have been summarized to the end of 1947.

A26.02 Hydrographic Data

The depth of water where the test board was installed was 28 ft, the tidal range 2.7 ft, the velocity of the current 0.15 knot. No disturbance of the test board was reported because of ships. In March 1946 the salinity of the water was determined to be 22,250 ppm, from samples taken at the test board in two separate laboratory tests. The pollution appears to have been limited to an oily film on the surface of the water, which persisted until the end of 1947. The following record of the temperature of the water in degrees F, based on readings made about the middle of each month or shortly thereafter, shows the general range at this location.

Month	1944	1945	1946	1947
January		86	85	87
February		77	85	80
March		80	85	88
April		80	80	86
May		87	80	83
June		86	80	87
July		88	82	82
August	86	88	85	--
September	--	88	85	82
October	--	88	85	--
November	86	85	82	84
December	86	85	87	--

## A26.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia katherinae, B. mexicana, B. zeteki, Teredo (Lyrodus) sp., T. affinis group, and T. massa group, were very active each year at this location. They occurred in 24 of the 37 control panels, ranging from minute pits to specimens up to 40 mm in length. Every control panel submerged from August 16, 1944 to August 16, 1945, contained Teredinidae, but they appeared only irregularly thereafter. These data show that the breeding season at this locality is more or less continuous. Teredinidae occurred in all except 3 of the 44 test panels, with most of the panels submerged for 8 months, and even one panel submerged for only 4 months being riddled. Specimens were recorded as attaining a maximum length of 210 mm in 2 months in the test panels. The attack rated as very heavy.

2. Limnoria. Limnoria also were active throughout the period covered by the test, occurring in 22 of the 37 control panels and in 37 of the 44 test panels. The attack in the latter, however, rated generally from a trace to slight, but attained a peak rating of moderate late in 1945.

3. Pholadidae. Pholadidae (Martesia and Hiata) occurred irregularly, appearing in only one control panel in 1947 and in all the test panels except one that were removed from November 16, 1944 to July 16, 1945, also in one panel in 1947. The only length recorded in the test panels was 16 mm. The Pholad attack rated slight in 1945.

## A26.04 Fouling Agents

1. Silt. Silt occurred on all the panels. The deposits on panels of both the control and test series ranged from traces to moderate.

2. Algae. A trace of red algae was recorded on a single test panel.

3. Invertebrate animal phyla.

a. Porifera (sponges). Sponges occurred sporadically on 8 of the 44 test panels. Most of these test panels had only a few colonies, but one panel was 80% covered.

b. Coelenterata (hydroids). Hydroids occurred on 32 of the 37 control panels and on all of the 44 test panels, the growths on the panels of both series mostly ranging from traces to light. Tubularia was the only form identified.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 9 of the 37 control panels and on 12 of the 44 test panels. Electra sp. occurred the most commonly, but Cryptosula pallasiana and Gemelliporida magniporosa also occurred. Filamentous Bryozoa occurred on

14 of the 37 control panels and on 22 of the 44 test panels. Bugula neritina occurred most frequently, but B. flabellata and B. sp. also were identified. One of the test panels was one-third covered.

d. Annelida (marine worms). Serpulid (Serpula) tubes occurred on 5 of the 37 control panels and on 22 of the 44 test panels, the maximum length recorded being 60 mm after 8 months' submergence. Mud worm tubes (Dasychone) occurred on 3 of the test panels, the maximum number recorded on any one being 60 tubes.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred on 25 of the 37 control panels and on 38 of the 44 test panels. They developed on the control panels every month of the year except December, but occurred most frequently from the middle of February to the middle of November. One panel was 75% covered. The maximum diameter recorded on the control panels was 12 mm, while that on the test panels was 22 mm after 4 months' submergence.

f. Mollusca (nonboring mollusks). Anomia (jingle-shells) occurred on 2 control panels and on 5 test panels; a maximum of 40 was recorded on any of the test panels. Maximum diameters recorded were 6 mm on a control panel and 15 mm on a test panel after 3 months' submergence. Ostrea (oysters) occurred on 3 of the 37 control panels and on 20 of the 44 test panels; a maximum of 60 was recorded on any of the test panels. Maximum diameters recorded were 14 mm on a control panel and 50 mm on a test panel after 8 months' submergence.

g. Chordata (tunicates). Tunicates occurred on 8 of the 44 test panels, one panel being 25% covered.

## A26.05 Summary and Conclusions

1. Installation. A test board of the panel type installed at the U. S. Naval Operating Base at Trinidad, British West Indies, on August 16, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

### 2. Test Results.

a. Borers. Teredinidae were very active each year at this location, and the breeding season appears to be more or less continuous. Most of the panels submerged for 8 months, and even a panel that was submerged for only 4 months, were riddled. The attack rated as very heavy. Limnoria also were active throughout the period covered by the test, but the attack rated generally from a trace to slight, although attaining a peak rating of moderate late in 1945. Pholadidae occurred irregularly, the attack rating slight in 1945.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The latter included sponges, hydroids, encrusting and filamentous Bryozoa, marine worms, barnacles, jingle-shells, oysters, and tunicates. Of these organisms, the hydroids and barnacles occurred with the greatest frequency, filamentous Bryozoa and serpulid worms occurred with less frequency, while the occurrence of the others was merely sporadic or occasional. Algae occurred on a single test panel.

3. Recent Addenda. The Teredinidae attack was very heavy at this station in 1948 and 1949, while that by Limnoria was rated as slight in 1948 and as moderate the following year.

## Section 27

### BAHIA, BRAZIL -- U. S. NAVAL AIR AND U. S. NAVAL OPERATING FACILITIES

#### A27.01 Location of the Test Stations and Test Boards

Test boards of the panel type were operated at the U. S. Naval Air Facility and at the U. S. Naval Operating Facility at Bahia, Brazil. The board operated at the first facility, designated by the symbol USNBB-1, was installed June 28, 1944. This board was lost overboard on December 2 after it had been in operation for only 4 months. A diver was sent down, but the board had broken loose from the anchor, and only the latter was recovered. A new board with panels 2 inches thick was installed on December 9.

The test board operated at the second facility, designated by the symbol USNBB-2, was installed June 25, 1944. The operation of this board also was interrupted, after it had progressed only 4 months, in order to change to panels 2 inches thick. The operation of both test boards was discontinued at the end of June 1945 because of the decommissioning of both these facilities. No details as to the exact location of either board were given, although the two facilities were said to be about 12 miles apart by water. It was also stated that the board at the second facility had been installed at the small boat pier there and that this location was in the harbor in the vicinity of untreated wood piling. As the development of marine borers and fouling organisms was essentially the same at both locations, a single report is presented to show the conditions which may be expected in this harbor.

#### A27.02 Hydrographic Data

1. USNBB-1 (U. S. Naval Air Facility). The depth of water where this test board was installed was 18 ft, the tidal range 9 ft, the current  $2\frac{1}{2}$  knots. The temperature of the water was 80° F in June 1944, when the test board was installed, and the same temperature in early December of the same year, when this board was lost and replaced by a new one. Pollution was negligible.

2. USNBB-2 (U. S. Naval Operating Facility). The depth of water where this test board was installed was 10 ft at low tide, the tidal range 8 ft; there was no appreciable current. The temperature of the water at the time of installation was 80° F. The pollution was of the usual harbor type.

#### A27.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia canalis, B. caribbea, B. katherinae, B. zeteki, B. sp., Teredo disconus, T. (Lyrodus) sp., T. (Psiloteredo) sp., and T. sp., were very active at both locations throughout the period covered by the tests. Because of the destructiveness of the

Teredinidae at both locations, it was requested in November 1944 that the panels on the test boards be removed and replaced with panels 2 inches thick. This change was made in December at the first location when the lost test board was replaced by a new one, and in November at the second location. However, this change failed to increase the length of life of the panels, as the attack proved to be proportionately as severe in the 2-inch panels as it had been in the 1-inch panels originally used. The detailed figures on the occurrence of Teredinidae at each location are summarized below.

a. USNBB-1 (U. S. Naval Air Facility). Teredinidae occurred in all of the 11 control panels, the number in the different panels ranging from 500 to 1,584, a maximum length of 52 mm being recorded. The breeding season at this location was continuous. Teredinidae also occurred in all of the 11 test panels, maximum lengths of 75, 190, 210, 230, and 345 mm being recorded in panels submerged for 1, 2, 3, 4, and 5 months, respectively. These panels were well filled in 2 months and riddled after being submerged for 3 or more months. The attack rated very heavy in both 1944 and 1945.

b. USNBB-2 (U. S. Naval Operating Facility). Teredinidae occurred in all of the 11 control panels, the number in different panels ranging from 55 to 660, a maximum length of 35 mm being recorded. The breeding season at this location was continuous. In the test panels, Teredinidae also occurred in all of the 11 panels, with a maximum length of 162 mm recorded after 4 months' submergence. These panels were riddled within 4 months. The attack rated very heavy in both 1944 and 1945, but did not appear to be as severe as at the other location.

2. Limnoria. Limnoria showed slight evidence of activity at both locations. At the Air Facility, they occurred on only the last control panel and in the last 3 test panels, the largest number on any panel being 33 forms. At the Operating Facility, Limnoria did not occur on any of the control panels, and occurred on only 3 test panels, where 440 tunnels were recorded on one panel in 1944, and 450 on one of the other 2 panels in 1945. Thus, the attack at the Air Facility rated none in 1944 and only a trace in 1945, while the attack at the Operating Facility rated slight in both years.

3. Pholadidae. Pholadidae (Hiata and Martesia) also were active at both locations. At the Air Facility, 3 specimens occurred in one of the control panels and in the last 6 of the 11 test panels, the largest number in any panel being 50. The attack was limited to 1945. At the Operating Facility, no Pholads occurred in the control panels, and they occurred in only 4 of the 11 test panels, the maximum number in any one being 25. Thus, the attack at the Air Facility rated zero in 1944 and moderate in 1945, while the attack at the Operating Facility rated slight both years.

## A27.04 Fouling Agents

1. Silt. Silt occurred as traces to mostly light deposits on all the control panels, and as traces to light or medium deposits on all the test panels at both locations.

2. Algae. Green algae, while absent at the Air Facility, occurred as traces to light growths on all the control and test panels except one of each series at the Operating Facility. A trace of red algae also was recorded on the last one of the test panels at the latter location.

### 3. Invertebrate animal phyla.

a. Porifera (sponges). From 2 to 4 colonies of an encrusting sponge occurred on 2 of the test panels at the Air Facility, but no sponges were recorded at the Operating Facility.

b. Coelenterata (hydroids). Hydroids occurred on all the panels, both control and test, at each location. The control panels mostly showed traces, while on the test panels the growths ranged from traces to light or moderate. Tubularia was the only form identified.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 7 of the 11 control panels and on 10 of the 11 test panels at the Air Facility. They also occurred on 7 of the 11 panels in both the control and test series at the Operating Facility, ranging from a few to numerous colonies at each location. Cryptosula pallasiana, Cryptosula sp., Electra crustulenta, Electra sp., Rhynchozoon phrynglossum, Savignyella lafonti, Schizoporella unicornis, Schizoporella sp., and Watersipora cucullata were identified. Filamentous Bryozoa occurred on 6 of the 11 control panels and on 8 test panels at the Air Facility. At the Operating Facility, they occurred on 3 of the 11 panels in both the control and test series, ranging from a mere trace to numerous colonies at each location. Bugula ditrupae, B. flabellata, B. neritina, and B. sp. were identified.

d. Annelida (annelid worms). A few serpulid (Serpula) tubes occurred on 2 of the 11 control panels and on 6 of the 11 test panels at the Air Facility. The maximum lengths recorded were 10 mm in the controls and 20 mm on one of the test panels submerged for 3 months. At the Operating Facility, a few serpulid tubes occurred on only one control panel and on 3 of the test panels, ranging up to 15 mm in length on the latter.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred on all the panels, both control and test, except on one of the controls at the Air Facility. Three control panels were from 10% to 30% covered, with a maximum diameter of 8 mm recorded. Six of the test panels submerged on December 9, 1944, and removed from 2 to 7 months later, respectively,

were 30% to 90% covered, and maximum diameters of 14 mm were recorded on panels submerged for 3, 4, and 5 months, respectively. At the Operating Facility, barnacles occurred sporadically on 5 of the 11 control panels and on 7 of the 11 test panels, but they were few in number. Maximum diameters of 9 mm were recorded on a control panel and 17 mm on a test panel, which had been removed after two months' submergence.

f. Mollusca (nonboring mollusks). Miscellaneous mollusks, which occurred occasionally (limited almost entirely to the Air Facility), were as follows: Anomia (jingle-shells) occurred on 4 each of the control and test panels at the Air Facility. Maximum diameters of 9 mm were recorded on a control panel and 20 mm on a test panel, after having been submerged for 4 months. Mytilus (mussels) occurred on a single control panel and on 5 test panels at the Air Facility. A trace of Ostrea (oysters) occurred on 3 test panels at the Air Facility. A trace of Pinctada radiata occurred on 2 test panels at each location. A solitary specimen of Pecten (scallops) occurred on a single test panel at the Air Facility.

g. Chordata (tunicates). Tunicates were recorded on the last 5 of the 11 test panels at the Air Facility. Only 3 to 20 colonies were recorded on any one panel. Botryllus schlosseri was identified on each panel, though other unidentified tunicates were present. At the Operating Facility, Botryllus schlosseri occurred on 3 of the control panels and on a single test panel, the number of colonies on any one panel ranging from 3 to 10.

## A27.05 Summary and Conclusions

1. Installation. Test boards of the panel type were operated from June 1944 to June 1945 at the U. S. Naval Air Facility and U. S. Naval Operating Facility located at Bahia, Brazil, about 12 miles apart by water, to determine the identity and prevalence of marine borers and fouling organisms at these locations.

### 2. Test Results.

a. Borers. Teredinidae were very active each year at both these locations, the breeding season being continuous. The attacks rated very heavy at both locations in 1944 and 1945, panels becoming filled or riddled within 2 months at the Air Facility and in 4 months at the Operating Facility. Increasing the thickness of the panels to 2 inches failed to prolong their life, the attack being just as severe proportionately in the thicker panels as it was in the thinner ones. Limnoria occurred to a slight extent at both locations, the attack rating zero in 1944 and only a trace in 1945 at the Air Facility, while at the Operating Facility it rated slight both years. Pholadidae also were active to some extent at both locations, the attack at the Air Facility rating zero in 1944 and moderate in 1945, while that at the Operating Facility rated slight both years.



b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The latter included encrusting sponges (absent at the Operating Facility), hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, miscellaneous nonboring mollusks, and tunicates. The hydroids at both locations and the barnacles and encrusting Bryozoa at the Air Facility occurred with the greatest frequency. The encrusting Bryozoa at the Operating Facility and the filamentous Bryozoa at the Air Facility occurred with less frequency. The occurrence of filamentous Bryozoa at the Operating Facility and of all the other organisms, as well as the algae, was merely sporadic or occasional.

## CASABLANCA, FRENCH MOROCCO -- U. S. NAVAL OPERATING BASE

A28.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the U. S. Naval Operating Base at Casablanca, French Morocco, from July 8, 1944 to June 1, 1945. This board was placed adjacent to the repair berth and against the edge of the stone dock at the most southeasterly end of the "Bassin Delande" in Casablanca Harbor. It was destroyed by accident, and another was installed adjacent to the tug berth at the Liberty Landing, approximately 600 ft northwest of the first one and almost in the center of the "Bassin Delande." This second test board also was destroyed, and a third board was installed March 1, 1945, at the location formerly occupied by the second. The test board at this location was designated by the symbol USNCB-1. The operation of this test board was discontinued after the removal of the panels on June 1, 1945, apparently as a result of decommissioning this Base.

A28.02 Hydrographic Data

The first test board, installed July 8, 1944, was placed in water 10 ft deep at mean low water where the tidal range was 8 ft and the current was negligible. The temperature of the water at the time of installation was 65° F. There was reported to be only slight pollution, but it was stated that oil slick may be present occasionally.

The second test board, installed November 22, 1944, was placed in water 11 ft deep at mean low water where the tidal range was 10 ft and the current was negligible. The temperature of the water at the time of installation was 60° F. Water pollution here also was slight and consisted chiefly of oil. The third test board was installed at this same location.

A28.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo (Lyrodus) sp. and Teredo sp., were active at this location throughout the period covered by the test and caused the greatest amount of damage to the panels. They occurred in all except one of the 8 control panels, but all were embryonic or minute specimens. A maximum of 175 was recorded in any of these panels. Breeding continued throughout the period of the test, namely from July to the end of May, and probably is continuous. Teredinidae occurred in all of the 8 test panels, ranging from embryonic or minute specimens to specimens up to 25 mm in length at the end of 3 months. As many as 660 specimens were recorded in each of the last 2 panels, which were submerged for 2 and 3 months, respectively. While these specimens did not attain any great length, because none of the test panels was submerged for more than

3 months at a time, their abundance and the favorable temperature of the water justify rating the attack as very heavy.

2. Limnoria. Limnoria occurred to a very slight extent during this brief test, which was not long enough to indicate the destructiveness of this particular marine borer. On the control panels, only 5 tunnels were recorded, and these were on the last panel. In the test panels, they occurred only on the first 2 and the last 2 of the 8 boards, the largest number on any panel being 15 to 20. The severity of attack thus rated a mere trace, but no panel was left submerged for longer than 3 months.

#### A28.04 Fouling Agents

1. Silt. Silt occurred, mostly as light deposits, on all the panels of both the control and test series.

2. Algae. Green algae occurred on 3 of the 8 panels in each series, the growths ranging from traces to light.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on all except one of the 8 panels in each series, rating as traces on the control panels and as traces or light on the test panels.

b. Bryozoa (filamentous). Filamentous Bryozoa occurred on 4 of the 8 control panels and on 3 of the same number of test panels, generally being fairly numerous.

c. Annelida (annelid worms). Serpulid (Serpula) tubes occurred abundantly on 4 of the 8 panels in each series, the first 2 of each being encrusted with them.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on 5 of the 8 panels in each series, ranging from a few to numerous. Maximum diameters of 6 mm were recorded on the control panels and of 13 mm on a test panel after having been submerged for 3 months.

e. Chordata (tunicates). Tunicates were numerous on a single test panel submerged for 3 months.

#### A28.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Operating Base at Casablanca, French Morocco, from July 8, 1944 until its discontinuance on June 1, 1945, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

## 2. Test Results.

a. Borers. Teredinidae were active at this location throughout the period covered by the test. The breeding season is probably continuous. While these borers did not attain any great length, because none of the test panels were submerged for more than 3 months, their abundance and the favorable temperature of the water justify rating the attack as very heavy. Limnoria occurred only as a mere trace, but would have been more abundant had the test run longer.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 5 phyla contributed to the fouling of the panels. The latter included hydroids, filamentous Bryozoa, serpulid worms, barnacles, and tunicates. Hydroids occurred with the greatest frequency; barnacles, serpulid worms, filamentous Bryozoa, and algae occurred with progressively less frequency.

The operation of the test board, which unfortunately was interrupted twice by accidental loss, was not continued long enough to provide conclusive information concerning the development and prevalence of marine borers and fouling organisms at this location, but it does show the general trend.

## BIZERTE, TUNISIA -- U. S. ADVANCED AMPHIBIOUS TRAINING BASE

A29.01 Location of the Test Station and Test Board

A test board of the panel type, designated by the symbol USNBT-1, was operated at the U. S. Advanced Amphibious Training Base at Bizerte, Tunisia, from June 19 to November 20, 1944. No information was given as to its exact location. This test board was washed away during a storm in December, and it was not found feasible to install a replacement, as this Base had been directed to be decommissioned soon afterward.

A29.02 Hydrographic Data

The depth of water where the test board was installed was 32 ft 9 in., the tidal range 12 in., the current approximately one knot. The temperature of the water was given as 73° F on July 21, 79° F on both August 21 and September 21, 69° F on October 21, and 54° F on November 23. The degree of pollution, as estimated by gas formation, was 15% each month from July to October, but in November there was no gas formation in a 48-hour culture.

A29.03 Marine Borers

1. Teredinidae. Teredinidae (Teredo sp. was the only identification) do not appear to have been very active at this location. In the control panels, 9 embryonic specimens were recorded in the first panel removed, 4 questionable pits in the second panel removed, and no specimens in the other 3 panels. In the test panels, Teredinidae were recorded to the extent of 2 specimens up to 65 mm long in the panel removed in October after 4 months' exposure, and 8 specimens up to 50 mm long in the panel removed in November after 5 months' exposure. On the basis of the brief test made, the attack could not be rated as being more than slight.

2. Limnoria. Limnoria were considerably more active and were responsible for the major part of the destruction of the panels. They were present on all control and test panels, and the infestation attained a peak in the last of the test panels removed in November, after 5 months' submergence, with from 20 to 30 tunnels per sq in. recorded in patches covering almost one-half of the panel (about 1,980). This attack is considered as rather low in the moderate rating. It is possible, however, that an even greater Limnoria attack might have been recorded had the test board been operated longer, as the population in the test panels more than doubled each month they were submerged, after the first month.

A29.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and

test series, the deposits mostly rating light on the panels of the control series and moderate on the panels of the test series.

## 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on all the panels of both the control and test series, the growths rating as traces on the controls and light on all panels of the test series after the first month.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa were found on the first one of the control panels and on all except the last one of the test panels. They rated from a few to numerous colonies on the panels on which they occurred. In all cases, they were identified as Cryptosula pallasiana. Filamentous Bryozoa occurred on 2 of the 5 control panels and on all 5 test panels, ranging from a few to numerous. Bugula flabellata and B. neritina were identified.

c. Annelida (annelid worms). Serpulid (Serpula) tubes were numerous on each of the first 4 control panels and on 4 of the 5 test panels.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on the first 3 of the 5 control panels and on all 5 test panels. One of the control panels and all of the test panels were covered except the last one, which was 90% covered. Maximum diameters of 10 mm were recorded on the control panels and 15 mm on 2 of the test panels after they had been submerged for 4 and 5 months, respectively.

e. Chordata (tunicates). Tunicates occurred on a single control panel and on 2 of the 5 test panels. Only a few colonies were recorded on 2 of these panels, but from 60 to 70 specimens were recorded on the last of the test panels removed in November, after 5 months' submergence.

## A29:05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Advanced Amphibious Training Base at Bizerte, Tunisia, from June 19, 1944 until its discontinuance after November 20, 1944, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

### 2. Test Results.

a. Borers. Teredinidae occurred irregularly and caused only a slight attack on the panels. Limmoria were active throughout the period covered by the tests, and the population was increasing rapidly when the test was discontinued. The severity of the attack was considered as low in the moderate rating, but undoubtedly would have been higher had the test been continued longer.

b. Fouling Organisms. Silt and invertebrate animals belonging to 5 phyla contributed to the fouling of the panels. The latter included hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, and tunicates. Of these organisms, hydroids occurred with the greatest frequency; encrusting and filamentous Bryozoa, serpulid worms, and barnacles occurred with somewhat less frequency; the occurrence of the tunicates was sporadic.

The operation of the test board was not continued long enough to provide conclusive information as to the development and prevalence of marine borers and fouling organisms at this location, but it does show the general trend.

## PALERMO, SICILY, ITALY -- U. S. NAVAL OPERATING BASE

A30.01 Location of the Test Station and Test Board

A test board of the panel type was installed August 21, 1944, and operated until September 24, 1945, at the U. S. Naval Operating Base at Palermo, Sicily, Italy. No information was given as to the location of this test board other than that it was in a basin at a shipyard operated in Palermo Harbor. It was designated by the symbol USNSI-1. The operation of this test board was discontinued because of the curtailment of military activity at this Base.

A30.02 Hydrographic Data

The depth of water at the location where the test board was installed was  $15\frac{1}{2}$  ft; the tidal range was  $8\text{-}\frac{3}{4}$  in.; as the board was in a basin, the current was zero. The temperature of the water at the time of installation was  $79^{\circ}$  F. A pollution test showed positive presumptive, coliaerogenes isolated.

A30.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo (Psiloteredo) sp. and T. (Lyrodus) sp., were active throughout the period covered by the test. They occurred in all except one of the 13 control panels, being mostly embryonic but ranging up to 8 mm in length in the panel submerged from June 25 to July 24, 1945. The number of specimens recorded in any one of the control panels varied from a few to approximately 400. The breeding season at this location extended from the middle of January to the middle of December. Teredinidae occurred in all the test panels. Six of the panels submerged on August 21 and one submerged on September 21 in 1944 became riddled after having been submerged from 3 to 8 months, and one submerged for 8 months was one-third destroyed. The rate of growth is indicated by the fact that, while the Teredinidae were embryonic in the test panel removed at the end of one month, they attained lengths up to 5 mm in the one removed at the end of 2 months, up to 88 mm in the one removed at the end of 3 months, up to 90 mm in the one removed at the end of 4 months, and up to 100 mm in the last one removed at the end of 8 months. The attack rated very heavy in both 1944 and 1945.

2. Limnoria. Limnoria were very active throughout the period covered by the test. This crustacean borer occurred on all except one of the control panels, the maximum number recorded on any panel being from 100 to 110. They occurred on all the test panels, where, with one exception, there was a steady increase in numbers from 15 in the first panel submerged for one month to from 80 to 100 per sq in. (10,500-13,200), including the associated Chelura, in the next to the last panel submerged for 8 months. The last panel was riddled. The attack thus rated very heavy in 1945.



3. Chelura. Chelura was not observed in the test panels until July 1945, when from 80 to 90 Limnoria and Chelura tunnels per sq in. were recorded on all surfaces. It continued to be abundant until the termination of the test.

#### A30.04 Fouling Agents

1. Silt. Silt occurred on all the control and test panels except those panels removed on August 22, 1945. The deposits rated mostly as traces on the control panels and light on the test panels.

2. Algae. Algae occurred as traces on 3 of the 13 control panels and as traces to light growths on 7 of the same number of test panels. Both red and green algae were present, but their occurrence was irregular.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 9 of the 13 control panels and on 11 of the same number of test panels, the growths rating as traces in all the panels infested.

b. Bryozoa (encrusting). Two colonies of an encrusting Bryozoa were recorded on one of the test panels.

c. Annelida (annelid worms). Serpulid (Serpula) tubes occurred more or less abundantly on 8 of the 13 control panels. No worms developed on any of the panels submerged between January 17 and June 25, 1945. The maximum length recorded on the control panels was 12 mm. However, Serpula developed from a few to abundant on all test panels, attaining lengths from 10 mm to 80 mm.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred only on the last 4 of the 13 control panels submerged for periods of a month each from May 22 to August 22, 1945. The maximum diameters recorded on any of these panels was 12 mm, and the number on any panel did not exceed 25. They occurred only in small numbers on 4 of the 13 test panels, where a maximum diameter of 8 mm was attained on one panel submerged for 8 months. Their occurrence appears to have been merely sporadic.

#### A30.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Operating Base at Palermo, Sicily, Italy, from August 21, 1944 until its discontinuance on September 24, 1945, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

## 2. Test Results.

a. Borers. Teredinidae were active throughout the period covered by the test, the breeding season at this location extending from the middle of January to the middle of December. The attack rated very destructive in both 1944 and 1945, with panels becoming riddled within 3 months. Limnoria also were very active throughout the period covered by the test, the attack rating very heavy in 1945; the last panel received was riddled. Chelura was not observed in the test panels until July 1945. After this date, it occurred abundantly along with Limnoria and continued to be abundant until the termination of the test.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 4 phyla contributed to fouling of the panels. The latter included hydroids, encrusting Bryozoa, serpulid worms, and barnacles. Of these organisms, hydroids and serpulid worms occurred with great frequency, while the occurrence of the others was merely sporadic.

## Section 31

### ADAK, ALASKA -- U. S. NAVAL OPERATING BASE

#### A31.01 Location of the Test Station and Test Board

A test board of the panel type, designated USNAA-1, was installed July 15, 1944, at the U. S. Naval Operating Base at Adak, Alaska. No other details of the location of this test board are available, except that it was suspended from the center of Pier No. 9, located in Sweeper Cove in Kuluk Bay on the northeastern side of the Island.

The test board was lost in November 1944 and a new one was installed on January 11, 1945. After the panels for September 1947 were removed and sent to the Laboratory, the test board was lost again, and a new one was installed on December 15, 1947, at the outboard end of Dock No. 9. The operation of this test board is being continued. The test results have been summarized to the end of 1947.

#### A31.02 Hydrographic Data

The depth of water where this test board was installed was 40 ft; the tidal range was 4 ft; the current was negligible. The average temperature of the water was given as 2° C (36° F). The salinity of the water was not determined. Very little pollution by oil and sewage was observed.

Where the new test board was installed on December 15, 1947, the depth of water was given as 70 ft at mean low water. No pollution was observed.

#### A31.03 Marine Borers

1. Teredinidae. Teredinidae occurred to a very limited extent at this location in 1946 and 1947, and no borers were recorded on either the control or test panels in 1944 or 1945. On the control panels, only 10 minute pits were recorded in the panel submerged from March 15 to April 15, 1946, and a questionable pit was recorded in the panel submerged from May 16 to June 14, 1947. In the test panels, Teredinidae were recorded in only 6 of the 37, and were limited almost entirely to 1946, occurring in only one panel in 1947. These borers ranged from minute pits to specimens up to 80 mm in length in one panel removed on April 15, 1946, after 7 months' submergence. In those panels where well-developed specimens occurred, the maximum number recorded was 19. The breeding season at this location appears to extend from March 15 to July 15. Bankia setacea was the only species identified. The attack rated slight in 1946 and only a trace in 1947.

2. Limnoria. Limnoria were more or less active in 1946 and 1947, but no specimens occurred in 1944 or 1945 except for 3 tunnels recorded on a single control panel in 1945. They occurred in only 12 of the 33

control panels, and only in those panels submerged from the middle of December to the middle of June. In the test panels, they occurred in 19 of the 37 but mostly in very small numbers. The attack rated only a trace most of the time but attained peak ratings of slight in 1946 and 1947.

#### A31.04 Fouling Agents

1. Silt. Silt occurred on all except 4 of the 37 control panels and on all except 2 of the 37 test panels. The deposits ranged from traces to light on the control panels, and from traces to light, or rarely moderate, on the test panels.

2. Algae. Traces of algae occurred on only 2 of the test panels.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 9 control panels and on 23 test panels. None was identified.

b. Annelida (marine worms). Serpulid (Serpula) tubes occurred on only one test panel.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred on 7 of the 37 test panels. Maximum diameters recorded were 8 mm on the control panels and 19 mm on the test panels after a submergence of 7 months. One of the control panels was 10% covered, and 14 of the test panels were from 50% to 85% covered.

#### A31.05 Summary and Conclusions

1. Installation. A test board of the panel type installed July 15, 1944, at the U. S. Naval Operating Base at Adak, Alaska, to determine the identity and prevalence of marine borers and fouling organisms at this location, is still being operated. The results of this test have been summarized to the end of 1947.

2. Test Results.

a. Borers. Teredinidae occurred to a very limited extent at this location in 1946 and 1947; no specimens were recorded in 1944 or 1945. The attack rated only slight on 1946 and only a trace in 1947. The breeding season at this location appears to extend from the middle of March through September. Limnoria also showed more or less activity in 1946 and 1947, but no activity in 1944 or 1945 except for 3 tunnels recorded on a single control panel in 1945. The attack rated only a trace most of the time but attained a peak rating of slight in 1946 and 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals contributed to fouling of the panels. The latter comprised hydroids, marine worms, and barnacles. Of these organisms, hydroids and barnacles occurred with great frequency, while the serpulid tubes, as well as the algae, occurred on only one or 2 panels. These findings were unusual, in that no Bryozoa, tunicates, or nonboring mollusks were recorded.

3. Recent Addenda. There were no Teredinidae recorded at this station in 1948 or 1949. Limnoria rated in the low slight category both years.

## DUTCH HARBOR, ALASKA -- U. S. NAVAL OPERATING BASE

A32.01 Location of Test Station and Test Board

A test board of the panel type, designated by the symbol USNDH-1, was operated at the U. S. Naval Operating Base at Dutch Harbor in a bay on the north side of Unalaska Island, Alaska, from July 1, 1944 to August 1, 1947, after which no further panels were received. It was later learned that this Base was decommissioned on November 1, 1947, and that no qualified personnel were available at Dutch Harbor to continue the operation of this test board after that date. No information was given as to the exact location of this test board.

A32.02 Hydrographic Data

The depth of water where the test board was installed was 25 ft, the tidal range 3.6 ft, the current zero. The temperature of the water at the time of installation was 46° F. The pollution was negligible.

A32.03 Marine Borers

1. Teredinidae. Teredinidae occurred to a very limited extent at this location in 1945 and 1946, and none was recorded in either the control or test panels in 1944 or 1947. In the control panels, only 5 embryonic and 8 juvenile specimens were recorded on 2 panels submerged from March 1 to May 1, 1946. In the test panels, Teredinidae occurred in 11 of the 37, but they occurred only during the months from March through July in 1945 and 1946, which indicates the breeding season at this location. The maximum length attained was 34 mm on a panel submerged for 8 months, starting on July 1, 1945. The largest number of specimens recorded on any one panel was 20 borers. Bankia setacea was the only form identified. The attack rated slight in 1945 and 1946 and none in 1947.

2. Limnoria. Limnoria showed slight evidence of activity throughout the test, first appearing in the panel removed on December 1, 1944, after a submergence of 5 months. In the control panels, only 2 tunnels were recorded in one panel submerged during March 1947. In the test panels, Limnoria occurred on 24 of the 37 but were absent on the first 4 panels. The maximum number on any of these panels was 35, so that the attack rated only a mere trace each year.

A32.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series, except the first panel of each. The deposits on the panels of

the control series ranged from traces to occasionally light, while those on the test series were mostly light or rarely moderate.

2. Algae. Algae occurred on 4 of the 37 control panels and on 20 of the same number of test panels. The growths rated as traces on the panels of the control series, and from traces to light, or rarely moderate, on the panels of the test series. Most of these forms were green algae, but a brown alga was noted on one test panel.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 12 control panels and on 34 test panels. They rated as traces on the panels of the control series, and from traces to light, or rarely moderate growths, on those panels of the test series.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 7 of the 37 control panels. Electra sp. was identified on one panel. A single colony of a filamentous Bryozoa occurred on one of the test panels.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred on 8 of the 37 control panels and on 35 of the same number of test panels. The maximum diameter recorded was 6 mm on the control panels and 19 mm on a test panel submerged for 8 months. Three of the control panels were from 25% to 70% covered, and 25 of the test panels were from 25% to 100% covered.

d. Mollusca (nonboring mollusks). Two specimens of Mytilus (mussels), 8 mm in length, were recorded on a single test panel.

A32.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Operating Base at Dutch Harbor, Alaska, from July 1, 1944 to August 1, 1947, after which no further panels were received. This base was decommissioned on November 1, 1947.

2. Test Results.

a. Borers. Teredinidae occurred to a very limited extent in 1945 and 1946, the attack rating slight in both these years; no Teredinidae occurred in 1947. The breeding season appears to be limited to the period extending from March through July. Limnoria showed slight evidence of activity throughout the test, but the attack rated only a mere trace each year.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 4 phyla contributed to fouling of the panels. The latter included hydroids, encrusting and filamentous Bryozoa, barnacles, and mussels.

Of these organisms, hydroids and barnacles occurred with great frequency, the latter being very abundant, while the occurrence of the other organisms was merely sporadic or occasional. Algae also occurred with considerable frequency on the panels of the test series..

3. Recent Addenda. Panels of a new test board installed October 6, 1948, has shown no Teredinidae and only a slight Limmoria attack up to the end of 1949.



## KODIAK, KODIAK ISLAND, ALASKA -- U. S. NAVAL OPERATING BASE

A33.01 Location of the Test Station and Test Boards

Five test boards of the panel type were installed July 15, 1944, at different locations at the U. S. Naval Operating Base at Kodiak, Kodiak Island, Alaska. Kodiak is located on Chiniak Bay on the eastern side of the Island. The first of these test boards, designated by the symbol USNKA-1, was installed at the Temporary Pier (Cargo Dock) in Womens Bay. The second, USNKA-2, was installed at the Permanent Pier (Oil Dock) in Womens Bay. The third, USNKA-3, was installed at the Marine Railway in Womens Bay. The fourth, USNKA-4, was installed at the Woody Island Pier; and the fifth, USNKA-5, was installed at the Army Pier in St. Paul Harbor at Kodiak.

Previous marine investigations at Kodiak had revealed that borer activity was greatest at the mud line. The original drawing of the test board furnished this Base recommended 8 panels, numbered from 1 to 8, exclusive of the control panel, with the board so suspended that the lower panel would be 2 ft above the mud line. Three additional panels, numbered 9 to 11 inclusive, were added to the test boards used at Kodiak, thus carrying the test panels to the mud line.

The test board at the Army Pier in St. Paul Harbor was lost by the breaking of the mooring chain after the panels were removed in November 1945, and evidently was not replaced, as no further panels from this board were received. On December 21, 1945, the test board at the Marine Railways was taken up and replaced by a new one for which the period of submergence was reduced from 8 to 4 months. However, in January 1947, the Naval Operating Base advised that they were unable to remove the panels from the test board at this location, as freezing of the bay had made it inaccessible. (The bay at this location remained frozen during February and March.) In May, the Base advised that the test boards at both the Marine Railway and the Temporary Pier had been destroyed by ice, and apparently these boards were not replaced, as no further panels were received from either of these locations. The panels at the Woody Island Pier were lost on July 20, 1947, for some unknown reason, and a new test board was installed there on August 15. The test board at this location and that at the Permanent Pier in Womens Bay are the only boards that are still being operated at Kodiak. The results of these tests have been summarized to the end of 1947.

A33.02 Hydrographic Data

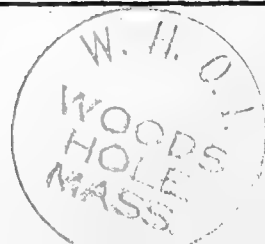
1. General. The depths of water where the test boards were installed were 28 ft at both the Temporary and Permanent Piers in Womens Bay 17 ft at the Marine Railway in Womens Bay, 14 ft at the Woody Island Pier, and 18 ft at the Army Pier in St. Paul Harbor. The tidal range at all these

locations was 17 ft. The range of temperature of the water at the different locations is given in the following table. The velocity of the current was considered to be slight at all locations.

2. Pollution. Chiniak Bay receives sewage from the Naval Operating Base and from the town of Kodiak. The bay is about 8.8 miles by 1.9 miles and is landlocked on its western and southern sides, and on the southern half of its eastern side. Elsewhere, it opens into the Pacific Ocean through a series of straits between islands. On July 15, 1944, five 4-oz samples of water, taken about 5 ft below the surface at each of the locations at which test boards were installed, were collected for pollution determinations. Two cc of each sample were planted in Dominick-Lauter medium. The samples from the Temporary Pier and the Army Pier were both strongly positive, and the sample from the Permanent Pier was moderately positive to this qualitative test for the coliaerogenes group of bacteria. While the samples from the Marine Railway and the Woody Island Pier were negative, it is believed that samples from all locations would give positive tests at one time or another. It was concluded from this test that the water of the bay is contaminated to a moderate degree.

Record of temperature of the water in degrees F, based on readings made at various times each month, showing the general range throughout the year at each location

Month	Temporary Pier Womens Bay	Permanent Pier Womens Bay	Marine Railway Womens Bay	Woody Island Pier	Army Pier St. Paul Harbor
January	1944 38 1945 33 1946 40 1947 40	1944 50 1945 46 1946 48 1947 48	1944 50 1945 52 1946 46 1947 46	1944 48 1945 50 1946 46 1947 46	1944 48 1945 46 1946 50 1947 51
February	1944 35 1945 33 1946 32 1947 32	1944 36 1945 33 1946 38 1947 38	1944 36 1945 33 1946 33 1947 33	1944 36 1945 33 1946 33 1947 33	1944 36 1945 36 1946 38 1947 38
March	1944 39 1945 40 1946 38 1947 34	1944 38 1945 40 1946 38 1947 34	1944 37 1945 39 1946 40 1947 40	1944 37 1945 38 1946 40 1947 34	1944 38 1945 38 1946 44 1947 38
April	1944 45 1945 38 1946 42 1947 42	1944 45 1945 38 1946 42 1947 38	1944 44 1945 44 1946 38 1947 42	1944 44 1945 44 1946 38 1947 40	1944 44 1945 44 1946 44 1947 44
May	1944 46 1945 52 1946 46 1947 46	1944 47 1945 52 1946 46 1947 48	1944 47 1945 52 1946 46 1947 46	1944 46 1945 48 1946 46 1947 46	1944 46 1945 48 1946 48 1947 48
June	1944 50 1945 52 1946 46 1947 46	1944 50 1945 52 1946 46 1947 48	1944 50 1945 52 1946 46 1947 46	1944 48 1945 50 1946 46 1947 46	1944 48 1945 46 1946 46 1947 46
July	1944 54 1945 52 1946 46 1947 46	1944 54 1945 52 1946 46 1947 48	1944 51 1945 52 1946 46 1947 46	1944 50 1945 50 1946 46 1947 45	1944 51 1945 50 1946 46 1947 46
August	1944 47 1945 47 1946 38 1947 38	1944 46 1945 46 1946 38 1947 42	1944 44 1945 48 1946 38 1947 44	1944 46 1945 46 1946 38 1947 44	1944 46 1945 46 1946 46 1947 46
September	1944 42 1945 36 1946 36 1947 36	1944 42 1945 36 1946 38 1947 42	1944 42 1945 36 1946 38 1947 44	1944 42 1945 36 1946 38 1947 44	1944 42 1945 37 1946 42 1947 42
October	1944 37 1945 34 1946 44 1947 44	1944 37 1945 34 1946 44 1947 40	1944 36 1945 34 1946 44 1947 44	1944 36 1945 34 1946 44 1947 40	1944 37 1945 37 1946 42 1947 42
November	1944 42 1945 36 1946 36 1947 36	1944 42 1945 36 1946 38 1947 42	1944 42 1945 36 1946 38 1947 44	1944 42 1945 36 1946 38 1947 44	1944 42 1945 37 1946 42 1947 42
December	1944 37 1945 34 1946 44 1947 44	1944 37 1945 34 1946 44 1947 40	1944 36 1945 34 1946 44 1947 44	1944 36 1945 34 1946 44 1947 40	1944 37 1945 37 1946 42 1947 42



1. Teredinidae. Teredinidae (Bankia setacea) were more or less active at all five locations, but it is noteworthy that at each site they failed to develop in the first 4 panels which were submerged on July 15 and removed, one each month, up to November 15, 1944. Moreover, on the control panels they failed to develop for a much longer period. No specimens developed on the control panels until after February 20, 1945, at the Temporary Pier and Army Pier; after January 16, 1946, at the Permanent Pier and Woody Island Pier; or after August 23, 1946, at the Marine Railway. It is quite evident, then, that Teredinidae simply did not occur at these locations from the date of the beginning of the test to the dates given above.

The control panels at all five locations showed very scanty development of Teredinidae over very brief periods in comparison to the rather extensive attacks recorded in the test panels. It is, therefore, difficult to determine the breeding season at these localities, although it appears to extend from late February to the middle of September, late October, or even to late December at locations where Bankia setacea is active and very destructive, as is the case at the Temporary Pier.

At all five locations, it was evident in each year of the tests that Bankia setacea occurred in greatest numbers and was most destructive in the lower panels of the test boards; namely, Nos. 8, 9, 10, and 11, which would locate the maximum attack close to the mud line. The detailed figures on the occurrence of Teredinidae is summarized by locations as follows:

a. Temporary Pier. Teredinidae occurred as minute pits or embryonic specimens in 7 of the 30 control panels and in 26 of the same number of test panels, attaining a maximum length of 485 mm in one of the control panels removed on June 20, 1945, after having been submerged for 11 months. Panels 9 to 11, inclusive, were riddled in 1945; in 1946, panels 8 to 11, inclusive, were riddled. The attack at this location rated very heavy both years.

b. Permanent Pier. Teredinidae occurred as minute pits in 5 of the 39 control panels in 1946 and 1947, but no specimens were recorded in 1944 and 1945. Teredinidae occurred in 35 of the 37 test panels, attaining a maximum length of 350 mm in a panel removed on August 15, 1947, after having been submerged for 13 months. None of the test panels was either filled or riddled, although submerged for 11 months during 1945 and 1946, and for 12 months during 1947. The attack at this location rated moderate in 1945, medium heavy in 1946, but only slight in 1947.

c. Marine Railway. Teredinidae occurred as minute pits in 2 of the last 3 of the 28 control panels received in 1946. They occurred in 20 of the 38 test panels, attaining a maximum length of 340 mm in one panel removed on June 20, 1945, after having been submerged for 11 months. This panel showed the heaviest attack of any, being well filled. The maximum attack at this location thus rated very heavy in 1945 and only a trace in 1946.

d. Woody Island Pier. Teredinidae occurred as minute pits in only one of the 37 control panels. They occurred in 22 of the 37 test panels, attaining a maximum length of 300 mm in one panel removed on June 20, 1945, after having been submerged for 11 months. The attack at this location rated moderate in 1945, medium heavy in 1946, and only a trace in 1947.

e. Army Pier. Teredinidae occurred as a few minute pits or embryonic specimens in 3 of the 16 control panels and in 10 of the 16 test panels, attaining a maximum length of 300 mm in 2 of the test panels removed on July 20 and August 21, respectively, in 1945, after having been submerged for 11 months. The attack at this location rated moderate in 1945.

2. Limnoria. Limnoria were more or less active at each of the five locations. Their occurrence is summarized for each place as follows:

a. Temporary Pier. Limnoria occurred on 12 of the 30 control panels, although none occurred until after April 15, 1945. Except for the last panel, which was left submerged for 3 months, the maximum number occurring on any panel was 110. Limnoria occurred on 18 of the 30 test panels, but not on those panels removed up to July 20, 1945. The attack rated only a trace in 1945, and medium heavy late in 1946 and early in 1947, in panels left submerged for 11 and 12½ months, respectively.

b. Permanent Pier. Limnoria occurred in only 4 of the 39 control panels, although none occurred until after September 23, 1946. The maximum number on any panel was 28. They occurred on all except the first 4 of the 39 test panels. The four exceptions had been submerged from one to 4 months each, respectively. The attack rated only a trace in 1945 and 1946 and slight in 1947.

c. Marine Railway. Limnoria occurred on 9 of the 28 control panels, although none appeared until after April 15, 1945. The maximum number on any panel was 25. They occurred on 27 of the 38 test panels. The attack rated slight in 1945 and medium heavy in 1946.

d. Woody Island Pier. Limnoria occurred sporadically in 8 of the 37 control panels, although none appeared until after August 21, 1945. The maximum number was only 4 in any panel. They occurred in all except 3 of the 37 test panels. The attack rated slight in 1945, 1946, and 1947.

e. Army Pier. Limnoria failed to develop in any of the 16 control panels, but occurred in all except 3 of the same number of test panels. The attack never rated more than a trace in 1945.

### A33.Q4 Fouling Agents

1. Silt. Silt occurred on all the panels at all five locations except on one control panel at the Permanent Pier, and on one test and one control panel at the Marine Railway. The deposits ranged from traces to light on the control panels and from traces to moderate on the test panels at the first four locations, but at the Army Pier they rated as mere traces on the control panels and from traces to light on the test panels.

2. Algae. Algae occurred frequently on the panels at the Woody Island Pier, but only rarely on the panels at the other four locations. They occurred on a single test panel at the Temporary Pier, on 4 control panels and one test panel at the Permanent Pier, on 2 control panels and one test panel at the Marine Railway, on 12 of the 37 control panels and 27 of the same number of test panels at the Woody Island Pier, and on 4 control panels and 3 test panels at the Army Pier. At the four locations where they occurred so infrequently, there were mere traces on the panels in practically all cases. However, at the Woody Island Pier, where they occurred quite frequently, the growths rated as traces to rarely light or medium on the control panels and from traces to heavy on the test panels. The algae were mostly green, but red and brown algae also occurred at the Woody Island Pier.

### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids and Metridium). Hydroids occurred with great frequency on the panels at all five locations. They were present on 7 of the 30 control panels and 28 of the 30 test panels at the Temporary Pier, on 9 of the 39 control panels and 33 of the 39 test panels at the Permanent Pier, on 10 of the 28 control panels and 26 of the 38 test panels at the Marine Railway, on 11 of the 37 control panels and 33 of the same number of test panels at the Woody Island Pier, and on 5 of the 16 control panels and 14 of the same number of test panels at the Army Pier. In most cases the growths were merely traces, but they rated up to light occasionally on the test panels at the Permanent Pier and Marine Railway and up to moderate on the test panels at the Woody Island Pier. Tubularia was identified at the latter location. A trace of Metridium, a member of a different group of Coelenterata, was recorded on 2 test panels at the Permanent Pier.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred quite frequently on the panels at all five locations. They occurred on 2 of the 30 control panels and 21 of the 30 test panels at the Temporary Pier, on 2 of the 39 control panels and 30 of the same

number of test panels at the Permanent Pier, on 26 of the 38 test panels at the Marine Railway, on 13 of the 37 test panels at the Woody Island Pier, and on 12 of the 16 test panels at the Army Pier. Two of the test panels at the Permanent Pier were 20% and 30% covered, respectively, after 11 months' submergence; one of the test panels at the Marine Railway was 15% covered after 5 months' submergence; two of the test panels at the Army Pier were 10% and 20% covered, respectively, after 11 months' submergence. Cribilina sp., Electra sp., Hippothoa hyalina, Schizoporella unicornis, and Tegella sp. were identified. Filamentous Bryozoa occurred to a slight extent on the panels at four of the five locations. They occurred on 6 of the 30 test panels at the Temporary Pier, on 2 of the 39 control panels and 8 of the 39 test panels at the Permanent Pier, on 2 of the 37 test panels at the Woody Island Pier, and on 3 of the 16 test panels at the Army Pier. Two of the test panels at the Permanent Pier were 30% and 50% covered, respectively, after 13 months' submergence. Bugula sp. was the only identification made.

c. Annelida (annelid worms). Serpulid (Serpula) tubes occurred more or less frequently on the test panels at all five locations, but appeared on only of the control panels. They occurred on a single control panel and on 4 of the 30 test panels at the Temporary Pier, on 7 of the 39 test panels at the Permanent Pier, on 14 of the 38 test panels at the Marine Railway, on 10 of the 37 test panels at the Woody Island Pier, and on 9 of the 16 test panels at the Army Pier. They occurred usually in small numbers, 160 being the maximum number recorded on any one panel.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred with great frequency on the panels at all five locations. They were on 8 of the 30 control panels and 29 of the 30 test panels at the Temporary Pier, on 12 of the 39 control panels and 37 of the same number of test panels at the Permanent Pier, on 9 of the 28 control panels and 31 of the 38 test panels at the Marine Railway, on 4 of the 37 control panels and 23 of the same number of test panels at the Woody Island Pier, and on 6 of the 16 control panels and all of the 16 test panels at the Army Pier. The specimens on the control panels were mostly embryonic to juvenile, but specimens up to 7 mm were recorded. On the test panels, maximum diameters of 15 mm in 11 months, 19 mm in 11 months, 12 mm in 8 months, 17 mm in 11 months, and 15 mm in 6 months were recorded for the respective locations in the order listed. At the Temporary Pier, 22 of the test panels were from 20% to 100% covered. At the Permanent Pier, 3 of the control panels were from 20% to 75% covered, and 30 of the test panels were from 25% to 100% covered. At the Marine Railway, 3 of the control panels were from 10% to 100% covered, and 18 of the test panels were from 10% to 100% covered. At the Woody Island Pier, 15 of the test panels were from 25% to 100% covered. At the Army Pier, 15 of the test panels were from 50% to 100% covered.

e. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred occasionally, mostly in small numbers, at all five locations as follows: Anomia (jingle-shells) occurred on 2 test panels at the Temporary Pier, on a single control panel and 4 test panels at the Permanent Pier, on 9 test panels at the Marine Railway, and on 2 test panels at the Woody Island Pier, 50 being the maximum number recorded on any one panel. Mytilus (mussels) occurred on 5 test panels at the Temporary Pier, on a single control panel and on 3 test panels at the Permanent Pier, on 9 test panels each at the Marine Railway and Woody Island Pier, and on 5 test panels at the Army Pier. The maximum number on any panel was 500 minute specimens. Saxicava occurred on 4 test panels at the Permanent Pier, on 2 test panels at the Marine Railway, on 3 test panels at the Woody Island Pier, and on 5 test panels at the Army Pier, 30 being the maximum number on any one panel.

f. Chordata (tunicates). The only evidence of tunicates was 4 specimens recorded on a single test panel at the Temporary Pier.

### A33.05 Summary and Conclusions

1. Installation. Of the 5 test boards of the panel type installed July 15, 1944 at different locations at Kodiak, Kodiak Island, Alaska, 3 were lost and discontinued after being carried away by ice, and the other 2 are still being operated. The results of the tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were more or less active at each of the five locations, but the intensity of the attack varied at the different locations and in different years. The attack at the Temporary Pier rated very heavy in both 1945 and 1946. At the Permanent Pier, it rated moderate in 1945, medium heavy in 1946, but only slight in 1947. At the Marine Railway, it rated very heavy in 1945 but only a trace in 1946. At the Woody Island Pier, there was a moderate attack of Teredinidae in 1945, medium heavy in 1946, and only a trace in 1947. At the Army Pier, the attack rated moderate in 1945. Bankia setacea, the only species present, clearly appeared to occur in greatest numbers and cause the most destruction in the lower panels, which would locate the maximum attack close to the mid line. The breeding season appears to extend from late February to the middle of September, late October, or even to late December at locations where B. setacea is active and destructive. Limnoria also were more or less active at all five locations and in different years. The attack at the Temporary Pier rated only a trace in 1945 and medium heavy late in 1946 and early 1947. At the Permanent Pier, it rated but a trace in 1945 and 1946 and slight in 1947. At the Marine Railway, it rated slight in 1945 and medium heavy in 1946.



At the Woody Island Pier, it rated slight in 1945, 1946, and 1947. At the Army Base, it never rated more than the trace recorded in 1945.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter included hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, miscellaneous nonboring mollusks, and tunicates. Of these organisms, hydroids and barnacles occurred with the greatest frequency by far, encrusting Bryozoa with less frequency, and serpulid worms with still less frequency, while the occurrence of the other worms was merely sporadic or occasional. Algae occurred frequently on the panels at the Woody Island Pier, but very rarely on the panels at the other locations.

3. Recent Addenda. There was no test board operated in 1948 at the Temporary Pier in Womens Bay. A new board, operated during 1949, registered a trace of Teredinidae and a medium heavy attack of Limnoria. At the Permanent Pier, there was a moderate attack by Teredinidae in 1948 but none whatever in 1949. Limnoria was rated as low slight in 1948 and as a trace in 1949 at this location. Teredinidae rated slight in 1948 and a trace in 1949 at the Marine Railway, where Limnoria was recorded as slight in the former year and as moderate in the latter. The test board at Woody Island Pier was discontinued after 1948, during which year it showed a trace of Teredinidae and a slight attack of Limnoria. No board was operated at the Army Pier during either year.

## Section 34

### SITKA, ALASKA -- U. S. NAVAL AIR STATION

#### A34.01 Location of the Test Station and Test Board

A test board of the panel type, designated by the symbol USNSA-1, was operated at the U. S. Naval Air Station at Sitka, Alaska, from November 15, 1944 until August 16, 1946, when it was discontinued because of the transfer of this Station to the Alaskan Native Service. The test board was installed on the outside corner of the Harbor Island Gravel Bunker Dock, about 6 ft from an arsenious-trioxide-treated pile. This location exposed it to the tidal currents of Sitka Harbor.

The complete destruction of summer-cut Sitka spruce (with bark off) by Teredo action was reported to be a matter of record at this Station. In order to combat this destruction of wooden marine structures, two types of treatment have been used on piling. The piling of the New Navy Dock was treated with arsenious trioxide, copper sulphate, and zine sulphate. In April 1946, it was stated that a recent inspection of this piling showed no Teredo action, and it was reported to be sound. The pier at Old Sitka is a partially completed, cancelled project. The piling used for this structure was treated by an electrolytic open-tank process, in which copper sulphate, sulphuric acid, and other chemicals were used. A small boat recently broke off a sturdy-looking pile to which it was tied. The ensuing curiosity lead to taking out several samples of electrolytic-treated piling. It was found that all such piling was completely destroyed in less than 2 years after installation. The electrolytic open-tank process is considered valueless against Teredo activity in this area. Figure 7 shows considerable action on the exterior of an electrolytic, copper-sulphate-treated pile, and figure 8 shows the interior of the same pile completely riddled, with full-grown Teredos in view.

It is a matter of record that other installations with this treatment have failed within a comparatively brief period.

#### A34.02 Hydrographic Data

The depth of water where the test board was installed was 10 ft at mean low water; the range of tide was 11 ft; the current was one-fourth knot. The temperature of the water at the time of installation was 47° F. The average salinity of the water was approximately 1,450 grains per gallon. The local pollution was said to be zero.

### A34.03 Marine Borers

1. Teredinidae. Teredinidae (Bankia setacea) were more or less active at this location throughout the period of the test. In the control panels, only 2 embryonic specimens occurred, and these specimens were in the panel submerged from July 16, 1945. They occurred in 12 of the 16 test panels, attaining a maximum length of 290 mm in 8 months. Six of the panels were from 25% to 100% filled in this time. The breeding season at this location can not be exactly determined from the brief test because of the extremely limited occurrence of Teredinidae in the control panels, but considering their occurrence in the test panels, it appears to extend from February to at least the middle of July. The attack rated very heavy in 1945 and medium heavy in 1946.

2. Limnoria. Limnoria were active at this location throughout the duration of the test. They occurred in all except one of the control panels, the maximum number being 850 in any one panel. They occurred in every one of the test panels. From the time the test board was submerged late in 1944 there was a rapid increase in the Limnoria population, which attained a peak rating of very heavy in the panel removed on July 16, 1945, after 8 months' submergence. After reaching the peak rating, the attack subsided somewhat, but again attained a peak rating of very heavy in the 8-month panel removed on January 15, 1946. It again subsided noticeably, but attained a rating of medium heavy in the panel removed on August 16, 1946, when the operation of the test board was discontinued.

### A34.04 Fouling Agents

1. Silt. Silt occurred as traces on 16 of the 21 control panels and as traces to occasionally light deposits on all of the 21 test panels.

2. Algae. Algae occurred on only one control panel and on 11 of the 21 test panels. The growths were mostly traces but were light occasionally. Most of these forms were green algae, but red and brown algae also occurred.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 8 control panels and on 15 test panels.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on 5 control panels and on 17 test panels. Cribilina annulata, Cryptosula pallasiana, Electra monostachys, Electra sp., Tegella unicornis, and a member of the Alderinidae were identified.

Filamentous Bryozoa occurred on 3 control panels and on 10 test panels. Bugula flabellata and Bugula sp. were the only forms identified.

c. Annelida (annelid worms). Serpulid (Serpula) tubes were not present on any of the control panels but occurred on 5 test panels.

d. Arthropoda (crustaceans). Balanus (barnacles) were not present on any of the control panels but occurred in small numbers on 2 test panels, the maximum diameter recorded being 4 mm after 8 months' submergence. A few amphipods occurred on one panel each of both the control and test panels.

e. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally as follows: Anomia (jingle-shells) occurred on one control panel and on 6 of the 21 test panels. The largest number on any one panel was 30, and the maximum size recorded was 15 mm on a panel submerged for 8 months. Mytilus (mussels) were not present on the control panels, but occurred on 7 of the 21 test panels. The maximum number on any panel was 60, and the maximum length recorded was 14 mm on a panel submerged for 8 months. Traces of Pecten (scallops) and Saxicava occurred on single test panels.

#### A34.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Air Station at Sitka, Alaska, from November 15, 1944 until its discontinuance on August 16, 1946, to determine the identity and prevalence of marine borers and fouling agents at this location.

#### 2. Test Results.

a. Borers. Teredinidae were more or less active at this location, the attack rating very heavy in 1945 and medium heavy in 1946. The breeding season is difficult to determine because of the extremely limited occurrence of Teredinidae in the control panels and the short duration of the test, but it appears to extend from February to at least the middle of July. Limnoria were active at this location throughout the period of the test, and the attacks attained peak ratings of very heavy by the summer of 1945 and again early in 1946.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter included hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles and amphipods, and nonboring mollusks. Of these organisms, hydroids and encrusting Bryozoa occurred with the greatest frequency; filamentous Bryozoa occurred with less frequency; while the occurrence of the others, as well as of the algae, was merely sporadic or occasional.

## INDIAN ISLAND, HADLOCK, WASHINGTON -- U. S. NAVAL MAGAZINE AND NET DEPOT

A35.01 Location of the Test Station and Test Board

A test board of the panel type, designated by the symbol USNII-1, was installed July 18, 1944, at the U. S. Naval Magazine and Net Depot at Indian Island, Hadlock, Washington. It was placed at the southwest corner of the dock on Indian Island, 150 ft out from the shore on the eastern side of the southern end of Port Townsend, on a branch of Admiralty Inlet leading southward into Washington from the Strait of Juan de Fuca between northwestern Washington and Vancouver Island. The location is east of Irondale and northeast of Hadlock in Jefferson County. The test board was installed in the vicinity of untreated piling as requested. (This location appears to have been selected because the piling at the ferry landing is treated, and the piling at the pier is steel.) The operation of this test board is being continued. The results have been summarized to the end of 1947.

Local experience with piling and dolphins indicated that an untreated tight-barked pile would deteriorate in 10 to 12 months. It was noted, however, that conditions have been found to vary to a great extent in various sections of the Sound. It was stated that this pile would be good for 3 to 5 years in the Discovery Bay area, while in the Quilcene Bay area, it would be good for only 6 to 8 months.

A35.02 Hydrographic Data

The depth of water at the location where the test board was installed was 23 ft, the tidal range 7 to 10 ft, the current approximately  $2\frac{1}{2}$  knots. The temperature of the water at the time of installation was  $55^{\circ}$  F. The salinity was given as 26.3 parts of chlorides as sodium chloride per thousand. The pollution was reported to be negligible.

A35.03 Marine Borers

1. Teredinidae. Teredinidae (Bankia setacea) were very active throughout the period of the test. The attack was so destructive that on November 6, 1945, it was requested that the panels be removed and a new series installed which would be submerged for 4 months instead of the previous 8-month basis. This change was made later in the month.

Teredinidae occurred in 12 of the 38 control panels, ranging from minute pits to embryonic or minute specimens. The breeding season was limited to the period beginning in the middle of March and running

through December. There were specimens in all except 5 of the 40 test panels, some panels becoming riddled in the short period of 6 months. All except 2 of the 9 consecutive panels submerged from 6 to 8 months up to October 19, 1945, were riddled, and one of these panels was well filled. A maximum length of 360 mm was recorded in a panel submerged for 8 months. The attack rated very heavy in 1945 and appeared to be equally heavy in 1946 and 1947, although the period of submergence had been reduced from 8 to 4 months.

2. Limnoria. Limnoria were active throughout the period of the test but never occurred in particularly destructive numbers. They occurred in 21 of the 38 control panels, but there were never more than 125 in any single panel, and no forms occurred until after March 18, 1945. In the test panels, they occurred in all except 2 of the 39, but the attack never exceeded a low slight rating in any one year.

#### A35.04 Fouling Agents

1. Silt. Silt occurred on 33 of the 38 control panels and on all except one of the same number of test panels. In the control panels, the deposits ranged from traces to occasionally light, while on the test panels they ranged from traces to mostly light, and moderate on one panel.

2. Algae. A trace of green algae occurred on a single test panel.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids and Metridium). Hydroids occurred on 8 of the 38 control panels and on 28 of the same number of test panels. They rated as traces on the control panels and from traces to occasionally light growths on the test panels. A solitary specimen of Metridium, a member of a different group of Coelenterata, occurred on a single test panel.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa were lacking on the control panels and occurred rather sparingly on 11 of the 39 test panels. Callipora craticula, Cheiloporina praelonga, Cryptosula sp., Dendrobeatia lichenoides, and Electra sp. were identified. Filamentous Bryozoa were lacking on the control panels but occurred more or less abundantly on 23 of the 39 test panels. Bugula pacifica, B. flabellata, and B. sp. were the only ones identified.

c. Annelida (annelid worms). Serpulid (Serpula) tubes likewise were lacking on the control panels, but they occurred on 10 of the 39 test panels, the largest number being 30 on any one panel.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on

15 of the 39 control panels and on 33 of the same number of test panels. Ten panels of the control series were from 25% to 75% covered, and 22 panels of the test series were from 25% to 100% covered. A maximum diameter of 7 mm was recorded on a control panel and 22 mm on a test panel, after they had been submerged for 4 months.

e. Mollusca (nonboring mollusks). A solitary specimen of Anomia (jingle-shells), with a diameter of 6 mm after 4 months' submergence, occurred on a single test panel. Single specimens of Mytilus (mussels) occurred on two of the test panels, one attaining a length of 12 mm after 4 months' submergence.

f. Chordata (tunicates). Tunicates occurred on one control panel and on 2 test panels. All were identified as Botryllus schlosseri.

### A35.05 Summary and Conclusions

1. Installation. A test board of the panel type installed July 18, 1944, at the U. S. Naval Magazine and Net Depot at Indian Island, Hadlock, Washington, to determine the identity and prevalence of marine borers and fouling organisms, is still being operated. The results of this test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active throughout the period of the test, the breeding season apparently lasting from the middle of March through December. The attack rated very heavy in 1945 and appeared to be equally heavy in 1946 and 1947, although the period of submergence was reduced from 8 to 4 months. Limnoria also were active throughout the period of the test, but the attack never exceeded a low slight rating in any one year.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter comprised hydroids and Metridium, encrusting and filamentous Bryozoa, serpulid worms, barnacles, jingle-shells and mussels, and tunicates. Of these organisms, barnacles occurred with by far the greatest frequency and abundance; hydroids, filamentous Bryozoa, and encrusting Bryozoa with regressively less frequency; while the occurrence of the others, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. There was a heavy attack by Teredinidae at this station in both 1948 and 1949. The Limnoria attack rated slight both years.

## SEATTLE, WASHINGTON -- U. S. NAVAL STATION

A36.01 Location of the Test Station and Test Boards

Test boards of the panel type were installed June 15, 1944, at different locations at the U. S. Naval Station at Seattle, Washington. One of these boards, designated by the symbol USNS-1, was installed at the southwest corner of Pier No. 90. The other, designated by the symbol USNS-2, was installed at the southwest corner of Pier No. 91. Both piers are located in Elliott Bay, Puget Sound. The operation of these test boards is being continued. The results of these tests have been summarized to the end of 1947.

On September 15, 1944, the Naval Station advised that the test board at Pier No. 91 had been destroyed. A new one was installed on October 15. On August 20, 1945, the Naval Station advised that the test board at this pier had again been destroyed and had been replaced by a new one on August 18. On February 15, 1945, the Naval Station advised that the test board at Pier No. 90 had been destroyed. This board was replaced by a new one on March 15. On November 29, 1945, news came from the Naval Station that the test board at this pier had again been destroyed. This board was replaced by a new one on February 8, 1946.

It was found by pulling and testing piling from different areas of the piers at this station that the piles had been damaged by marine borers so extensively as to lose their structural value. These piles had been in place 11 months when they were pulled for tests. Figure 9 shows sections of an untreated pile, removed from Pier No. 91, which was almost completely destroyed by marine borers.

A36.02 Hydrographic Data

The depths of water where the test boards were installed were 30 ft at Pier No. 90 and 33.5 ft at Pier No. 91. The tidal range was 19.3 ft (from -4.5 to 14.8 ft). The velocity of the current was tidal flow only, but on October 15, 1946, it was stated to be 600 ft per hour measured by the U. S. Coast and Geodetic Survey Office. The measurements were taken one hour before and two hours after low water. The direction of the water current one hour before low water was  $108^{\circ}$ ; after low water,  $360^{\circ}$  or due north. The temperature of the water at the time of installation was  $52^{\circ}$  F at Pier No. 90 and  $56^{\circ}$  F at Pier No. 91. The degree of pollution was given as 10,000 Bacillus coli per 100 cc. By request of the Public Works Department of the Naval Station, analyses were made at the Sanitary Engineering Laboratory on four samples of water collected from Elliott Bay off Pier No. 91, following the completion of



dredging operations in the vicinity of the test boards. The samples were collected at 6-hour intervals throughout a 24-hour period. Each sample was taken at such time as to correspond approximately with high-tide and low-tide elevations, occurring from 1200 on June 24 to 0800 on June 25, 1946. The results of these determinations indicate that the 5-day B.O.D. of the waters of Elliott Bay at the point of collection varies from 4 to 6 and averages 4.75 ppm. A chemical analysis of these samples indicates that the salinity of Elliott Bay water, based on the sulphate ( $SO_4$ ) content and chloride (Cl) content, is 16,033 ppm or 1.6 percent by weight.

### A36.03 Marine Borers

1. Teredinidae. Teredinidae (Bankia setacea) were very active at both locations throughout the period covered by the tests. The attacks were so destructive that panels were becoming riddled in a few months. The detailed figures on the occurrence of Teredinidae at each of these locations are summarized below.

a. USNS-1 (Pier No. 90). Teredinidae, ranging from minute pits to minute specimens, occurred in 24 of the 35 control panels, the breeding season extending from the middle of March to the middle of January. They occurred in all except one of the 35 test panels, being absent in the first of the 4-panel series. The maximum length recorded was 280 mm (about 11 inches) in a panel submerged for 5 months. Sixteen of these panels were either filled or riddled, and they became riddled in the short period of 3 months. The attack at this location rated very heavy each year, beginning with 1944. (See figure 10.)

b. USNS-2 (Pier No. 91). Teredinidae, ranging from minute pits to specimens up to 4 mm in length, occurred in 22 of the 35 control panels. At this location, the breeding season clearly extended from the middle of January to the middle of December. They occurred in all except 4 of the 42 test panels, being absent in 4 at the start of 3 different series of panels. The maximum length recorded was 280 mm (about 11 inches) in a panel submerged for 5 months. Twenty-one of these panels were either filled or riddled, and they became riddled in as short a period as 3 months. The attack at this location rated very heavy in 1945, 1946, and 1947. It doubtless would have rated heavy also in 1944 had not the test been interrupted by loss of the board.

2. Limnoria. Limnoria also were active each year at each location, but never occurred in particularly destructive numbers. Their occurrence, which was the same for each location, is summarized as follows :

a. USNS-1 (Pier No. 90). Limnoria occurred irregularly on 20 of the 35 control panels, the maximum number of tunnels being only 20

on any single panel. They occurred on all except one of the 35 test panels, being absent in only one panel at the start of a new series. The attack rated slight in 1945 and merely a trace in 1946 and 1947.

b. USNS-2 (Pier No. 91). Limmoria occurred irregularly on 17 of the 35 control panels, the maximum number of tunnels being only 45 on any panel. They occurred on 32 of the 42 test panels, being absent on all the group of 8 submerged in August and removed in October and November 1945. The attack rated slight in 1945 and only a trace in 1946 and 1947.

#### A36.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series. The deposits ranged from traces to light on the control panels and from traces to moderate, and sometimes oily, on the test panels.

2. Algae. A trace of a green alga occurred on a single test panel at Pier No. 90.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 15 of the 35 control panels and on 30 of the 35 test panels at Pier No. 90, and on 10 of the 35 control panels and on 37 of the 42 test panels at Pier No. 91. The growths rated as traces on the panels of the control series, and as traces, or rarely light, on the panels of the test series. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on the panels at both locations. At Pier No. 90 they were on 28 of the 35 test panels, and at Pier No. 91 they occurred on 4 of the 35 control panels and on 28 of the 42 test panels. Cheiloporina praelonga, Cribilina sp., Cryptosula sp., Electra sp., Lichenopora sp., Schizoporella unicornis, Schizoporella sp., and Tegella unicornis were identified. Filamentous Bryozoa occurred more or less abundantly on some of the test panels at both locations. At Pier No. 90 they occurred on 9 of the 35 test panels, and at Pier No. 91 they occurred on a single control panel and on 6 of the 42 test panels. Bugula flabellata and Bugula sp. were identified.

c. Annelida (annelid worms). Serpulid (Serpula) tubes occurred on a single control panel and on 13 of the 35 test panels at Pier No. 90, while at Pier No. 91 they occurred on only 2 test panels. The number on any one panel was small in most cases, but 300 worms were recorded on one of the test panels at Pier No. 90.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred with considerable frequency and in great abundance on the panels at both locations. At Pier No. 90 they occurred on 11 of the 35 control panels and on 24 of the same number of test panels, attaining a maximum

diameter of 6 mm on the control panels and 11 mm on a test panel after 4 months' submergence. At Pier No. 91 they appeared on 12 of the 35 control panels and on 23 of the 42 test panels, attaining a maximum diameter of 6 mm on the control panels and 12 mm on a test panel after 4 months' submergence. At Pier No. 90, 19 of the test panels were from 20% to 100% covered, while at Pier No. 91, 6 of the control panels were from 25% to 70% covered and 17 of the test panels were from 20% to 100% covered.

e. Mollusca (nonboring mollusks). A trace of Mytilus (mussels) occurred on a single test panel at each location. A length of 32 mm after 4 months' submergence was recorded for a single specimen at Pier No. 90.

f. Chordata (tunicates). Two colonies of tunicates occurred on a single control panel at Pier No. 91.

### A36.05 Summary and Conclusions

1. Installation. Two test boards of the panel type installed June 15, 1944, at different locations at the U. S. Naval Station at Seattle, Washington, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active at both locations, the breeding season extending from the middle of March to the middle of January at Pier No. 90 and from the middle of January to the middle of December at Pier No. 91. The attack at both locations rated very heavy each year, with panels becoming riddled in as short a period as 3 months at each location. Limnoria also were active, the attack rating slight at both locations in 1945 and only a trace in 1946 and 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, marine worms, barnacles, mussels, and tunicates. Of these organisms, hydroids occurred with the greatest frequency; barnacles and encrusting Bryozoa occurred with less frequency, while the occurrence of the others, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. The Teredinidae attack was very heavy at Pier No. 90 during 1948 and 1949, and in both years the Limnoria attack rated as slight. The same situation obtained at Pier No. 91 during both years.

## Section 37

### BREMERTON, WASHINGTON -- PUGET SOUND NAVAL SHIPYARD

#### A37.01 Location of the Test Station and Test Boards

Three test boards of the panel type were installed June 16, 1944, at different locations at the Puget Sound Naval Shipyard on the Sinclair Inlet from Puget Sound at Bremerton, Washington. The first test board, designated by the symbol USNPS-1, was installed at the south end of the Receiving Station Pier. The second, designated by the symbol USNPS-2, was installed on the east side of Pier No. 1 (Fuel Oil Pier). The third, designated by the symbol USNPS-3, was installed at the south end of Pier No. 8.

On June 20, 1946, the Shipyard advised that the test board USNPS-3 at Pier No. 8 had been removed, chain and all, by an unknown party, and that a new board had been installed on June 19, 1946. The operation of these test boards is being continued, and the results of these tests have been summarized to the end of 1947.

#### A37.02 Hydrographic Data

1. USNPS-1 (Receiving Station Pier). The depth of water where this test board was installed was 20 ft at mean low water. The tidal range from mean low water to mean high water was 11.7 ft; from extreme low water to extreme high water it was 19.8 ft. The velocity of the current was zero. The temperature of the water at the time of installation was 60° F, and further data are given in the table below. The pollution was very slight. The salinity of the water at the depth of the test board was given as 1,000 grains per gallon on March 28, 1946.

2. USNPS-2 (Pier No. 1 - Fuel Oil Pier). The depth of water where this test board was installed was 22 ft at mean low water, and the tidal range was the same as that given for the first location. The current was zero. The temperature of the water at the time of installation was 59° F. Further temperature data are given in the table. The pollution was very slight. The salinity of the water at the depth of the test board was given as 1,040 grains per gallon on March 28, 1946.

3. USNPS-3 (Pier No. 8). The depth of water where this test board was installed was 21 ft at mean low water. The tidal range was the same as that given for the first location. The current was zero. The temperature of the water at the time of installation was 57° F, and further temperature data are given in the table. The pollution was very slight. The salinity of the water at the depth of the test board was given as 1,040 grains per gallon on March 28, 1946.

On December 9, 1946, the Shipyard advised that extensive dredging operations had been in progress in the area between the Shipbuilding Ways and the west boundary since May 14, 1946, and that these operations had caused considerable turbidity in the water because of a large amount of suspended silt. At that time, pollution tests showed Bacillus coli heavy at the Receiving Station Pier and medium at the other two locations. This extensive dredging continued until the end of 1946, and dredging continued in the vicinity of the Receiving Station Pier until the end of March 1947, when heavy pier construction in this area continued to keep the water somewhat turbid as late as the middle of August 1947.

The following record of temperature of the water in degrees F, from readings made about the middle of each month, shows the general range throughout the year at each location.

Month	Receiving Station Pier			Pier No. 1 (Fuel Oil Pier)			Pier No. 8		
	1944	1945	1946	1944	1945	1946	1944	1945	1946
January		--			--			--	
February		46			46			46	
March		--			--			--	
April		46			46			46	
May		--			--			--	
June	60	52		59	54		57	54	
July	56			56			58		
August	--			--			--		
September	55			55			53		
October	--			--			--		
November	49		48	51		48	50		48
December	44			56			46		

### A37.03 Marine Borers

1. Teredinidae. Teredinidae (Bankia setacea) were very active at all three locations throughout the period covered by the tests. On March 27, 1947, the Shipyard advised that panels on the test boards were more or less completely eaten away because of the activity of these borers, and it was requested that the panels on these boards be removed and new boards

installed, to be operated on a 4-month basis instead of the previous 8-month basis. This change was made at all three locations on June 24. The detailed figures on the occurrence of Teredinidae at each of these locations are summarized below.

a. Receiving Station Pier. Teredinidae occurred in 13 of the 38 control panels, although no forms were recorded prior to April 16, 1945, and they made their appearance in only one panel after March 17, 1947. They ranged from minute pits and embryonic specimens to specimens up to 10 mm in length. The breeding season appeared to be limited to the period lasting from February through November. Teredinidae occurred in 40 of the 45 test panels, although no forms occurred until September 16, 1944. A maximum length of 446 mm (18 in.) was recorded after 8 months' submergence, and 9 of the panels submerged for this length of time was filled or riddled. The attack at this location rated very heavy each year after 1944.

b. Pier No. 1 (Fuel Oil Pier). Teredinidae occurred in 10 of the 38 control panels, although no forms were recorded prior to April 16, 1945, or after March 17, 1947. They ranged from minute pits to juvenile specimens, but a maximum length of 45 mm was recorded in one panel inadvertently submerged for  $2\frac{1}{2}$  months. The breeding season appeared to be limited to the period lasting from February through November. Teredinidae occurred in 40 of the 45 test panels, with a maximum length of 522 mm (21 in.) recorded in a panel submerged for 8 months. Seventeen of these panels submerged for 8 or more months were filled or riddled. The attack at this location rated very heavy each year after 1944.

c. Pier No. 8. Teredinidae, ranging from minute pits to juvenile specimens, occurred in 10 of the 36 control panels, but only 2 minute specimens had appeared prior to June 16, 1945. The breeding season appeared to extend from February through November. Teredinidae occurred in 38 of the 44 test panels, with a maximum length of 560 mm (about  $22\frac{1}{2}$  in.) recorded in a panel submerged for 8 months. Of the panels that were submerged for 6 or more months, 16 were filled or riddled. The attack at this location rated very heavy each year after 1944.

2. Limnoria. Limnoria were active at each of the locations but occurred generally in small numbers. Their occurrence may be summarized for each location as follows:

a. Receiving Station Pier. Limnoria occurred sporadically on 12 of the 38 control panels, but were not recorded after March 17, 1947. The largest number on any one panel was 33 forms. They occurred on 39 of the 45 test panels, but not until after October 16, 1944.

The number on any one panel never exceeded a trace rating, except in one panel removed early in 1947 after 10 months' submergence, where a peak low in the moderate rating was attained.

b. Pier No. 1 (Fuel Oil Pier). Limnoria occurred in 19 of the 38 control panels, but no forms were recorded after June 24, 1947. The largest number on any one panel was 75 forms. They also occurred on 43 of the 45 test panels. During 1945 and 1946 the attack was merely low in the slight rating, but in 1947 it attained a peak rating of moderate.

c. Pier No. 8. Limnoria occurred in 22 of the 36 control panels. The largest number on any one panel was 115 forms. They occurred on all except one of the 44 test panels. The attack rated slight in 1945, attained a peak rating of moderate in 1946, and lapsed to low in the slight rating in 1947.

It is of interest to note that panels made of a number of different kinds of wood were used on all 3 test boards in 1944. The woods used included Douglas fir, western hemlock, western white pine, and cedar. In addition, panels of Douglas fir with heartwood and sapwood also were used. Unfortunately, the use of the different kinds of wood did not always coincide with the incidence of the Tereido attack. It was perfectly clear from an analysis of the results, however, that one kind of wood was filled or riddled by Bankia setacea as readily as another, and it made no difference whether the Douglas fir panels were of heartwood or sapwood. It is also relevant to note that western hemlock has been recommended for piling by some engineers because of its alleged resistance to attack by marine borers. The results of these tests clearly show that this kind of wood was riddled by Bankia setacea and attacked by Limnoria just the same as were the other kinds of wood.

#### A37.04 Fouling Agents

1. Silt. Silt occurred on all the panels at all three locations, except on 2 control panels at each location and on single test panels at Pier No. 1 (Fuel Oil Pier) and Pier No. 8. The deposits mostly ranged from traces to light on the panels of the control series and from light to moderate on those of the test series.

2. Algae. A trace of a green alga occurred on a single test panel at Pier No. 1 (Fuel Oil Pier).

#### 3. Invertebrate animal phyla.

a. Porifera (sponges). Two small sponges occurred on a single test panel at the Receiving Station Pier.

b. Coelenterata (hydroids and Metridium). Hydroids occurred with great frequency on the panels at all three locations. They were present on 17 of the 38 control panels and 38 of the 45 test panels at the Receiving Station Pier, on 16 of the 38 control panels and 42 of the 45 test panels at Pier No. 1 (Fuel Oil Pier), and on 13 of the 36 control panels and 34 of the 44 test panels at Pier No. 8. The growths generally rated as traces on the panels of the control series and from traces to light on the panels of the test series. Tubularia was identified at each location. A trace of Metridium occurred on a single test panel at Pier No. 1 (Fuel Oil Pier) and on 2 of the control panels and 4 of the test panels at Pier No. 8.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on one test panel at both the Receiving Station Pier and Pier No. 1 (Fuel Oil Pier) and on three test panels at Pier No. 8. Cryptosula pallasiana was identified on one test panel at the last-named location. Filamentous Bryozoa occurred more or less abundantly on the panels at all three locations. They were present on 2 of the 38 control panels and 15 of the 45 test panels at the Receiving Station Pier, on 3 of the 38 control panels and 10 of the 45 test panels at Pier No. 1 (Fuel Oil Pier), and on a single control panel and 10 of the 44 test panels at Pier No. 8. Bugula sp. was identified on a panel at the last-named location.

d. Annelida (annelid worms). Traces of serpulid (Serpula) tubes occurred on 3 test panels at the Receiving Station Pier and on four test panels at both Pier No. 1 (Fuel Oil Pier) and Pier No. 8.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred with great frequency and in abundance on the panels at all three locations. They appeared on 22 of the 38 control panels and on all 45 test panels at the Receiving Station Pier, on 21 of the 38 control panels and all 45 test panels at Pier No. 1 (Fuel Oil Pier), and on 15 of the 36 control panels and all except one of the 44 test panels at Pier No. 8. On the control panels, maximum diameters of 10, 10, and 8 mm were recorded, and on the test panels, maximum diameters of 20, 20, and 16 mm, in 8 to 9 months, were recorded for the respective locations in the above order. Many tubular forms, which develop as a result of crowding, occurred at each location. The maximum length of these forms was 30 mm. At the Receiving Station Pier, 8 control panels were from 50% to 100% covered, and 42 test panels were from 60% to 100% covered.

f. Mollusca (nonboring mollusks). Mytilus (mussels) occurred on 14 of the 45 test panels at the Receiving Station Pier, on a single control panel and 15 of the 45 test panels at Pier No. 1 (Fuel Oil Pier), and on a single control panel and 10 of the 44 test panels at Pier No. 8. The largest number occurring on any one test panel at these



respective locations, in the order named, was 120, 160, and 20; their maximum lengths were 40 mm in 10 months, 55 mm in 9 months, and 22 mm in 8 months.

g. Chordata (tunicates). Tunicates occurred on a single control panel and 2 test panels at the Receiving Station Pier, on a single control panel and 7 test panels at Pier No. 1 (Fuel Oil Pier), and on a single panel of both the control and test series at Pier No. 8. A maximum number of 30 colonies on any one panel was found. Botryllus schlosseri was the only species identified.

## A37.05 Summary and Conclusions

1. Installation. Three test boards of the panel type installed June 16, 1944, at three different locations at the Puget Sound Naval Shipyard, Bremerton, Washington, are still being operated. The results of these tests have been summarized to the end of 1947.

### 2. Test Results.

a. Borers. Teredinidae were very active each year at each of the locations. The breeding season appeared to extend from February or March through November. The attack rated very heavy each year after 1944 at each location, panels submerged for 8 months frequently becoming filled or riddled. Limnoria were active at each location but generally occurred in small numbers only, the severity of attack varying at the different locations and in different years. At the Receiving Station Pier, it never exceeded a trace except on one panel removed early in 1947 after 10 months' submergence, where a peak low in the moderate rating was attained. At Pier No. 1 (Fuel Oil Pier), the attack was low in the slight rating in 1945 and 1946 but attained a peak rating of moderate in 1947. At Pier No. 8, it rated slight in 1945, attained a peak rating of moderate in 1946, and lapsed to low in the slight rating in 1947.

It became apparent from the use of panels made of a number of different kinds of coniferous woods, including the heartwood and sapwood of Douglas fir, at the three locations in 1944, that Bankia setacea and Limnoria attack one kind of wood as readily as another.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The latter comprised sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, mussels and jingle-shells, and tunicates. Of these organisms, hydroids and barnacles occurred with great frequency; filamentous Bryozoa and mussels occurred with moderate frequency; while the occurrence of the others, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. At the Receiving Station Pier, there was a trace of Teredinidae in 1948 and a slight attack in 1949. Limnoria rated a trace in both years at this location. The Teredinidae attack was heavy in 1948 and very heavy in 1949 at the Fuel Oil Pier, where the attack by Limnoria rated a trace in both years. A medium heavy onslaught of Teredinidae and a slight attack of Limnoria was recorded in both 1948 and 1949 at Pier No. 8.

## Section 38

### TACOMA, WASHINGTON -- TODD PACIFIC SHIPYARDS, INC.

#### A38.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the Todd Pacific Shipyards, Inc., at Tacoma, Washington, from September 15, 1944 until March 19, 1946, when it was discontinued. This board was located approximately 180 ft from the north end of Outfitting Pier No. 4, which is approximately 2,880 ft long, located in the Wapato Waterway. It was placed in the area showing the greatest degree of infestation by marine borers. Original diver inspections and subsequent removal of piling from the dock has indicated a substantially greater degree of infestation on the piling where the mud line was in deeper water. This test board was designated by the symbol USNTW-1.

#### A38.02 Hydrographic Data

The depth of water where the test board was installed was 27.5 ft at low tide; the tidal range was given as 16 ft from extreme low to extreme high tide; the velocity of the current was not reported. The temperature of the water at the time of installation was 57° F at high tide and 56° F at low tide (temperatures taken 27 ft below surface at both high and low tides). In both instances, the temperature was taken at minus 15 ft below 0.0 water. Eight 8-in. sanitary sewer lines expelled sewage under this dock from toilet facilities serving approximately 15,000 people daily. One 8-in. sewer line outlet was located approximately 75 ft from the test board.

#### A38.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia setacea and Teredo (Lyrodus) sp., were active throughout the period of the test, occurring in 11 of the 19 control panels and in all except 2 of the 26 test panels. Of the control panels, two submerged for 4 months were 50% filled; one submerged for 5 months was 75% filled; and two submerged for 6 and 7 months, respectively, were completely filled. Specimens up to 80 mm long were found in one of the panels submerged for 4 months. The breeding season extends from the middle of December to the middle of November.

One of the test panels exposed for 4 months was filled with specimens up to 190 mm in length. All 11 panels submerged for from 5 to 8 months were riddled, and several were at least half destroyed, with specimens ranging up to 350 mm in length. The attack by Teredinidae at this location rated very heavy and appears to be continuous throughout the year.

2. Limnoria. Limnoria occurred in 6 of the 19 control panels and in 19 of the 26 test panels. In the test panels there was a slow, but more or less gradual, build-up from the beginning of the test, but the maximum attack, even after 8 months' exposure, did not exceed a low slight rating and rated only a trace most of the time.

#### A38.04 Fouling Agents

1. Silt. Silt occurred as traces on 15 of the 19 control panels and as traces to light deposits on 25 of the 26 test panels.

#### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 7 of the 19 control panels. They also occurred as traces on the first 14 of the test panels submerged up to November 15, 1945, but no forms occurred thereafter. Bugula flabellata was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa were lacking on the control panels but occurred on 16 test panels. Their occurrence on the latter resembled that of the hydroids in that, with the exception of the first panel, they occurred regularly on all panels removed before November 15, 1945, but occurred subsequently only on the last 2 panels in the test. They ranged from a few up to 35 colonies per panel. Schizoporella unicornis was identified repeatedly; Cheiloporina praelonga also was identified. Filamentous Bryozoa were recorded on only 3 of the test panels.

c. Annelida (annelid worms). Traces of serpulid (Serpula) worms were recorded on only 4 test panels.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on only 2 control panels, where the maximum diameter was 2 mm. On the test panels, they occurred regularly on all panels removed from July 6 to November 15, 1945, after 8 months' submergence. One panel was 10% covered; one, 40%; one, 50%; and three, 100%. Strangely, however, despite their abundance during this period, there were no barnacles on the test panels at any other time. The maximum diameter recorded was 15 mm in a panel submerged 8 months.

#### A38.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the Todd Pacific Shipyards, Inc., at Tacoma, Washington, from September 15, 1944 until its discontinuance on March 19, 1946, to determine the identity and prevalence of marine borers and fouling agents at this location.

## 2. Test Results.

a. Borers. The attack by Teredinidae at this location rated very heavy; the breeding season appears to extend from the middle of December to the middle of November. All panels exposed for five or more months were riddled, and several were at least half destroyed. Limnoria were active throughout the test, but the maximum attack, even after 8 months' submergence, did not exceed a low slight rating and rated only a trace most of the time.

b. Fouling Organisms. Silt and invertebrate animals belonging to 4 phyla contributed to the fouling of the panels. The phyla included hydroids, encrusting and filamentous Bryozoa, serpulid worms, and barnacles. Silt occurred with great regularity on nearly all the panels. Hydroids and encrusting Bryozoa occurred with great regularity during the first half of the test, but hydroids failed to occur subsequently, and encrusting Bryozoa did not appear again until at the end of the test. Barnacles were present in great abundance on a series of test panels submerged at monthly intervals during a period of 6 months, but failed to occur on test panels at any other time. The occurrence of filamentous Bryozoa and serpulid worms was only occasional.

## Section 39

### ASTORIA, OREGON -- U. S. NAVAL STATION TONGUE POINT

#### A39.01 Location of the Test Station and Test Board

A test board of the panel type was installed at the U. S. Naval Station at Astoria, Oregon, on July 18, 1944, and operated until February 18, 1946. It was later requested that the operation of this test board be discontinued because no marine borers were present at this location. The station is located about 8 miles upstream from the mouth of the Columbia River, i.e., from where the river empties into the Pacific Ocean. The test board was located at the extreme north end of Pier No. 2 and was designated by the symbol USNAO-1.

The port of Astoria docks, which were leased by the Navy Department, were constructed between 1914 and 1921, and the original piling was still in place in 1944. The piling was reported to be in excellent condition below the low water level, but it had rotted out between the tidal ranges. The piles under the docks had been cut off at approximately the 3-ft. elevation and reposted up to the main decks of the piers. The maximum decay occurred close to mean high water, but there had been absolutely no indication of decay or of disintegration of the piles below mean low water. Moreover, there had been no indication of any wooden piling at this Station having been damaged by marine borers.

#### A39.02 Hydrographic Data

The depth of water at the location where the test board was installed was 18.1 ft below mean low water; the tidal range was 12 ft (from -2 to +10 ft); the current was reported to vary from 0 to 6 knots. The temperature of the water at the time of installation was 65° F. The salinity of the water surrounding the Naval Station varies greatly each day, changing from nearly 100% fresh at ebb tide to a considerable salt content at flood tide. The water carried considerable silt, but was not strongly polluted with acids because of the large volume of flow.

#### A39.03 Marine Borers

There was no evidence whatever of activity of any marine borers during the approximately 1½-year period covered by the test. In fact, the daily variation of the water from saline to practically fresh water would preclude the possibility of either Teredinidae or Limnoria becoming established at this location.

#### A39.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control

and test series except on 2 of the former. The deposits ranged from traces to light on the panels of the control series, and from moderate to heavy, and occasionally oily, on the panels of the test series.

## 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces or light growths on 12 of the control panels, although no forms occurred on any of the 4 removed after October 18, 1945. They occurred on all of the 19 of the test panels, the growths being mostly moderate or heavy.

b. Arthropoda (crustaceans). Barnacles occurred on only 2 of the 19 control panels and on 6 of the same number of test panels. One of the test panels was 25% covered. Maximum diameters of 4 mm were recorded on the control panels and 12 mm on a test panel which had been submerged for 8 months. Amphipods (mostly Corophium) occurred on 10 control panels and on 16 of the 19 test panels, frequently being numerous, particularly on the test panels.

## A39.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Station at Astoria, Oregon, from July 18, 1944 until its discontinuance on February 18, 1946, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

### 2. Test Results.

a. Borers. There was no evidence whatever of activity of marine borers during the approximately 1½-year period covered by the test. The daily variation of the water from saline to practically fresh would preclude the possibility of either Teredinidae or Limnoria becoming established at this location.

b. Fouling Organisms. Silt and invertebrate animals belonging to 2 phyla contributed to the fouling of the panels. The invertebrate animals comprised hydroids, and barnacles and amphipods, the latter being largely Corophium. Of these organisms, the hydroids occurred with considerable frequency, Corophium occurred with less frequency, and barnacles occurred with still less frequency.

## Section 40

### VALLEJO, CALIFORNIA -- MARE ISLAND NAVAL SHIPYARD

#### A40.01 Location of the Test Station and Test Boards

Three test boards of the panel type were installed June 20 and 21, 1944, in different locations at the Mare Island Naval Shipyard, Vallejo, California. Mare Island is located at the eastern side of San Pablo Bay, and the piers where the test boards are located are in Mare Island Strait, sometimes called the Napa River, between Mare Island and Vallejo. The first of these test boards, designated by the symbol USNMI-1, is located near the north end of the Shipyard on the south side of the east end of Shipbuilding Ways No. 8. The second, designated by the symbol USNMI-2, is located near the south end of the industrial yard, on the north side of Finger Pier No. 21 about 50 ft west of the eastern end. The third, designated by the symbol USNMI-3, is located near the southeastern end of Mare Island, about 15 ft from the southeastern corner of the Naval Ammunition Depot Pier, at Berth 34-E.

The test board at Finger Pier No. 21, which was lost sometime after the panels were removed, was replaced by others on September 21, 1944; a new board was installed about 5 ft inboard from the old location on December 23. On October 25, 1945 it was reported that the test board at Finger Pier No. 21 was lost because of ship movements or tides, and that the board at the Naval Ammunition Depot Pier was swept under this pier and was fouled, so that it could not be withdrawn until favorable low tides would permit dismantling. Both boards were replaced by new boards at the same locations on December 6, 1945. The operation of these test boards is being continued. The results of these tests have been summarized to the end of 1947.

#### A40.02 Hydrographic Data

1. USNMI-1 (Shipbuilding Ways No. 8). The depth of water where this test board was installed was 9 ft below mean low water. It was installed with its lower end at a depth of 7 ft and its top at a depth of one ft below mean low water. The usual range of tide was 6.2 ft from mean low water to mean high water. The extreme high water (February 13, 1938) was 9.5 ft above mean low water. The extreme low water was 2.6 ft below mean low water, and the extreme indicated variation in the water was 12.1 ft. The velocity of the current in Mare Island Strait



varies with the stage of the tide, reaching a maximum of approximately 4 miles per hour. The temperature of the water at the time of installation was 64° F. A sample of the channel water, taken in the immediate vicinity of the test board on June 26, 1944, contained 12,620 ppm of salt. During the one-year period prior to the installation of the test board, the salinity of the channel water varied from approximately 4,000 to 24,000 ppm. The water had a dirty, muddy-brown color and contained some visible foreign material.

2. USNMI-2 (Finger Pier No. 21). The depth of water where this test board was installed was 22 ft below mean low water. The board was installed with its lower end at a depth of 20 ft and the top at a depth of 14 ft below mean low water. The tidal range and velocity are the same as the readings given for the first test board. The temperature of the water at the time of installation was 64° F. A sample of the channel water taken June 26, 1944, in the immediate vicinity of this test board contained 12,920 ppm of salt. The water was moderately dirty and contained some visible foreign material.

3. USNMI-3 (Naval Ammunition Depot Pier). The depth of water where this test board was installed was 20 ft below mean low water. The board was installed with its lower end at a depth of 16 ft and the top at a depth of 10 ft below mean low water. The tidal range and velocity are the same as the readings given for the first test board. The temperature of the water at the time of installation was 63° F. A sample of the channel water taken in the immediate vicinity of the test board on June 26, 1944, contained 13,260 ppm of salt. The water was moderately dirty.

Further data on the temperature and salinity records, as well as on the pH reaction of the water at these locations, are given in the three following tables:

Record of temperature of the water in degrees F, based on readings taken at various times each month, showing the general range throughout the year at each location

Month	Shipbuilding Ways No. 8					Finger Pier No. 21					Naval Ammunition Depot Pier				
	1944	1945	1946	1947	1948	1944	1945	1946	1947	1948	1944	1945	1946	1947	1948
January		48	51.8	44	52		47.7	51.0	44	52		47.0	50.8	44	51
February		52.5	46.5	50	48		52.0	46.7	50	48		53.5	46.8	50	48
March		52.3	53	54			52.3	53	54			53.0	53	54	
April		61.2	62	61			60.2	60	61			60.5	60	61	
May		63.5	64	66			62.8	64	68			62.8	64	66	
June	64	61.0	--	68		64	65.0	--	68		63	66.0	--	68	
July	67.5	68.6	72	72		66.5	67.7	68	72		66	68.5	68	72	
August	65.8	--	53	70		--	--	53	70		--	--	53	70	
September	--	--	48	--		65.0	--	48	--		--	--	48	--	
October	62.6	65.5	47	67		62.5	--	46	67		62	--	47	67	
November	55.0	--	38	60		54.8	--	38	60		55.5	--	38	60	
December	51.5	52.5	52	52		52.5	54.7	51	52		51.5	53.5	51	52	

Record of salinity of water (p/m), based on readings taken at various times each month, showing the general range at each location

Month	Shipbuilding Ways No. 8			Finger Pier No. 21			Naval Ammunition Depot Pier			
	1944	1945	1946	1944	1945	1946	1944	1945	1946	1947
January		12,000	328 13,500		12,290	296 12,800		10,630	758 12,600	
February		5,080	6,300		5,240	5,575 8,400		6,940	6,100 10,800	
March		7,210	5,940		7,400	6,020 8,100		7,730	5,720 7,300	
April		7,060	5,380		7,320	5,970 10,500		4,900	3,080 9,700	
May		6,480	6,480		6,740	5,100 14,700		7,130	3,970 14,600	
June		9,300	-----		9,400	-----		9,400	-----	16,500
July		13,000	11,400		12,400	11,600 20,900		12,700	11,100 21,100	
August		19,870	16,100		-----	16,100 21,100		-----	13,900 19,900	
September		22,200	18,000		-----	17,400 -----		22,200	17,400 -----	
October		19,020	16,100		-----	17,200 18,800		-----	16,400 18,900	
November		15,400	16,700		-----	16,900 13,900		-----	16,700 15,100	
December		11,765	14,600		8,720	15,100 17,100		12,625	14,400 17,000	

Record of the pH reaction of the water, based on readings made at various times each month, showing the general range throughout the year at each location

Month	Shipbuilding Ways No. 8			Finger Pier No. 21			Naval Ammunition Depot Pier		
	1945	1946	1947	1945	1946	1947	1945	1946	1947
January		--	7.7		--	7.7		--	7.7
February		--	7.6		--	7.6		--	7.6
March		7.9	7.6		7.9	7.5		8.0	7.7
April		7.7	7.7		7.6	7.7		7.7	7.7
May		7.5	7.3		7.5	7.5		7.5	7.8
June		--	7.4		--	7.1		--	7.5
July	7.8	7.0	7.7	7.9	7.0	7.7	8.0	6.5	7.7
August		7.4	7.5		7.5	6.8		7.7	7.5
September		7.6	--		7.8	--		8.1	--
October		7.0	7.3		7.0	7.2		7.2	7.4
November		7.8	7.5		7.8	7.5		7.9	7.4
December		7.6	7.5		7.5	7.5		--	7.5

#### A40.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo navalis and T. (Lyrodus) sp., were active at all three locations throughout the period covered by the tests. The detailed figures on their occurrence at each of these locations are summarized below.

a. Shipbuilding Ways No. 8. Teredinidae occurred in 9 of the 37 control panels. They ranged from minute pits and embryonic specimens to those specimens up to 20 mm in length. The breeding season at this location appeared to extend from the middle of May through October. In the test panels, Teredinidae occurred in 29 of the 38, with a maximum length recorded in one panel submerged for 8 months. Two of these panels were filled after having been submerged for 8 and 9 months, respectively. The attack at this location rated very heavy in 1945, moderate in 1946, and very heavy in 1947.

b. Finger Pier No. 21. Teredinidae occurred in 8 of the 32 control panels, but there were none in the panels removed from September 21, 1944 to May 23, 1947, with the exception of the panel submerged from September 3 to October 9, 1946. They ranged from minute pits to specimens up to 42 mm in length. The breeding season at this location appeared to extend from the middle of May through October. Teredinidae occurred in 16 of the 32 test panels and again none occurred in the panels removed from September 21, 1944, to September 3, 1946, but they did occur in every panel thereafter. A maximum length of 320 mm (about 15 inches) was recorded in a panel submerged for 9 months. The last 2 of these panels were filled. At this location there was no attack in 1945; the attack in 1946 rated moderate; and in 1947, very heavy.

c. Naval Ammunition Depot Pier. Teredinidae occurred in 6 of the 32 control panels here, but there were none in the panels removed from October 23, 1944 to May 23, 1947, except in the panel submerged from September 3 to October 9, 1946. The specimens ranged from minute pits to individuals up to 25 mm in length. The breeding season appeared to extend from the middle of May through October. Teredinidae occurred in 23 of the 35 test panels, with a maximum length of 135 mm recorded on one panel submerged for 8 months. Six consecutive panels removed from late 1944 to early 1945 were riddled, and one panel taken out in 1947 was filled. The attack at this location rated very heavy in 1944 and 1945, moderate in 1946, and very heavy in 1947.

2. Limnoria. No evidence of Limnoria occurred in either the control or test panels at any of the three locations.

#### A40.04 Fouling Agents

1. Silt. Silt occurred on all the panels except 2 of the control panels at Shipbuilding Ways No. 8. The deposits, in general, ranged from traces to light or rarely moderate on the panels of the control series and from light to moderate on the panels of the test series.

2. Algae. Traces of green algae appeared on a single panel of each of the control and test series at Shipbuilding Ways No. 8.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred with great frequency on the panels at all locations. They were on 25 of the 37 control panels and 36 of the 38 test panels at Shipbuilding Ways No. 8 on 14 of the 32 control panels and 27 of the 32 test panels at

Finger Pier No. 21, and on 24 of the 35 control panels and 31 of the 32 test panels at the Naval Ammunition Depot Pier. The growths generally rated as traces or rarely moderate on the panels of the control series and from traces to moderate on the panels of the test series. Tubularia occurred at all locations, and Pennaria sp. was identified at the Naval Ammunition Depot Pier.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on the panels at all locations. They were on 2 of the 37 control panels and 13 of the 38 test panels at Shipbuilding Ways No. 8, on 4 of the 32 control panels and 8 of the same number of test panels at Finger Pier No. 21, and on a single one of the 35 control panels and 13 of the 32 test panels at the Naval Ammunition Depot Pier. Electra sp. was the only form identified, and this form occurred at all three locations. One of the test panels at Shipbuilding Ways No. 8 was 50% covered and one test panel at the Naval Ammunition Depot Pier was 25% covered. A trace of a filamentous Bryozoan (Bugula sp.) occurred on a single control panel at the Naval Ammunition Depot Pier.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred with great frequency and abundance on the panels at all three locations. They were on 25 of the 37 control panels and all 38 of the test panels at Shipbuilding Ways No. 8, on 20 of the 32 control panels and 27 of the same number of test panels at Finger Pier No. 21, and on 25 of the 35 control panels and 29 of the 32 test panels at the Naval Ammunition Depot Pier. On the control panels, maximum diameters of 9, 8, and 8 mm were recorded for the locations in the above order, while on the test panels, maximum diameters of 18, 12, and 18 mm were attained in 8, 4, and 8 months, respectively. At Shipbuilding Ways No. 8, 20 of the control panels were 40% to 100% covered, and all 38 of the test panels were 20% to 100% covered. At Finger Pier No. 21, 13 of the control panels were 30% to 90% covered, and 23 of the test panels were 5% to 100% covered. At the Naval Ammunition Depot Pier, 18 of the control panels were 40% to 100% covered, and 21 of the test panels were 30% to 100% covered. Corophium occurred on a single test panel at Shipbuilding Ways No. 8, on 4 of the test panels at Finger Pier No. 21, and on 3 of the test panels at the Naval Ammunition Depot Pier, the largest number appearing on any panel being 100 forms. Other amphipods occurred on 3 of the test panels at both Finger Pier No. 21 and the Naval Ammunition Depot Pier.

d. Mollusca (nonboring mollusks). Mytilus (mussels) occurred on 20 of the 38 test panels at Shipbuilding Ways No. 8, on 2 of the control panels and 15 of the test panels at Finger Pier No. 21, and on 7 of the control panels and 25 of the test panels at the Naval Ammunition Depot Pier. A maximum length of 17 mm was recorded on the

control panels, and maximum lengths of 40, 38, and 42 mm were recorded on the test panels at these locations in 8½, 9, and 9 months, respectively. At Shipbuilding Ways No. 8, 2 of the test panels were 60% to 100% covered, and at the Naval Ammunition Depot Pier, 4 of the test panels were 25% to 100% covered.

e. Chordata (tunicates). A few colonies of tunicates (Botryllus schlosseri) occurred on a single test panel at Finger Pier No. 21.

#### A40.05 Summary and Conclusions

1. Installation. Three test boards of the panel type installed at different locations at the Mare Island Naval Shipyard at Vallejo, California, on June 20 and 21, 1944, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were active at all locations throughout most of the period covered by the tests, the breeding season at each place apparently extending from the middle of May through October. At Shipbuilding Ways No. 8, the attack rated very heavy in 1945, moderate in 1946, and very heavy in 1947. At Finger Pier No. 21, there was no attack in 1945, only a moderate one in 1946, but a very heavy attack in 1947. At the Naval Ammunition Depot Pier, the attack rated very heavy in 1944 and 1945, moderate in 1946, and very heavy in 1947. No evidence of Limnoria occurred in either the control or test panels at any of the three locations.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, barnacles and amphipods, mussels, and tunicates. Of these organisms, hydroids and barnacles occurred with greatest frequency, with the latter in unusual abundance; mussels occurred with considerable frequency; encrusting Bryozoa occurred with less frequency; and the occurrence of the others, as well as the algae, was purely sporadic or occasional.

3. Recent Addenda. The Teredinidae attack was moderate in 1948 and slight in 1949 at Shipbuilding Ways No. 8. There was no evidence of Limnoria either year at this location. At Finger Pier No. 21, a medium heavy attack of Teredinidae occurred in 1948, and a moderate attack occurred in 1949. Again, no Limnoria occurred either year at this location. Examination of panels from the test board at the Naval Ammunition Depot Pier revealed a moderate Teredinidae attack in 1948 and a medium heavy onslaught the following year. No Limnoria at all made their appearance either year on this test board.

## Section 41

### SAN FRANCISCO, CALIFORNIA -- SAN FRANCISCO NAVAL SHIPYARD

#### A41.01 Location of the Test Station and Test Board

A panel-type test board was installed on July 5, 1944, at Hunter's Point, San Francisco, California, at the station formerly known as the U. S. Naval Drydocks, but now designated the U. S. Naval Shipyard. When an attempt was made to remove the first panels on August 12, it was discovered that the board was missing. A new one was at once installed, and the test is considered to have begun on the last-named date.

The board was installed at the end of the second pier east of Drydock No. 5 between berths 57 and 58. This pier, a timber structure, extends 400 ft into San Francisco Bay. This test board was designated by the symbol USNMI-4. The operation of this test board is being continued, and the results of the test have been summarized to the end of 1947.

The destructive attacks by Teredinidae in the San Francisco Bay region have long been of major concern, and a number of intensive studies of the situation have been made and published. The destructiveness of Teredinidae is well illustrated in figure 11, which shows an untreated Ponderosa pine pile from the storage boom dolphin at Hunter's Point, which was driven on February 8, 1943, and broke on June 18, 1943.

#### A41.02 Hydrographic Data

The depth of water where the test board was installed was 26 ft at mean low water. The tidal range was 9 ft, with a mean range of 6 ft. The current velocity was given as 2.2 knots (at time of tropic currents). The temperature of the water at the time of the original installation in July was 64° F. Two samples of water from the Bay, taken 23 ft below mean low water, were submitted to the Industrial Laboratory for analysis of salinity in 1946. One taken at SubBase (end of Pier B), 2 hours after low tide on March 20, showed a salinity (expressed as sodium chloride) of 23.1 parts per thousand. The second, taken at SubBase (head of Pier B), at high tide on March 21, showed a salinity (expressed as sodium chloride) of 22.2 parts per thousand. The Coast and Geodetic Survey Publication DW-2, November 1941, gives the following information on San Francisco Bay salinity.



## Salinity expressed as sodium chloride in parts per thousand

Month	Dumbarton Bridge 1937	Yerba Buena 1947
January	31.9	29.1
February	26.5	25.5
March	20.1	19.7
April	16.0	19.2
May	19.9	----
June	22.5	----
July	25.0	29.0
August	27.7	30.7
September	29.5	31.8
October	30.0	31.8
November	----	----
December	----	----

A41.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia setacea, Teredo (Lyrodus) diegensis, and Teredo navalis, were very active at this location throughout the period of the test. They occurred in 18 of the 40 control panels, ranging from minute pits to embryonic specimens. The breeding season appears to extend from March to the middle of January. Teredinidae occurred in all of the 39 test panels (one panel was not received). Specimens up to 440 mm in length were recorded in a panel submerged for 8 months, and 13 of the panels in 1945 and 1946 were filled or more or less completely riddled in 8 months. The attack in 1945 and 1946 was very heavy, but in 1947 it rated only moderate.

2. Limnoria. Limnoria were quite active throughout the period of the test. They occurred on 28 of the 40 control panels, with a maximum number of 660 recorded on 2 of these panels in 1946. They occurred in all except one of the 39 test panels. The Limnoria attack never rated more than slight in 1945 and 1946 but attained a rating of medium heavy in 1947.

#### A41.04 Fouling Agents

1. Silt. Silt occurred as traces to light deposits on all except 3 of the 40 control panels and as light to moderate deposits on all of the 39 test panels.

2. Algae. Traces of green algae occurred on a single panel of both the control and test series.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on 25 of the 40 panels and as traces to light growths on 37 of the 39 test panels. Tubularia was identified repeatedly.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred sparingly on a single control panel and on 4 of the 39 test panels. Cryptosula sp. was the only one identified. Filamentous Bryozoa occurred more or less abundantly on 7 of the 40 control panels and on 23 of the 39 test panels. Bugula flabellata and Bugula sp. were the only identifications.

c. Arthropoda (crustaceans). Balanus (barnacles) occurred in unusual abundance on 27 of the 40 control panels and on all of the 39 test panels. Eleven of the control panels were 25% to 100% covered, and 34 of the test panels were 20% to 100% covered. Maximum diameters of 9 mm were recorded on a control panel and 13 mm on a test panel after 8 months' submergence. Corophium occurred abundantly on a single test panel.

d. Mollusca (nonboring mollusks). Mytilus (mussels) occurred on a single control panel and on 19 of the 39 test panels. They ranged in numbers from a few to 40 or 50. A maximum diameter of 17 mm was recorded on a control panel and 31 mm on a test panel after 8 months' submergence. A solitary specimen of Anomia (jingle-shells), 12 mm in diameter, occurred on a single test panel.

e. Chordata (tunicates). Traces of tunicates (Botryllus schlosseri) occurred on a single control panel and on 2 of the test panels.

#### A41.05 Summary and Conclusions

1. Installation. A test board of the panel type installed at the U. S. Naval Drydocks at Hunter's Point, San Francisco, California, on August 12, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

## 2. Test Results.

a. Borers. Teredinidae were very active at this location throughout the period of the test, the breeding season apparently extending from March to the middle of January. The attack rated very heavy, in 1945 and 1946 but only moderate in 1947. Limnoria also were quite active throughout the period of the test. The attack never rated more than slight in 1945 and 1946 but attained a rating of medium heavy in 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, barnacles and amphipods, mussels and jingle-shells, and tunicates. Hydroids and barnacles occurred with great frequency, the latter occurring in unusual abundance. Filamentous Bryozoa occurred with considerably less frequency, while the occurrence of the others, as well as the algae, was purely sporadic or occasional.

3. Recent Addenda. At this station, the Teredinidae attack rated as heavy in 1948 and very heavy the following year. Limnoria attained a medium heavy rating in 1948 and a moderate rating in 1949. Chelura was plentiful in both years.

## PORT CHICAGO, CALIFORNIA -- U. S. NAVAL MAGAZINE

A42.01 Location of the Test Station and Test Boards

Three test boards of the panel type were installed January 3, 1945, at the U. S. Naval Magazine at Port Chicago, California. This installation is located west of where the Sacramento and San Joaquin Rivers enter Suisun Bay, east of the Mare Island Naval Shipyard on San Pablo Bay at Vallejo. The first of these test boards, designated by the symbol USNMI-5, is located near the northeast corner of the Barge Pier. The second, designated by the symbol USNMI-6, is located about 65 ft west of the northeast corner of Wharf No. 2, and the third, designated by the symbol USNMI-7, is located about 25 ft west of the northeast corner of Wharf No. 3. The second of the boards is east of the first, and the third is east of the second. The test board at the Barge Pier was found to be missing in March 1947, so a new board was installed on April 4. The operation of these test boards is being continued, and the results of these tests have been summarized to the end of 1947.

A42.02 Hydrographic Data

1. Test Board No. 1 (USNMI-5). The depth of water where this test board was installed is 35 ft below mean low water. The board was installed with its top at a depth of 18 ft and its lower end at a depth of 24 ft below mean low water. The usual range of tide was 4.5 ft, i.e., from 5.3 ft to 0.8 ft above low water. The highest estimated tide was 8.0 ft above low water, and the lowest estimated tide was 2.0 ft below low water. The estimated extreme variation in the water height was 10.0 ft. The strength of current was not reported. Water temperature at the time of installation was 46° F. A sample of channel water taken in the immediate vicinity of the test board on January 3, 1945, contained 862 ppm of salt. The water was very clear.

2. Test Board No. 2 (USNMI-6). The depth of water where this test board was installed was 28½ ft below low water. The board was installed with its top at a depth of 21 ft and its lower end at a depth of 27 ft below water. The tidal range, temperature, and pollution were the same as data given for Test Board No. 1. A sample of water taken in the immediate vicinity of the test board on January 3, 1945, contained 217 ppm of salt.

3. Test Board No. 3 (USNMI-7). The depth of water where this test board was installed was 27 ft below low water. The board was installed with its top at a depth of 19 ft and its lower end at a depth of 25 ft below low water. The tidal range, temperature, and pollution were the same as data given for Test Board No. 1. A sample of water taken in the immediate vicinity of the test board on January 3, 1945, contained 135 ppm of salt. Further data on the temperature, salinity, and pH reaction of the water at these locations are given in the tables below.

4. Water Temperature. The following record of water temperature in degrees F, from readings made at various times each month, shows the general range throughout the year at each location.

Month	Barge Pier			Wharf No. 2			Wharf No. 3		
	1945	1946	1947	1945	1946	1947	1945	1946	1947
January	46	49	43	46	49	43	46	49	43
February	48	47	52	48	46	52	48	46	52
March	50	52	54	50	52	54	50	52	54
April	54	58	--	54	58	62	54	58	54
May	63	--	64	63	--	64	62	--	64
June	62	65	--	62	65	--	62	65	--
July	68	70	67	68	70	67	68	70	67
August	68	51	67	68	51	71	68	51	71
September	68	48	70	68	48	70	68	46	70
October	66.5	46	64	66.5	46	64	66.5	46	65
November	60	38	56	60	38	56	60	38	56
December	51	51	47	51	51	47	51	51	47

5. Water Salinity. The following record of salinity of the water (as sodium chloride in parts per million), made at various times each month, shows the general range throughout the year at each location.

Month	Barge Pier			Wharf No. 2			Wharf No. 3		
	1945	1946	1947	1945	1946	1947	1945	1946	1947
January	862	24	8,200	217	28	5,800	135	32	5,700
February	142	3,870	2,080	149	1,960	1,420	149	1,370	850
March	232	120	240	232	60	160	174	100	110
April	130	79	-----	91	93	1,980	39	86	1,220
May	46	-----	7,460	52	-----	7,460	46	-----	6,500
June	1,250	413	-----	660	538	-----	460	216	-----
July	1,850	5,640	7,600	1,080	3,970	5,700	630	2,290	5,300
August	7,470	9,320	13,000	5,200	7,150	13,400	4,000	6,230	13,700
September	8,270	11,000	11,300	5,870	7,350	11,200	3,730	7,080	9,800
October	6,700	7,920	12,150	3,700	4,260	11,100	2,400	3,280	10,900
November	5,660	12,300	6,800	1,810	7,700	3,300	3,000	7,700	2,700
December	713	10,900	9,800	326	7,600	6,900	286	7,600	6,100

6. Hydrogen-Ion Determination. The following record of pH determination of the water, made at various times each month, shows the general range throughout the year at each location.

Month	Barge Pier		Wharf No. 2		Wharf No. 3	
	1946	1947	1946	1947	1946	1947
January	---	7.6	---	7.8	---	7.7
February	---	7.3	---	7.5	---	7.6
March	8.0	7.0	7.8	7.6	8.1	7.6
April	7.7	---	7.7	7.2	7.8	7.6
May	---	7.8	---	7.7	---	7.5
June	7.0	---	6.5	---	7.4	---
July	8.0	7.7	8.2	7.7	7.6	7.8
August	8.2	7.9	7.9	7.6	8.0	7.7
September	7.6	7.3	7.5	7.5	7.7	7.5
October	7.8	7.4	7.8	7.6	7.8	7.6
November	8.1	7.8	8.0	7.9	8.1	8.1
December	7.6	7.7	7.5	7.5	7.5	7.4

## A42.03 Marine Borers

1. Teredinidae. There was relatively little evidence of the activity of Teredinidae, including Teredo navalis and T. sp., at any of these locations except during 1947. The details of the occurrence of these borers at each location is summarized below.

a. Barge Pier. Only 3 minute pits occurred in 2 of the control panels submerged from August 8 to October 6, 1947. Teredinidae were recorded in 5 of the 31 test panels, but none at all were noticed until the latter part of 1946. The largest number found in any of the test panels was 67 in one panel submerged from April 25 to December 10, 1947. The maximum length recorded was 90 mm in 2 panels, each submerged for 6 months. The breeding season at this location appears to be relatively brief, apparently lasting from August to early October. There was no attack in 1945, only a single specimen was recorded late in 1946, and the attack in 1947 rated only moderate.

b. Wharf No. 2. There were only 2 minute pits in the control panel submerged from September 5 to October 6, 1947. Teredinidae occurred only in the last 5 test panels, which had been submerged from November 4, 1946 to December 10, 1947. The largest number in any test panel was 64 in one panel submerged from December 15, 1946 to September 5, 1947. The maximum length recorded was 65 mm, this specimen appearing in a panel submerged 9 months. The breeding season at this location seems to be extremely brief, probably lasting only from August to early October. There was no attack in 1945 or 1946, and that of 1947 rated only moderate.

c. Wharf No. 3. Only 2 minute pits occurred in the control panel submerged from September 5 to October 6, 1947. Teredinidae occurred only in the last 3 test panels, which had been submerged from February 26 to December 10, 1947. The maximum length recorded was 60 mm in this same panel after being submerged for  $7\frac{1}{2}$  months. The breeding season at this location is extremely brief, apparently being limited to September and early October. There was no attack in 1945 or 1946, and that in 1947 rated very slight.

The slight to relatively light Teredo attacks at these locations are unquestionably caused by the low salinity conditions which prevail during a large part of the year and which are unfavorable for the development of borers. It is interesting to note, in this connection, that the attack at Wharf No. 2 was lighter than that at the Barge Pier, and that the attack at Wharf No. 3 was lighter than that at Wharf No. 2.

In other words, the intensity of attack diminished from west to east. A study of the figures given in table 2 indicates that the salinity of the bay water also diminishes as one proceeds eastward toward the mouths of the Sacramento and San Joaquin Rivers. Here we see clearly the connection between the rate of intensity of marine borer attack and the salinity of the water. The salinity records for 1945 through 1947, for all three of the test board locations at Port Chicago, disclose a wide range of variation for different times of the year. At no time was the water even half as saline as normal ocean water, and the salinity was generally extremely low during the first half of each year, especially during the summer months when the water is merely brackish.

2. Limnoria. The only evidence of Limnoria at any of the three locations was a single tunnel found in a test panel at Wharf No. 2 and 3 tunnels found in a test panel at Wharf No. 3. Both of these panels had been submerged for 9 months and were removed early in June 1946.

#### A42.04 Fouling Agents

1. Silt. Silt occurred as traces to moderate or rarely heavy deposits on all the panels of both the control and test series at all three locations.

2. Algae. Traces of green algae occurred on a single panel of the control series and on one of the test series at Wharves 2 and 3.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids and Metridium). Hydroids occurred on 24 of the 31 control panels and on 24 of the 26 test panels (5 panels not received) at the Barge Pier. At Wharf No. 2, they occurred on 22 of the 33 control panels and on 32 of the 33 test panels. At Wharf No. 3, they occurred on 25 of the 33 control panels and on 32 of the 33 test panels. The growths mostly rated from traces to moderate on the panels of the control series and from traces to moderate, or occasionally heavy, on the panels of the test series. Tubularia was identified on several panels. Three colonies of Metridium a member of a different group of Coelenterata, occurred on a single test panel at Wharf No. 2.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on a single control panel and on 3 of the 26 test panels at the Barge Pier, on a single control panel and on 3 of the 33 test panels at Wharf No. 2, and on 2 of the 33 control panels and 3 of the 33 test panels at Wharf No. 3. Electra sp. was identified on a few of these panels. Filamentous Bryozoa occurred on a single test panel at the Barge Pier.



c. Arthropoda (crustaceans). Balanus (barnacles) occurred with great frequency and in great abundance on the panels at all three locations. At the Barge Pier, they were on 11 of the 31 control panels and on 23 of the 26 test panels. Fifteen of these control panels were 15% to 100% covered, and 21 of the test panels were 30% to 100% covered. A maximum size of 7 mm was recorded on a control panel and 12 mm on a test panel after 6 months' submergence. At Wharf No. 2, barnacles occurred on 20 of the 33 control panels and on 29 of the 33 test panels. Fourteen of the control panels were 25% to 100% covered, and 28 of the test panels were 50% to 100% covered. A maximum diameter of 8 mm was recorded on a control panel and 15 mm on a test panel after 9 months' submergence. At Wharf No. 3, barnacles occurred on 16 of the 33 control panels and on 28 of the 33 test panels. Twelve of the control panels were 40% to 100% covered, and 25 of the test panels were 60% to 100% covered. A maximum diameter of 9 mm was recorded on a control panel and 15 mm on a test panel after 9 months' submergence. Traces of amphipods occurred on a single control panel at both the Barge Pier and Wharf No. 2 and on 3 of the control panels and 2 of the test panels at Wharf No. 3. Isopods occurred on single panels of both the control and test series at the Barge Pier, on 2 panels each of the control and test series at Wharf No. 2, and on 2 control panels and 4 test panels at Wharf No. 3. The largest number on any one panel was 50 isopods.

d. Mollusca (nonboring mollusks). Mytilus (mussels) occurred on 10 of the 26 test panels at the Barge Pier, on 7 of the 33 test panels at Wharf No. 2, and on 8 of the 33 test panels at Wharf No. 3. The largest number on any panel was 33 mussels. Maximum lengths of 25 mm were recorded at each location after 7, 8, and 9 months' submergence, respectively.

#### A42.05 Summary and Conclusions

1. Installations. Three test boards of the panel type installed at different locations at the U. S. Naval Magazine at Port Chicago, California on January 3, 1945, to determine the identity and prevalence of marine borers and fouling organisms, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae showed relatively little activity at all three locations. The low salinity of the water, which appears to have been merely brackish during the spring months, was unfavorable for their development. The breaking season at these locations appears to be extremely short, apparently lasting only from August to early October at the Barge Pier and Wharf No. 2 and from September to early October at Wharf No. 3.

There was no attack at any location in 1945, and only a single specimen was recorded at the Barge Pier in 1946. In 1947, the attacks rated moderate at the Barge Pier and Wharf No. 2 but only very slight at Wharf No. 3. The only evidence of Limnoria at any of the three locations was a single tunnel found in a test panel at Wharf No. 2 and 3 tunnels found in a test panel at Wharf No. 3.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 4 phyla contributed to fouling of the panels. The latter comprised hydroids and Metridium; encrusting and filamentous Bryozoa; barnacles, amphipods and isopods; and mussels. Of these organisms, hydroids and barnacles occurred with great frequency, the latter in unusual abundance; mussels occurred rather infrequently; while the occurrence of the others, as well as the algae, was purely sporadic or occasional.

3. Recent Addenda. There were no Teredinidae whatever at the Barge Pier during 1948 and 1949. Limnoria also were absent. At Wharf No. 2, there was no change in the conditions already reported above. No Teredinidae appeared on the test or control panels at Wharf No. 3 in 1948, and the damage from a set in 1949 rated only a trace. There have been no Limnoria at this location since 1946.

## PORT HUENEME, CALIFORNIA -- U. S. NAVAL STATION

A43.01 Location of the Test Station and Test Boards

Two test boards of the panel type were installed June 15, 1944, at different locations in the harbor of what was then the Advanced Base Depot, but is now the U. S. Naval Station at Port Hueneme south of Ventura, California. The first of these boards, designated as USNPH-1, was installed under the LST Wharf B between bents 12 and 13 from the shore end. The second, designated as USNPH-2, was installed under Wharf No. 1, 50 ft east of the west end of Transit Shed No. 1. No untreated wood piling is in place in the harbor, and both test boards are located approximately 6 ft from creosoted piling. The operation of these test boards is being continued, and the results have been summarized to the end of 1947.

It was stated on December 26, 1944, that structural timbers recently removed from Wharf D, located near Wharf B, were found to be in an advanced stage of destruction from Teredo action. This material was Douglas fir, surface-treated with creosote, which was installed in 1940. It was anticipated that several more timbers would have to be removed and replaced with new material.

Decomposition during transit had progressed to such an extent that the identification of fouling organisms was impossible on 2 of the test panels of Test Board No. 1 and on one test panel of Test Board No. 2.

A43.02 Hydrographic Data

1. Test Board No. 1 (USNPH-1). The depth of water where this test board was installed was 14.5 ft at mean low tide; the tidal range varied from about 2.7 to 8.1 ft; the current velocity was said to be zero. The temperature of the water at the time of installation was 57° F. In samples of ocean water taken near Test Board No. 1 on November 21, 1945, the sample analysis showed a salinity of 30,725 ppm; and in samples taken February 22, 1946, the sample analysis showed a salinity of 31,600 ppm. In regard to pollution, it was stated on July 12, 1944, that the untreated sewage of the U. S. Naval Base is released into the harbor at a point approximately 200 ft from the test board for a period of 4 hours per week. However, in April 1946, it was stated that water pollution is regarded as light and that waste lines discharging into Hueneme Harbor comprise only the following: a line from 3 automotile wash racks passing approximately 3 gallons per minute of waste containing chemicals used for washing cars; a leaching

line 8 in. in diameter from sludge beds of Imhoff tanks; and a 14-in. by-pass discharging raw sewage, which is used only in case of emergency, as normally all sewage passes through Imhoff tanks for treatment.

2. Test Board No. 2 (USNPH-2). The depth of water where this test board was installed was 24.5 ft at mean low tide; the tidal range varied from about 2.7 to 8.1 ft; the current velocity was said to be zero. The temperature of the water at the time of installation was 59° F. The data in regard to salinity and pollution for this test board are the same as those for Test Board No. 1. Both test boards are suspended 8 ft above the mud line, with the bottom approximately 2 ft from that line.

The following record of the temperature of the water in degrees F, based on readings made mostly around the middle of each month and 3 ft above the mud line, shows the general range at each location.

Month	Test Board No. 1				Test Board No. 2			
	1944	1945	1946	1947	1944	1945	1946	1947
January		59	54	58		59	54	58
February		56	--	58		56	--	59
March		57	56	58		57	56	58
April		56	59	58		55	54	58
May		57	58	56		56	58	58
June		62	59	63		61	58	64
July		59	58	58		59	56	58
August		61	58	62		61	58	60
September		61	63	64		61	63	64
October		61	60	64		61	60	63
November		56	62	58		56	61	58
December	59	57	--	58	60	57	--	56

Temperatures of the water at both locations were recorded both at the surface and at 3 ft above the mud line. As a rule, the temperature at the surface was only one or two degrees higher than that taken 3 ft above the mud line, which indicated that there was little vertical variation.

#### A43.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia setacea, Teredo

navalis, T. (Lyrodus) diegensis, T. (Lyrodus) sp., and T. sp., were very active each year at both locations. In the control panels, they occurred in all but 2 of the 40 on Test Board No. 1; while on Test Board No. 2, they occurred in all except 2 of the 41 panels. The Teredinidae observed ranged from minute pits to embryonic or minute specimens and often occurred in large numbers. It is clearly apparent that the breeding season at this location is continuous throughout the year.

Teredinidae occurred in all the test panels except in one at each location, and these panels were the first in the 4-panel series which had been submerged for only one month each. The destruction by Teredinidae at both these locations was so severe that panels were becoming filled or riddled in 4 or 5 months; and after the test had run for 5 months, the panels were removed and blocks 3 inches thick were installed. However, the attack still continued to be severe, and on November 15, 1945, the period of submergence was reduced from 8 to 4 months. Even with 4-month submergence, many of the panels were more or less filled by the tunnels of Teredinidae, particularly in the panels on Test Board No. 1. The attack rated very heavy each year at both locations.

2. Limnoria. Limnoria were relatively active at both locations throughout the period covered by the tests, although never occurring in destructive numbers. In the control panels, they occurred in 3 of the 40 on Test Board No. 1, and these panels had only 2, 2, and 6 tunnels, respectively. On Test Board No. 2, they occurred in 18 of the 41 panels, 30 tunnels being the maximum number in any one panel; none occurred prior to June 15, 1945.

Limnoria occurred in every test panel of Test Board No. 1 submerged after February 14, 1946, but only 4 tunnels occurred in any of the panels submerged prior to that date. In the test panels of Test Board No. 2, Limnoria were more plentiful, occurring in 38 of the 60, but only in two panels during 1944. On Test Board No. 1, the Limnoria attack never rated more than a trace in any year; while on Test Board No. 2, it rated only a trace most of the time, but attained a peak rating of moderate late in 1945 and a rating of slight in the last test panel in 1947.

#### A43.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both test boards, the deposits ranging from traces to light, or rarely moderate, on the panels of the control series and generally from traces to moderate on those of the test series. The deposits on a number of panels at both locations were oily.

2. Algae. Algae, mostly green, occurred on 2 control panels and on one test panel of Test Board No. 1 and on a single control panel of Test Board No. 2, the growths rating as a trace or light.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 15 of the 40 control panels and on 39 of the 56 test panels of Test Board No. 1; on Test Board No. 2 they occurred on 17 of the 41 control panels and on 42 of the 56 test panels. The growths rated as traces on the panels of the control series and, in general, as traces to light on the panels of the test series. Tubularia occurred frequently.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on 11 of the 40 control panels and on 49 of the 56 test panels of Test Board No. 1; on Test Board No. 2 they occurred on 9 of the 41 control panels and on 40 of the 45 Test panels. On the test panels, 9 of the Test Board No. 1 and 15 of Test Board No. 2 were from 50% to 80% covered. Cryptosula pallasiana, Holoporella brunnea, Lichenopora sp., Schizoporella unicornis, and Tegella sp. were identified. Filamentous Bryozoa occurred more or less abundantly on 7 of the 40 control panels and on 26 of the 56 test panels of Test Board No. 1; on Test Board No. 2 they occurred on 11 of the 41 control panels and on 32 of the 56 test panels. Bugula flabellata, B. neritina, B. sp. were identified.

c. Annelida (annelid worms). Calcareous worm tubes occurred on 25 of the 56 test panels of Test Board No. 1 and on a single control panel and 34 of the 56 test panels of Test Board No. 2. On Test Board No. 1, the maximum number on any one test panel was 35 and the maximum diameter recorded was 40 mm after 4 months' submergence. On Test Board No. 2, the maximum number on any one test panel was 150, and the maximum diameter recorded was 50 mm after 4 months' submergence. Both Serpula and Spirorbis occurred.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred in small numbers and infrequently on the panels at both locations. They were recorded on 5 of the test panels of Test Board No. 1 and on a single control panel and 15 of the 56 test panels of Test Board No. 2, On this test board, a maximum diameter of 6 mm was recorded on a single control panel and 12 mm on the test panels after 4 months' submergence. Amphipods (nearly all Corophium) occurred on 2 of the control panels and on a single test panel of Test Board No. 1, while on Test Board No. 2, they occurred on only a single control panel. In no case was their number particularly large.

e. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred occasionally at both locations as follows: A few small specimens

of Mytilus (mussels) occurred on 4 of the control panels of Test Board No. 1 and on a single control panel and on 5 of the test panels of Test Board No. 2. A trace of Anomia (jingle-shells) occurred on 4 of the test panels of Test Board No. 2. A few juvenile specimens of Pecten (scallops) occurred on 2 of the test panels of Test Board No. 1.

f. Chordata (tunicates). A few colonies of tunicates were recorded on the first panels in both the control and test series of Test Board No. 1 and on a single control panel and two of the test panels in Test Board No. 2. Botryllus schlosseri was the only form identified.

#### A43.05 Summary and Conclusions

1. Installation. Two test boards of the panel type installed at the U. S. Naval Station at Port Hueneme, California, on June 15, 1944, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active at both locations, and it is clearly apparent that the breeding season is continuous throughout the year. The destruction by Teredinidae was so severe at both locations that after the tests had run 5 months, thicker test panels were used, and the period of submergence was reduced from 8 to 4 months. The attack rated very heavy each year at both locations, particularly so on Test Board No. 1. Limnoria were more or less active at both locations throughout the period covered by the tests. The attack never rated more than a trace in any year on Test Board No. 1, while on Test Board No. 2, it rated only a trace most of the time, but attained a peak rating of moderate late in 1945 and a rating of slight in the last test panel removed in 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The phyla included hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles and amphipods, miscellaneous nonboring mollusks, and tunicates. Of these organisms, hydroids, encrusting and filamentous Bryozoa, and calcareous worm tubes occurred with the greatest frequency, while the occurrence of the others, as well as of the algae, was purely sporadic.

3. Recent Addenda. At Test Board No. 1, there was a very heavy attack by Teredinidae in both 1948 and 1949. The attack by Limnoria at this location was slight in each of those years. Teredinidae were also very heavy on the panels of Test Board No. 2 in both years, while

Limnoria rated as moderate in 1948 and slight the following year at this point. Chelura put in an appearance on this board in 1949. A new board, installed at the Light Station by the U. S. Coast Guard June 1, 1948, showed evidence of very heavy attack from Teredinidae sets in both 1948 and 1949. Limnoria rated low in the slight category here each year.



Section 44

SAN PEDRO, CALIFORNIA -- TERMINAL ISLAND NAVAL SHIPYARD

A44.01 Location of the Test Station and Test Board

A test board of the panel type was installed June 14, 1944, at the U. S. Operating Base, now the Terminal Island Naval Shipyard at San Pedro, California. It was installed at the south end of Approach Pier No. 1 at the U. S. Naval Drydocks, and was designated by the symbol USNTI-1. The operation of this test board is being continued. The results have been summarized to the end of 1947.

A44.02 Hydrographic Data

The depth of water where the test board was installed was 44 ft M.L.W. datum, and the tidal range was 8 ft (plus or minus). The velocity of the current was stated to be approximately 500 ft per hour (various directions) on March 15, 1946. The temperature of the water at the time of installation was 64° F. The following figures concerning salinity, pH reaction, and pollution were given on June 24, 1944, based on a sample of sea water taken from the end of Pier No. 1 at the east ladder and at a depth of 10 ft:

	<u>ppm</u>
Dissolved oxygen	6.8
Hydrogen sulphide	none
Salinity (as NaCl)	30,990
pH (at 25° C)	7.75

The condition of the water varied at frequent intervals, being variously reported as clear, fairly clear, murky, silty from dredging operations (June 14, 1946), with sewage, oil, and other debris on the surface, and very dirty with oil and sewage.

Further data on temperature and salinity are given in the following tables:

Record of the temperature of the water in degrees F,  
 based on readings made on or close to the 14th day of  
 each month from samples taken at a depth of 10 ft

Month	1944	1945	1946	1947
January		58	56	60
February		58	56	62
March		57	59	64
April		56	60	66
May		60	62	68
June	64	66	64	65
July	--	67	69	65
August	63	70	70	68
September	66	70	68	70
October	63	64	63	66
November	62	62	58	63
December	58	55	60	64

Salinity determination of water from samples taken  
at a depth of 10 ft at Approach Pier No. 1, U. S. Naval  
Drydocks

Date	Chlorides		As sodium chloride	
	part per million	grains per gallon	parts per million	grains per gallon
<u>1946</u>				
Mar. 14	22,100	1,295	37,000	2,156
Apr. 15	21,600	1,260	35,600	2,080
May 15	21,600	1,260	35,600	2,080
June 14	20,800	1,210	34,500	2,000
July 15	22,016	1,280	36,326	2,112
Aug. 14	21,700	1,260	35,700	2,080
Sept. 13	21,700	1,260	35,700	2,080
Oct. 14	21,700	1,260	35,700	2,080
Nov. 14	22,000	1,290	36,500	2,130
Dec. 13	21,000	1,230	34,700	2,030
<u>1947</u>				
Jan. 14	21,900	1,280	36,100	2,110
Feb. 14	21,600	1,260	35,600	2,080
Mar. 14	18,500	1,060	29,900	1,740
Apr. 14	20,700	1,210	33,950	1,995
May 14	18,900	1,100	28,180	1,815
June 14	20,290	1,180	33,490	1,950
July 14	24,900	1,450	42,400	2,465
Aug. 14	21,500	1,250	36,500	2,125
Sept. 15	21,600	1,260	35,500	2,080
Oct. 15	23,300	1,360	38,200	2,240
Nov. 14	21,000	1,230	34,700	2,000
Dec. 15	21,000	1,230	34,700	2,000

#### A44.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia setacea, Teredo navalis, T. (Lyrodus) diegensis, T. (Lyrodus) sp., and T. sp., were very active at this location. They occurred in 36 of the 42 control panels, ranging from minute pits to embryonic specimens, and in every calendar month of the year, thus indicating that the breeding season here is continuous. They occurred in every one of the 49 test panels except the first and second of the new 4-panel series, which was started on November 14, 1946. Specimens were recorded up to 250 mm in length after 8 months' submergence, and panels in 1945 were riddled after having been submerged for only 3 to 6 months. The attack by Teredinidae was so destructive that on this date the panels were removed and a new 4-panel series was started. The attack rated very heavy each year.

2. Limnoria. Limnoria showed some evidence of activity throughout much of the period covered by the test but never occurred in more than trace numbers. They occurred in only 8 of the 42 control panels, and there were only from 1 to 5 tunnels in each panel infested. They occurred in 27 of the 49 test panels, but there were never more than 36 tunnels in any panel; and none occurred in 1945 in the panels submerged after March 15. Thus, it can be seen that the Limnoria attack never rated more than a trace.

#### A44.04 Fouling Agents

1. Silt. Silt occurred on all the panels, the deposits generally rating from traces to light on the panels of the control series, and from traces to moderate, or sometimes heavy, on the panels of the test series. In some cases the deposits were oily.

2. Algae. A trace of a green alga occurred on only one control panel.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 18 of the 42 control panels and on 30 of the 49 test panels, the growths rating traces on the panels of the control series and ranging generally from traces to light on the panels of the test series. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred rather abundantly on the panels, being recorded on 24 of the 42 in the control series and on 46 of the 49 in the test series. Three of the test panels were from 50% to 80% covered after having been submerged for 5 to 8 months. Cryptosula pallasiana occurred frequently, and Cryptosula sp., Crisulipora occidentalis, Holoporella brunnea,

Schizoporella unicornis, and Schizoporella sp. also were identified. Filamentous Bryozoa also occurred rather abundantly, being recorded on 9 of the 42 panels in the control series and on 44 of the 49 in the test series. Three of the test panels were 25%, 50%, and 85% covered, respectively, after having been submerged for 4 to 6 months. Bugula flabellata and Bugula sp. were the only forms identified.

c. Annelida (marine worms). Serpulid (Serpula) tubes occurred on 11 of the 42 control panels and on 26 of the 49 test panels. Four consecutive test panels submerged for 4-month periods at monthly intervals beginning July 15, 1946, were 75%, 75%, 30%, and 45% covered, respectively. Maximum lengths of 25 mm were recorded on the control panels and 45 mm on the test panels after 7 months' submergence.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred in small numbers on 6 of the 42 control panels and on 39 of the 49 test panels. Maximum diameters of 6 mm were recorded on the control panels and 25 mm on the test panels after 8 months' submergence. The maximum number recorded on any test panel was only 30 barnacles. Amphipods (nearly all Corophium) occurred on 5 control panels and on 2 test panels.

e. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred on the panels as follows: Mytilus (mussels) occurred on 3 of the 42 control panels and on 22 of the 49 test panels. Maximum lengths of 14 mm were recorded on the control panels and 57 mm on a test panel after 4 months' submergence. A few specimens of Modiolus (horse mussels) occurred on 3 of the test panels. A few specimens of Pecten (scallops) occurred on 16 of the test panels. Traces of Anomia (jingle-shells) occurred on 4 of the test panels. Several specimens of Saxicava occurred on 5 of the test panels.

f. Chordata (tunicates). Tunicates occurred on 9 test panels. Ciona occurred a number of times and Molgula also was recorded.

#### A44.05 Summary and Conclusions

1. Installation. A test board of the panel type installed at the Terminal Island Naval Shipyard at San Pedro, California, on June 14, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active at this location, infesting panels in every calendar month of the year, thus indicating that the breeding season is continuous. The attack, which was so destructive that the period of submergence for the panels was reduced

from 3 to 4 months, rated very heavy each year. Limnoria showed some evidence of activity throughout much of the period covered by the test but never occurred in more than trace numbers.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, serpulid tubes, barnacles and amphipods, miscellaneous nonboring mollusks, and tunicates. Of these organisms, hydroids, encrusting and filamentous Bryozoa, and barnacles occurred with the greatest frequency; serpulid tubes, mussels, and scallops occurred with somewhat less frequency; while the occurrence of the others, as well as of the algae, was purely sporadic.

3. Recent Addenda. The attack by Teredinidae sets was moderate in 1948 and very heavy in 1949 on Test Board USNTI-1. The Limnoria attack was slight here both years. A board installed near Paint Shop No. 1 indicated a heavy attack by Teredinidae in 1948 but only slight in the following year. Limnoria were medium heavy here both years. A third board, installed near the south end of the Finger Pier on 1 September 1949, showed no evidence of Teredinidae to the end of that year and only a slight attack by Limnoria.

## Section 45

### SAN DIEGO, CALIFORNIA -- U. S. NAVAL SUPPLY DEPOT FUEL FACILITY AND THE U. S. NAVAL STATION

#### A45.01 Location of the Test Stations and Test Boards

Test boards of the panel type were installed on July 17, 1944, at the U. S. Naval Fuel Annex (changed to U. S. Naval Supply Depot Fuel Facility in 1947) and on August 3, 1944, at the U. S. Naval Repair Base (now the U. S. Naval Station) in San Diego Bay, at San Diego, California. The first of these, designated by the symbol USNSD-1, was installed at the northern end of the T-shaped Fueling Pier at the Fuel Facility. The second, designated by the symbol USNSD-2, was installed on the south side (outboard end) of the south Mole Pier at the Naval Station. As all piles used in waterfront structures at this Station are either concrete or treated Douglas fir, it was impossible to locate the test board adjacent to untreated piling.

Because of disintegration of the test boards and extreme high tides during the last week of June 1946, both boards were lost. On account of the severity of the marine borer attacks at these locations, it was requested that the new boards of 4-panel series be installed so that the panels would be submerged on a 4-month basis instead of on the 8-month basis which was being employed. These were installed in August at the Fuel Facility, and probably in July at the Naval Station. The operation of these test boards is being continued and the results of these tests have been summarized to the end of 1947.

#### A45.02 Hydrographic Data

1. USNSD-1 (U. S. Naval Supply Depot Fuel Facility) The depth of water where this test board was installed was 29 ft; the tidal range was 10.28 ft (from -2.12 to -8.16); the velocity of the current was unknown. The temperature of the water at the time of installation was 66° F, and the water was clear with the exception of the occasional oil pollution caused by fueling activities.

2. USNSD-2 (U. S. Naval Station). The depth of water where this test board was installed was 17 ft; the tidal range was 10.28 ft (-2.12 to -8.16); the water was quiet. The temperature of the water at the time of installation was 72° F. Pollution was said to be negligible, the water being clear. However, the surface of the water subsequently was variously reported to be clear, slightly oily, not too dirty or oily, and with an oily, dirty, dark color and traces of oil. On August 7, 1946, it was reported that marine growths were "blooming."

Further data on the temperature and salinity of the water at this location are given in the following tables.

Record of the temperature of the water in degrees F,  
based on monthly readings, showing the general range

Month	1946	1947	1948
January		58	59
February		--	
March		62	
April		--	
May	63	70	
June	72	70	
July	--	72	
August	74	81	
September	--	74	
October	--	72	
November	63	62	
December	60	60	



Salinity determination of the water in parts per million

Month	1946		1947		1948	
	Chlorides	Total dis- solved solids (gravimetric method)	Chlorides	Total dis- solved solids (gravimetric method)	Chlorides	Total dis- solved solids (gravimetric method)
January			33,345	35,000	32,175	35,000
February			33,867	35,000		
March			29,952	36,750		
April			32,175	37,250		
May	18,439	29,580	32,760	34,750		
June	18,600	23,660	32,375	36,000		
July	-----	-----	31,590	33,000		
August	-----	-----	32,175	35,500		
September	-----	-----	32,500	35,500		
October	-----	-----	33,345	36,000		
November	32,175	36,262	31,590	38,000		
December	29,835	34,839	31,005	35,500		

#### A45.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo navalis, T. (Lyrodus) diegensis, T. (Lyrodus) sp., and T. sp. were very active at the Fuel Facility throughout the period covered by the test but showed relatively little activity at the Naval Station. On account of their destructiveness, it was requested on August 1, 1946, that a new series of test boards be installed at both locations in which the period of submergence would be reduced from 8 to 4 months. This request was made about a month after the test boards at both locations were carried away by high tides and before new ones had been installed to replace them.

a. USNSD-1 (U. S. Naval Supply Depot Fuel Facility). Teredinidae occurred in 26 of the 30 control panels, ranging from minute pits or embryonic specimens to some up to 20 mm in length, with a maximum of 450 recorded in any one panel. The breeding season at this location was continuous. They occurred in every one of the 30 test panels, the panels becoming filled after 8 months' submergence and riddled or destroyed if left in longer. A maximum length of 230 mm was recorded after 13 months' submergence. The attack rated very heavy in 1945, 1946, and 1947.

b. USNSD-2 (U. S. Naval Station). Teredinidae occurred in only 5 of the 38 control panels at this location, and nearly all were embryonic. The breeding season here extended only from March to the middle of August in 1945, with merely minute pits recorded subsequently and these only in the panel submerged from April 14 to May 13, 1947. They occurred in 17 of the 45 test panels but almost always in small numbers. There were none at all in the panels submerged from April 5 to September 11 in 1946. The maximum number recorded in any month was 50 in a panel that had been submerged from August 3, 1944 to April 5, 1945. The maximum length recorded was 135 mm after 8 months' submergence. The attack at this location rated zero or a trace most of the time, but it attained peak ratings of moderate in 1945 from an infestation in 1944, and slight in 1947.

2. Limnoria. Limnoria were active at both locations throughout the periods of the tests, occurring in all the panels of both series at both locations except in 2 control panels at the Naval Station. At both locations, the Limnoria population increased rapidly after the start of the tests and attained peak ratings of very heavy in 1945, after the panels had been exposed for 8 months. The attack at both locations was less severe in 1946; while in 1947, it again was very heavy at the Fuel Facility, although light at the Naval Station.

#### A45.04 Fouling Agents

1. Silt. Silt occurred on all except one control and one test

panel at both locations, the deposits ranging from traces to light or rarely moderate on the control panels and from traces to moderate on the test panels.

2. Algae. Algae, ranging from a trace to a light growth, occurred on 2 of the test panels at the Naval Station.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred with great frequency at both locations. At the Fuel Facility, they were on 27 of the 30 control panels and on all 30 of the test panels. At the Naval Station, they appeared on 19 of the 38 control panels and on 30 of the 45 test panels. They ranged from traces to light growths on the panels of both series. Tubularia occurred with great frequency and was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly at both locations but with greater frequency at the Fuel Facility. At this location, they occurred on 16 of the 30 control panels and on 25 of the 30 test panels; while at the Naval Station, they occurred on only 2 of the 38 control panels and on 14 of the 45 test panels. At the Fuel Facility, one of the control panels, which inadvertently was left submerged for 3 months, was 90% covered, and 5 of the test panels were from 50% to 90% covered after 2 to 9 months' submergence. One test panel was 80% covered in 2 months, and 2 were 90% covered in 3 months. Cryptosula pallasiana, Electra sp., Holoporella brunnea, Lichenopora sp., Rhynchozoon tumulosum, Schizoporella unicornis, Schizoporella sp., and Tegella sp. were identified. Filamentous Bryozoa also occurred more or less abundantly at both locations but with greater frequency at the Fuel Facility. At this location, they occurred on 16 of the 30 control panels and on 25 of the 30 test panels; while at the Naval Station, they occurred only on 11 of the 45 test panels. Bugula flabellata and Bugula sp. were the only ones identified.

c. Annelida (annelid worms). Serpulid (Serpula) worms occurred with great frequency at both locations. At the Fuel Facility, they were on 16 of the 30 control panels and on 24 of the 30 test panels; while at the Naval Station, they appeared on 14 of the 38 control panels and on 29 of the 45 test panels. At the Fuel Annex, 7 of the control panels were from 30% to 100% covered and 4 of the test panels were from 50% to 100% covered. At the Naval Station, 4 of the control panels were from 10% to 100% covered and 19 of the test panels were from 10% to 90% covered. Maximum lengths of 35 mm were recorded on a control panel and 60 mm on a test panel after 5 months' submergence. Balanus (barnacles) occurred with great frequency at both locations. At the Fuel Facility, they were on 14

of the 30 control panels and on 17 of the 30 test panels. At the Naval Station, they occurred on 11 of the 38 control panels and on 28 of the 45 test panels. At the Fuel Facility, a maximum diameter of 9 mm was recorded on the control panels and 29 mm on a test panel after 13 months' submergence. At the Naval Station, a maximum diameter of 11 mm was recorded on a control panel and 20 mm on a test panel after 8 months' submergence. One of the control panels at each location was 25% covered, and 4 of the test panels at each location were from 25% to 33% covered. *Corophium* occurred on a single control panel at the Fuel Facility and on one control and one test panel at the Naval Station. The largest number recorded on any one panel was 125 specimens.

d. Mollusca (nonboring mollusks). Miscellaneous nonboring mollusks occurred occasionally as follows: A trace of *Mytilus* (mussels) occurred on 2 of the test panels at the Naval Station. One panel submerged for 8 months contained specimens up to 25 mm in length. A trace of *Pecten* (scallops) occurred on a single control panel and on 4 test panels at the Fuel Facility. One panel submerged 4 months had specimens up to 5 mm in diameter. A few specimens of *Saxicava* occurred on 2 test panels at the Fuel Facility. No sizes were recorded.

e. Chordata (tunicates). Tunicates occurred more or less abundantly on 7 of the 30 control panels and on 9 of the 30 test panels at the Fuel Facility; while at the Naval Station, they occurred on 5 of the 38 control panels and on 19 of the 45 test panels. One of the test panels at the latter location was 85% covered. *Botryllus schlosseri* and *Ciona* were identified.

#### A45 05 Summary and Conclusions

1. Installation. Test boards of the panel type installed at the U. S. Naval Supply Depot Facility and the U. S. Naval Station at San Diego, California, on July 17 and August 3, 1944, to determine the identity and prevalence of marine borers and fouling organisms, are still being operated. The results of the test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. *Teredinidae* were very active at the Fuel Facility throughout the periods covered by the tests but showed relatively little activity at the Naval Station. At the Fuel Facility, the breeding season was continuous, and the attack rated very heavy in 1945, 1946, and 1947. At the Naval Station, the breeding season extended only from March to the middle of August in 1945, with only 3 minute pits recorded subsequently. The attack rated none or a trace most of the time but attained peak ratings

of moderate in 1945 resulting from an infestation in 1944, and slight in 1947. Limnoria were active at both locations throughout the periods covered by the tests, attaining peak ratings of very heavy in 1945 but were less severe in 1946; while in 1947, they again were very heavy at the Fuel Facility though light at the Naval Station.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles and amphipods, miscellaneous nonboring mollusks, and tunicates. Of these organisms, hydroids, encrusting and filamentous Bryozoa, serpulid worms, and barnacles occurred with great frequency; tunicates occurred with less frequency; while the occurrence of the others, as well as the algae, was purely sporadic or occasional.

3. Recent Addenda. The attack from the Teredinidae set in 1948 rated very heavy at the Fuel Facility board, while that from the set of the following year was only light. The Limnoria attack was heavy here in 1948 and medium heavy in 1949. There was no evidence of Teredinidae on the board at the Naval Station in 1948 and only a trace from the 1949 set. Limnoria was medium heavy here in 1948 but only slight the following year.

## BALBOA, CANAL ZONE -- U. S. NAVAL STATION

A46.01 Location of the Test Station and Test Boards

Two test boards of the panel type were installed June 15, 1944, at the U. S. Naval Station at Balboa, Canal Zone. This Station is located at the western end of the Panama Canal on the Pacific Ocean side of the Isthmus of Panama. The test boards were installed near the San Juan Dump on the west bank of the Canal at the north end of Balboa Harbor, just across from Balboa. Two kinds of wood were used for panels, namely Southern yellow pine and Douglas fir, as both kinds are used in waterfront structures at this Station. These test boards were designated by the symbols USNCZ-1 and USNCZ-2, the first board having panels of Southern yellow pine and the second, panels of Douglas fir. The test boards were suspended from an untreated wooden dock and were covered at all times by salt water at the Pacific end of the Canal. They were installed approximately 3 ft from an untreated pine pile.

On November 20, 1945, a new series of panels was installed on Test Board No. 1, for which the period of submergence was reduced from 8 to 4 months on account of the destructiveness of the Teredinidae. The operation of the second test board was discontinued at this time, as it gave essentially the same results with respect to marine borers as did the first board.

In January 1946, the near collapse of the untreated pile structure, from which Test Board No. 1 was still suspended, necessitated the relocation of that board; it was installed on a pile cluster (treated piling) 50 ft south of its original location. The operation of this test board is being continued, and the results of these tests have been summarized to the end of 1947.

A46.02 Hydrographic Data

1. The mean depth of water at the location where the test boards were installed was 22 ft. The maximum range of tide was 22 ft, and the normal range was 12 ft. The velocity of the current was approximately 3 knots. The temperature of the water was given as 75° F to 80° F, though whether this is the range for the year is not clear. It was reported that a slight dilution of the salt water may occur at this location because of fresh water discharged from the canal locks located approximately  $1\frac{1}{2}$  miles upstream from the test boards. To determine the degree of pollution of the water at this location, samples were taken from the end of the wooden pier near the salvage yard on three successive days at high, mean, and low water. Tests made on these

D A T A S H E E T  
Pollution Test on the Waters of Balboa Harbor  
Vicinity of the Naval Station

Date and time of collection	Condition of tide	pH	Bacteria per milliliter at 37° C	Confirmed B. Coli in portions mls 10 1.0 0.1 0.01	Indicated No. B. Coli per 100 ml	Chlorides parts per million	Biochemical oxygen demand B.O.D. 5 days at 20° C ppm	Temperature of sample deg C	Initial dissolved oxygen ppm	Percent saturation	Residual dissolved oxygen after 5 days at 20° C	Percent saturation after 5 days at 20° C (hypothetical)
<u>19th</u>												
<u>June 28</u>												
9:20 a.m.	High: 9:01 a.m.	7.2	1,200	Pos Pos Pos Neg	1,000		2.33	27.0	5.35	77.8	3.02	38.4
12:15 p.m.	Mean: 12:15 p.m.	8.6	1,400	Pos Pos Neg Neg	100		2.40	26.5	5.00	70.5	2.60	33.0
3:20 p.m.	Low: 3:33 p.m.	8.8	4,100	Pos Pos Neg Neg	100		2.47	26.5	5.00	70.5	2.53	32.2
<u>June 29</u>												
9:50 a.m.	High: 9:51 a.m.	8.7	870	Pos Pos Pos Pos	10,000	16,400	2.00	26.8	4.50	65.9	2.50	31.8
1:30 p.m.	Mean: 1:29 p.m.	8.7	345	Pos Pos Neg Neg	100	15,500	2.60	26.5	4.80	69.6	2.20	28.0
4:00 p.m.	Low: 4:26 p.m.	8.8	1,100	Pos Neg Pos Neg	100	15,900	2.35	26.6	5.10	72.5	2.75	35.0
<u>June 30</u>												
10:48 a.m.	High: 10:48 a.m.	8.5	5,000	Pos Pos Pos Neg	1,000	14,100	2.44	26.2	4.60	65.5	2.16	27.5
2:20 p.m.	Mean: 2:24 p.m.	8.7	1,600	Pos Pos Pos Neg	1,000	14,100	1.73	26.5	4.70	64.6	2.92	37.2
5:00 p.m.	Low: 5:19 p.m.	8.7	4,900	Pos Pos Pos Neg	1,000	13,600	2.30	26.5	5.10	71.5	2.80	35.6
Average		8.5	2,280		1,600	14,933	2.29	26.5	4.35	69.8	2.61	33.2

samples included bacteriological examinations, dissolved oxygen, biochemical oxygen demand, pH determinations, and temperature readings.

2. Pollution Criteria. The following excerpt from a report by W. D. Fedde, Acting Chief Chemist in charge of the Testing Laboratories of the Municipal Engineering Division, Miraflores Water Purification Plant, is submitted because of the valuable information it contains with reference to pollution at this location.

#### Report on

#### Pollution Tests on Waters of Balboa Harbor in Vicinity of the U. S. Naval Operating Base, West Bank

#### Discussion

From time to time, various standards have been proposed as bases for working criteria limiting pollution of watercourses. In this connection, the Royal Commission standard in Great Britain provided that sewage effluents should contain not more than 30 ppm of suspended matter and should have a 5-day B.O.D. at 65° F not exceeding 20 ppm. As the basis of the sewage effluent standard, the Commission formulated the working rule that the 5-day B.O.D. of a stream of water, after receiving an effluent, should not exceed 4 ppm in order to maintain satisfactory conditions in the stream at a summer temperature of 65° F and under dry-weather conditions.

The dissolved oxygen content of a watercourse should not be allowed to fall to a point where a nuisance will be created or where fish life will be destroyed. Recent surveys of the U. S. Bureau of Fisheries, as reported by Ellis, have indicated that the desirable minimum dissolved oxygen content should not be less than 5 ppm in order to provide favorable conditions for the development of a normal variety of native fish life. Furthermore, if the percentage saturation of dissolved oxygen in a watercourse is not permitted to fall below 50 percent, it is likely that no nuisance will exist.

In connection with the disposal of sewage by dilution in harbors, estuaries, and the sea, it should be pointed out that sea water contains 20 percent less dissolved oxygen than fresh water under similar conditions of temperature and pressure. Sea water also exerts a precipitating effect on the colloids in sewage, a condition that favors the formation of sludge banks when sewage is discharged into salt water. As sludge deposits decompose, hydrogen sulphide is formed in greater abundance in salt water than in fresh water, caused by the breaking down of the sulphates contained in sea water.

#### A46.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia canalis, B. gouldi,



B. mexicana, B. (Nausitora) sp., were extremely active each year in the panels of both test boards. They occurred in all except 2 of the 44 control panels of Test Board No. 1 and in all except one of the 18 that were received from Test Board No. 2. The uncontaminated panel was the last one removed after 5 days' submergence. Most of the specimens in these panels were embryonic or minute, but some specimens up to 52 mm and 40 mm in length were recorded in Test Boards No. 1 and No. 2, respectively. Teredinidae were found infesting the control panel every month of the year, thus showing that the breeding season at this location is continuous. Infestation and development in these panels were lowest, however, from the middle of February to the middle of April.

Teredinidae occurred in all the test panels of Test Board No. 1 except in a panel that was removed in November 1945, after having been submerged for only 5 days, and in all of Test Board No. 2 except the first and last, the latter of which was removed after having been submerged for only 5 days. In both test boards, the majority of the test panels were either filled or riddled by Teredinidae. In Test Board No. 1, they continued to be generally filled, or occasionally riddled, even after the period of submergence was reduced from 8 to 4 months. The maximum length of specimens recorded was 250 mm in Test Board No. 1 and 290 mm in Test Board No. 2. The attack by Teredinidae at this location is rated very heavy.

2. Limnoria. Limnoria also occurred in both test boards throughout the period of operation. They occurred as mere traces in 30 of the 44 control panels received from Test Board No. 1, and in 6 of the 18 control panels in Test Board No. 2. They also occurred, mostly as traces, in 44 of the 51 test panels received from Test Board No. 1 and in 20 of the 25 in Test Board No. 2. In Test Board No. 1, the maximum attacks attained ratings of slight in 1946 and 1947; while in Test Board No. 2, only mere traces were recorded.

3. Pholadidae. Pholadidae, including Martesia and Hiata, also occurred at this location. In Test Board No. 1, juvenile specimens were recorded in only 2 control panels and from 1 to 20 specimens occurred irregularly on 18 of the 51 test panels, the maximum length being 28 mm. In Test Board No. 2, juvenile specimens were recorded on only 2 control panels and from 1 to 6 specimens occurred irregularly on 7 of the 25 test panels, the length not being recorded. The Pholad attack thus rates as slight in Test Board No. 1 and practically only a trace in Test Board No. 2.

#### A46.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series on both test boards. On Test Board No. 1, the deposits

ranged from traces to moderate on both the control and test panels; while on Test Board No. 2, they ranged from traces to light on panels of both series.

2. Algae. Traces of green and brown algae occurred on a single test panel of Test Board No. 1.

3. Invertebrate animal phyla.

a. Porifera (sponges). A few sponges were recorded on 3 test panels on Test Board No. 1 and on a single test panel on Test Board No. 2. A single specimen of an encrusting sponge occurred on one control panel of the latter test board.

b. Coelenterata (hydroids). Hydroids occurred on 38 of the 44 control panels and on all except one of the 50 test panels on Test Board No. 1. On Test Board No. 2, they occurred on all 18 control panels and on all of the 25 test panels, except the last panel in each series, the uncontaminated one having been removed after only 5 days' submergence. Tubularia was the only form identified.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa were more or less abundant on the panels of both test boards. On Test Board No. 1, they occurred on 36 of the 43 control panels and on 33 of the 50 test panels. Four control panels were from 50% to 100% covered. On Test Board No. 2, they occurred on 14 of the 18 control panels received and on 17 of the 25 test panels. Electra crustulenta, E. monostachys, E. sp., Acanthodesia serrata, Cryptosula pallasiana, Cryptosula sp., Schizoporella sp., and Gemelliporida typica were identified. Filamentous Bryozoa also were relatively abundant on the panels of both test boards. On Test Board No. 1, they occurred on 32 of the 43 control panels and on 41 of the 50 test panels. Five each of the control and test panels were from 50% to 75% covered. On Test Board No. 2, they occurred on 12 of the 18 control panels received, and on 18 of the 25 test panels. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Brachiopoda (brachiopods). A few brachiopods occurred on a single control panel and on 2 test panels of Test Board No. 1, also on two each of the control and test panels of Test Board No. 2.

e. Annelida (marine worms). Serpulid (Serpula) tubes occurred more or less abundantly on the panels of both test boards. On Test Board No. 1, they occurred on 8 of the 43 control panels and on 21 of the 50 test panels. The maximum length was 15 mm on the control panels and 70 mm on the test panels. The maximum number on any one of the latter was 60 worms. On Test Board No. 2, they occurred on 3

of the 18 control panels received and on 11 of the 25 test panels. The maximum length was 10 mm on the control panels and 20 mm on the test panels. The maximum number on any of these test panels was 20.

f. Arthropoda (crustaceans). Balanus (barnacles) occurred fairly frequently on the panels of Test Board No. 1 but only sporadically on the panels of Test Board No. 2. On Test Board No. 1, they occurred on 27 of the 43 control panels and on 27 of the 50 test panels. The maximum diameter recorded was 18 mm on the control panels and 42 mm on the test panels after 4 months' submergence. Eight control panels and 5 test panels were from 50% to 80% covered. On Test Board No. 2, barnacles occurred on 5 of the 18 control panels received and on 4 of the 25 test panels. The maximum diameter recorded was 8 mm on the control panels and 12 mm on the test panels.

g. Mollusca (nonboring mollusks). Miscellaneous mollusks occurred sporadically on the panels of both test boards. Anomia (jingle-shells) occurred on 5 of the 43 control panels and on 15 of the 50 test panels in Test Board No. 1; while in Test Board No. 2, they occurred on 4 each of the control and test panels. Maximum diameters of 8 mm were recorded on the control panels and of 15 mm on the test panels. The maximum number on a test panel was 40. Traces of Ostrea (oysters) occurred on a single control panel and on 12 test panels of Test Board No. 1 and on five test panels of Test Board No. 2. A trace of Vermetidae occurred on a single test panel of each test board.

h. Chordata (tunicates). A few colonies of tunicates occurred on occasional panels of both test boards. They occurred on 3 control panels and on 5 test panels of Test Board No. 1 and on 2 control panels and a single test panel of Test Board No. 2. Botryllus schlosseri was the only one identified.

#### A46.05 Summary and Conclusions

1. Installation. Of the 2 test boards of the panel type installed at the U. S. Submarine Base at Balboa, Canal Zone, on June 15, 1944, one is still being operated, and the other was discontinued in November 1945. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were active every month of the year, showing that the breeding season is continuous at this location. The attack was very heavy on both test boards, with panels becoming filled, or occasionally riddled, even after the period of submergence was reduced from 8 to 4 months. Limnoria were present throughout

the period covered by the tests, but the attack usually did not exceed a trace. In Test Board No. 1, maximum attacks rated slight in 1946 and 1947; but in Test Board No. 2, only mere traces were recorded. Pholadidae also occurred at this location, the attack rating slight in Test Board No. 1 and practically a mere trace in Test Board No. 2.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 8 phyla contributed to fouling of the panels. The latter comprised sponges, hydroids, encrusting and filamentous Bryozoa, brachiopods, marine worms, barnacles, miscellaneous nonboring mollusks, and tunicates. Hydroids and encrusting and filamentous Bryozoa occurred most frequently, barnacles somewhat less frequently, while the occurrence of the others was purely sporadic or occasional. Algae occurred as traces on two test panels of Test Board No. 1.

3. Recent Addenda. Test Board No. 1 showed a very heavy attack from sets of Teredinidae in 1948 and 1949. The attack by Limnoria was slight in each of these years. Pholads (Hiata and Martesia) were medium heavy in 1948, but their attack in 1949 rated only slight. A test board installed at the Navy Pier No. 2 on June 3, 1948, showed a trace of Teredinidae from the set of 1948 and a moderate attack from the set of 1949. There was a trace of Limnoria on the panels of this board each year. Pholads (Hiata and Martesia) were moderate here in both years.

## MIDWAY ISLANDS -- U. S. NAVAL OPERATING BASE

A47.01 Location of the Test Station and Test Board

A test board of the panel type was installed July 21, 1944, at the U. S. Naval Operating Base at the Midway Islands, located in the northwestern Hawaiian Islands in the central Pacific Ocean. The test board was located in the extreme east end of a small boat haven which has a 50-ft entrance-opening facing northward into the open lagoon. The basin floor is coral and coral sand. The test board is protected from boats by an untreated wood fender pile which forms part of the dock. It is designated by the symbol USNX-2. This test board is still being operated, and the results of this test have been summarized to the end of 1947.

Because of the severity of the combined attack of Limnoria and Teredinidae, the original panels were replaced by 2-inch-thick panels on April 21, 1945; in November of this year, it was requested that the panels be removed and replaced by a new series in which the period of submergence would be reduced from 8 to 4 months. On December 15, 1945, the Naval Operating Base advised that they could not comply with this request because the test board had been either totally destroyed or washed away by strong undercurrents. A new test board of the 4-panel series was installed on this last-named date.

On May 15, 1947, the Naval Operating Base advised that the test board was lost because of the failure of the supporting cable. A new board, using the 4-panel series, was installed in a more protected location on April 1, 1947, but shortly after the first set of panels was forwarded, the test board was carried away during a storm. A new one was not installed until October 1 of the same year. The operation of this test board is being continued, and the results of the test have been summarized to the end of 1947.

A47.02 Hydrographic Data

The depth of water where the test board was installed was 12.25 ft. The board was installed so that the top of the upper panel was 4 ft below the surface of the water, and the lower panel was 2 ft above the bottom of the basin. The tidal range was 1.2 ft, and the velocity of the current was said to be zero. The temperature of the water at the time of installation was 78° F. A temperature reading of 60° F was reported on August 26, 1946. The average salinity of the water in the vicinity of the test board was given as 18,000 ppm. The boat basin was reported as not being contaminated by artificial sources other than those normally expected for an area where from 20 to 25 small boats are moored.

#### A47.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo (Lyrodus) sp. and Teredo sp., were active through the period of the test. They occurred in 23 of the 29 control panels received (one was destroyed by the postal authorities), ranging in size from minute pits to embryonic or minute specimens, and up to 15 mm in length. The maximum number in any one of these panels was 2,015. They occurred in every calendar month of the year, proving that the breeding season at this location is continuous. Teredinidae occurred in 25 of the 29 test panels received. Specimens were recorded up to 145 mm in length after 6 months' submergence, although the lengths could not be measured in several panels because of their almost complete destruction by Limnoria. Two of these panels, one removed on October 15, 1946, and the other on November 15, after 4 months' submergence, were 50% filled. The attack rated moderate each year except 1946, when it attained a peak rating of medium heavy.

2. Limnoria. Limnoria were extremely active throughout the period of the test, occurring in every one of the control panels and even occurring in large numbers the first month. The prodigious number of 7,260 tunnels were estimated to be in one panel submerged from May 15 to June 15, 1946. Limnoria occurred in all the test panels and so abundantly that the attack penetrated to a depth of 8 mm in 5 months and almost completely through a 2-inch panel in 6 months. The panels were from 75% to 90% destroyed after 8 months' submergence, and others were still partially destroyed even after the period of submergence was reduced to 4 months. The Limnoria attack was recorded as extremely heavy each year except in 1947, when the test board was operated only briefly; it was the most severe attack recorded from any locality.

3. Pholadidae. No Pholadidae were recorded from this location.

#### A47.04 Fouling Agents

1. Silt. Silt occurred as traces to light or moderate deposits on all the panels of both the control and test series.

2. Algae. Green algae occurred as traces to rarely light or moderate growths on 4 each of the 29 control panels and on 5 of the same number of test panels.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces

on 17 of the 29 control panels and on 18 of the same number of test panels. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Six colonies of an encrusting Bryozoa occurred on the last panel in the test series. Filamentous Bryozoa occurred more or less abundantly on 4 of the 29 control panels and on 9 of the same number of test panels. Bugula sp. was the only form identified. Filamentous Bryozoa occurred more or less abundantly on 4 of the 29 control panels and on 9 of the same number of test panels. Bugula sp. was the only form identified.

c. Annelida (marine worms). Serpulid (Serpula) tubes occurred, often in great abundance, on 25 of the 29 control panels and on 26 of the same number of test panels, the maximum length on any panel being 20 mm. Eleven of the control panels were from 25% to 100% covered, and 7 of the test panels were from 50% to 100% covered.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred in rather scanty numbers on 14 of the 29 control panels and on 10 of the same number of test panels, the maximum number being only 300 on any one panel. A maximum diameter of 6 mm was recorded on the control panels and 12 mm on 2 test panels after 3 and 4 months' submergence, respectively.

e. Chordata (tunicates). From 10 to 12 colonies of tunicates occurred on 2 test panels.

#### A47.05 Summary and Conclusions

1. Installation. A test board of the panel type, installed at the U. S. Naval Operating Base at the Midway Islands in the central Pacific Ocean on July 21, 1944, is still being operated. The results of this test have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were active each year, and the breeding season was continuous. The attack rated moderate each year except 1946, when it attained a peak rating of heavy. Limnoria were extremely active throughout the period of the test. Except during 1947, when the test board was operated only briefly, the attack was extremely heavy throughout the year, and panels were almost completely destroyed in 8 months. The panels continued to be partially destroyed even after the period of submergence had been reduced to 4 months. This is the most severe Limnoria attack that has been recorded from any locality. No Pholadidae were recorded from this location.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, and tunicates. Of these organisms, serpulid worms occurred with the greatest frequency and abundance, hydroids with less frequency, barnacles with still less frequency, while the occurrence of the others, as well as the algae, was purely sporadic.

3. Recent Addenda. There were very heavy attacks of Teredinidae at this location from sets in 1948 and 1949. The Limnoria attack was extremely severe in each of these years, several panels being from 25% to 80% destroyed in 1949. There were no Pholads.



## PEARL HARBOR, HAWAII -- PEARL HARBOR NAVAL SHIPYARD

A48.01 Location of the Test Station and Test Boards

Four test boards of the panel type were installed July 3 and 4, 1944, at different locations at the Pearl Harbor Naval Shipyard, Pearl Harbor, Hawaii. This harbor is located on the south side of the Island of Oahu. The first of the boards, designated by the symbol USNH-1, was placed under a marginal timber wharf (Berth A-12) located near the entrance to the harbor. This new wharf is constructed of creosoted piles and timbers. The test board is located 6 ft inside the fender system and  $5\frac{1}{2}$  ft from the nearest pile. The second board, designated by the symbol USNH-2, was placed under the so-called "1010 Wharf" (Berth B-1) which is of concrete construction. The fender system on this wharf is constructed of treated timber extending from deck to water line. The test board is located 6 ft from the fenders. The third board, designated by the symbol USNH-3, was placed under a marginal wharf (DE wharf, Berth DE-5), about one-half mile upchannel from the first test board. This wharf had been in place for about one year, and all submerged members were heavily encrusted with barnacles and other marine growth. The timber piles were creosoted. The test board was located 6 ft inside the fender system and 5 ft from the nearest pile. The fourth board, designated by the symbol USNH-4, was placed under the Fuel Oil Pier (Berth H-2) at Kuahua. This pier is of concrete construction with a spring-type fender system of creosoted timber, which does not project into the water. The test board was placed 12 ft inside the fender system. The operation of these test boards is being continued, and the results have been summarized to the end of 1947.

A48.02 Hydrographic Data

1. USNH-1 (Timber Wharf). The depth of water where this test board was installed was 40.2 ft; the tidal range was given as 3 ft (from -.5 to +2.5 ft); the velocity of the current was negligible. The temperature of the water at the time of installation was 78° F. Pollution of water by sewage and wastes varies with the quantity of shipping and anchorage. As an average, little if any evidence of influence on normal conditions was apparent from these causes. In fact, pollution by sewage wastes and oil was considered negligible in general throughout the period covered by the tests.

2. USNH-2 (1010 Wharf). The depth of water where this test board was installed was 29 ft. The tidal range and temperature of the water were the same as given for test board USNH-1. There is usually an oil film on the surface of the water at this point, and considerable

sewage pollution exists. The water here is practically stagnant.

3. USNH-3 (DE Wharf). The depth of water where this test board was installed was 25.3 ft. The tidal range and temperature of the water are the same as given for the first test board. Pollution and current are negligible.

4. USNH-4 (Fuel Oil Pier). The depth of water where this test board was installed was 28.6 ft. The tidal range and temperature of the water were the same as given for the first test board. There is a considerable amount of fuel oil on the surface of the water in this area, and pollution from sewage is also appreciable. There is more current at this site than at the other test boards, but it was estimated to have a maximum velocity of only 0.2 knot.

Further data on the temperature and salinity of the water at the different locations are given in the following tables.

Record of temperature of the water in degrees F, based on readings taken at various times each month, showing the general range throughout the year at each location

Month	Timber Wharf (Berth A-12)			"1010 Wharf" (Berth B-1)			DE Wharf (Berth DE-5)			Fuel Oil Pier (Berth H-2)		
	1945	1946	1947	1945	1946	1947	1945	1946	1947	1945	1946	1947
January	78	70	70	80	72	72	76	72	72	78	70	70
February	78	70	70	80	70	70	78	68	68	78	73	73
March	76	77	77	78	76	76	76	76	76	77	78	78
April	74	76	76	75	77	77	76	78	78	74	77	77
May	78	76	76	76	76	76	76	76	76	74	76	76
June	76	78	78	80	78	78	78	76	76	78	76	76
July	76	76	76	80	78	78	78	77	77	78	77	77
August	76	79	78	81	79	79	81	79	79	78	79	79
September	--	82	79	--	76	80	--	77	77	--	80	80
October	80	80	78	82	80	79	80	78	78	82	79	79
November	76	78	77	79	76	78	76	76	76	81	76	76
December	80	76	72	78	78	72	79	72	72	78	74	74

Record of salinity of water (grains per gallon), based on readings taken at various times each month, showing the general range at each location

Month	Timber Wharf (Berth A-12)		"1010 Wharf" (Berth B-1)		DE Wharf (Berth DE-5)		Fuel Oil Pier (Berth H-2)	
	1946	1947	1946	1947	1946	1947	1946	1947
January		1,895		1,900		1,840		1,910
February		1,850		1,830		1,770		1,840
March	1,820	1,805	1,840	1,750	1,800	1,760	1,830	1,810
April	1,810	1,810	1,940	1,920	2,020	1,780	1,845	1,870
May	1,900	1,910	1,850	1,870	1,850	1,825	1,900	1,910
June	1,860	1,890	1,890	1,890	1,850	1,870	1,860	1,910
July	1,940	1,850	1,875	1,890	1,850	1,840	1,880	1,880
August	1,915	1,950	1,930	1,970	1,900	1,940	1,900	1,960
September	2,020	1,860	1,900	1,860	2,000	1,820	1,930	1,840
October	1,810	1,850	1,880	1,850	1,750	1,850	1,790	1,850
November	1,860	1,890	1,835	1,870	1,825	1,880	1,845	1,860
December	1,770	1,890	1,780	1,890	1,710	1,870	1,640	1,890

1. Teredinidae. Teredinidae, including Bankia hawaiiensis, Teredo affinis, T. milleri, T. parksi, T. trulliformis, T. (Lyrodus) diegensis, T. (Lyrodus) sp., and T. sp., were very active at all four locations throughout the period covered by the test. The severity of attack was such that it was requested in November 1944 that all panels be removed from the test boards and replaced with panels 2 inches thick. This change was made in December. However, increasing the thickness of the panels did not prolong their length of life, since the attack was just as severe proportionately in the two-inch panels as in the one-inch panels. In November 1945 it was requested that all panels on the test boards be removed and that a new series be installed and operated on a 4-month basis instead of on the 8-month basis which was being employed. The change to the new series of panels was made in December. The detailed figures on the occurrence of Teredinidae at each of these locations are summarized below.

a. USNH-1 (Timber Wharf). Teredinidae occurred in all 41 control panels, ranging from minute pits or embryonic specimens to specimens up to 30 mm in length. Five of these panels were 40%, 50%, 50%, 75%, and 90% filled, respectively. The breeding season was continuous. Teredinidae also occurred in all except 3 of the 48 test panels, none occurring in the first 2 panels or in the first one in the new series installed when the change was made to thicker panels in December 1944. A maximum length of 250 mm (10 inches) was recorded in a panel submerged for 7 months. Thirty-eight of the 48 test panels were either filled or riddled, although most of them had been submerged for only 4 months. One test panel became riddled in as short a period as 2 months. The attack was extremely destructive each year, including 1944.

b. USNH-2 (1010 Wharf). Teredinidae occurred in all 41 control panels, ranging from minute pits or embryonic specimens to those up to 25 mm in length. Two of these panels were 30% and 40% filled, respectively. The breeding season was continuous. Teredinidae also occurred in all 48 test panels, with a maximum length of 220 mm (about 9 inches) recorded in a panel submerged for 3 months. Nineteen test panels were either filled or riddled, although most of them had been submerged for only 4 months. One of these panels became filled within 3 months. The attack was extremely destructive each year, including 1944.

c. USNH-3 (DE Wharf). Teredinidae occurred in all except 2 of the 41 control panels, ranging from minute pits or embryonic specimens to those up to 25 mm in length. The breeding season was continuous. Two of these panels were 40% filled, and 2 were completely filled. Teredinidae occurred in all 48 test panels, with a maximum length of 240 mm (about 9½ inches) recorded in a panel submerged for 4 months.



Twenty-seven test panels were either filled or riddled, although most of them had been submerged for only 4 months. One of these panels became filled within 3 months. The attack was extremely destructive each year, including 1944.

d. USNH-4 (Fuel Oil Pier). Teredinidae occurred in 38 of the 41 control panels, ranging from minute pits or embryonic specimens to specimens up to 25 mm in length. The surfaces of two of these panels were 30% and 75% filled, respectively, by minute pits made by both Teredinidae and Pholadidae. The breeding season was continuous. The most rapid development of Teredinidae in the control panels at all four locations occurred from the middle of March to the middle of September. Teredinidae also occurred in all 48 test panels, with a maximum length of 180 mm (about 7 inches) recorded in one panel submerged for 5 months. Twenty-six of the test panels were either filled or riddled, although most of them had been submerged for only 4 months. One of these panels became filled within 2 months. The attack was extremely destructive each year, including 1944.

2. Limnoria. Limnoria showed more or less activity at all locations; the occurrence is for each location is summarized below.

a. USNH-1 (Timber Wharf). Limnoria occurred on 34 of the 41 control panels, although none occurred up to November 3, 1944. The maximum number on any panel was 660 forms. Limnoria occurred also on all except 3 (including the first 2) of the 48 test panels. The attacks attained peak ratings of medium heavy in 1945, 1946, and 1947.

b. USNH-2 (1010 Wharf). Limnoria occurred on 37 of the 41 control panels, the maximum number of tunnels being 2,000 recorded on any single panel. They occurred on 46 of the 48 test panels. The attacks attained peak ratings of medium heavy in 1945 and 1946 and very heavy in 1947.

c. USNH-3 (DE Wharf). Limnoria occurred on 21 of the 41 control panels, although only on 4 up to July 13, 1946. The maximum number on any one panel was 200 forms. They occurred on 37 of the 48 test panels, but were absent on all except on the first panel until April 9, 1945. The attacks attained peak ratings of slight in 1945 and 1946 and very heavy in 1947.

d. USNH-4 (Fuel Oil Pier). Limnoria occurred on 17 of the 41 control panels, although none occurred until after March 11, 1946. The maximum number on any one panel was only 12 forms. Limnoria occurred on 23 of the 48 test panels, also, but occurred on only 2 panels up to March 11, 1946. The attacks attained peak ratings of slight in 1945, 1946, and 1947.

3. Pholadidae. Pholadidae (Hiata and Martesia) showed more or less activity at all four locations. However, it was difficult to evaluate the severity of the attack because the panels were frequently riddled by Teredinidae and also more or less severely attacked by Limnoria in some cases. The occurrence of Pholads is summarized below for each location.

a. USNH-1 (Timber Wharf). Pholadidae occurred on 7 of the 41 control panels, the maximum number being 60 on any one panel. They occurred in 21 of the 48 test panels. Of 7 consecutive test panels in 1945, three were 20%, 50%, and 50% filled, respectively, the fourth was filled, the fifth and sixth were well filled, and the seventh was riddled. One panel became well filled in 5 months. Sizes were rarely recorded. The attacks rated very heavy in 1945, moderate in 1946, and none in 1947.

b. USNH-2 (1010 Wharf). Pholadidae occurred on 12 of the 41 control panels, the maximum number on any one being 8 per sq in. (1,056). They occurred in 35 of the 48 test panels also. Three of the test panels were 25%, 50%, and 80% filled, respectively, and three were well filled. One became well filled in 5 months. Specimens up to 30 mm long were recorded. The attacks rated very heavy in 1945 and 1946 and slight in 1947.

c. USNH-3 (DE Wharf). Pholadidae occurred in 7 of the 41 control panels, one being 40% filled with juvenile specimens of both Teredinidae and Pholadidae. Pholadidae also occurred in 35 of the 48 test panels. Two of the 6 test panels were 25% filled, two were 75% filled, and two were well filled. One test panel was well filled within 3 months. Specimens up to 40 mm long were recorded. The attacks rated very heavy in 1944 and 1946 and heavy in 1945 and 1947.

d. USNH-4 (Fuel Oil Pier). Pholadidae occurred in 12 of the 41 control panels, the surfaces of 2 panels being 30% and 75% filled, respectively, with pits caused by both Teredinidae and Pholadidae. Pholadidae also occurred in 36 of the 48 test panels. Five of the 11 test panels were 10%, 20%, 25%, 33%, and 50% filled, respectively; two were filled; three were well filled; and one was riddled. One of these panels was filled within 2 months. Specimens up to 45 mm long were recorded. The attacks rated very heavy in 1944 and 1945 and medium heavy in 1946 and 1947.

#### A48.04 Fouling Agents

1. Silt. Silt occurred on all the panels, both control and

test, except on one or 2 panels of each series at each location. The deposits generally ranged from traces to light on the panels of the control series and from traces to light, or rarely moderate, on the panels of the test series.

2. Algae. Algae occurred on 2 test panels at the Timber Wharf, on a single control panel and 4 test panels at the "1010 Wharf", and on a single control panel and 3 test panels at the DE Wharf. The algae were mostly green, but brown and red ones also occurred. The growths were mostly traces or occasionally light.

3. Invertebrate animal phyla.

a. Porifera (sponges). One colony of sponges was recorded on one test panel and three colonies on another panel at the Fuel Oil Pier.

b. Coelenterata (hydroids). Hydroids occurred with great frequency on the panels at all four locations. They were on 36 of the 41 control panels and 41 of the 48 test panels at the Timber Pier, on 31 of the 41 control panels and 39 of the 48 test panels at the "1010 Wharf", on 22 of the 41 control panels and 38 of the 48 test panels at the DE Wharf, and on 25 of the 41 control panels and 41 of the 48 test panels at the Fuel Oil Pier. The growths mostly rated as traces on the panels of the control series and as traces or occasionally light on the panels of the test series. Tubularia was the only form identified.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred abundantly at one location but were almost lacking at the other locations. At the Timber Wharf, they occurred on 15 of the 41 control panels and on 27 of the 48 test panels. Five of the test panels were 40%, 50%, 60%, and 75% covered, respectively. Their only occurrence at the other locations was on single panels of both the control and test series at the "1010 Wharf" and on a single control panel at the DE Wharf. None was identified. Filamentous Bryozoa occurred more or less abundantly at all four locations. They were manifest on 12 of the 41 control panels and on 17 of the 48 test panels at the Timber Wharf, on 33 of the 41 control panels and 39 of the 48 test panels at the "1010 Wharf", on 9 of the 41 control panels and 25 of the 48 test panels at the DE Wharf, and on 11 of the 41 control panels and 24 of the 48 test panels at the Fuel Oil Pier. One of the test panels at the DE Wharf was 10% covered, and one test panel at the Fuel Oil Pier was 5% covered. Bugula flabellata, B. neritina, and B. sp. were identified.

d. Annelida (annelid worms). Serpulid (Serpula) tubes occurred with great frequency and abundance on the panels at all locations.



At the Timber Wharf, they showed up on 28 of the 41 control panels and on 38 of the 48 test panels. One of the test panels was 10% covered. At the "1010 Wharf", they were on 39 of the 41 control panels and on all 48 test panels. Seventeen of the control panels were from 20% to 100% covered, and 18 of the test panels were from 20% to 100% covered. At the DE Wharf, they occurred on 38 of the 41 control panels and on 45 of the 48 test panels. Five of the control panels were from 15% to 50% covered, and 5 of the test panels were from 50% to 75% covered. At the Fuel Oil Pier, there were serpulid tubes on 37 of the 41 control panels and on 43 of the 48 test panels. Eleven of the control panels were from 20% to 100% covered, and 5 of the test panels were from 5% to 60% covered.

e. Arthropoda (crustaceans). Balanus (barnacles) also occurred with great frequency and in great abundance on the panels at all four locations. At the Timber Wharf, they occurred on 30 of the 41 control panels and on 45 of the 48 test panels. Four of the control panels were from 20% to 40% covered, and 17 of the test panels were from 20% to 100% covered. At the "1010 Wharf", they were on 36 of the 41 control panels and on 44 of the 48 test panels. Twelve of the control panels were from 10% to 100% covered and 20 of the test panels were from 20% to 90% covered. At the DE Wharf, barnacles appeared on 32 of the 41 control panels and on 47 of the 48 test panels. Five of the control panels were from 15% to 50% covered, and 29 of the test panels were from 10% to 100% covered. At the Fuel Oil Pier, they occurred on 30 of the 41 control panels and on 46 of the 48 test panels. Seventeen panels of both series were from 25% to 100% covered. On the control panels, maximum diameters of 9, 14, 18, and 12 mm were recorded for the respective locations in the order in which they are listed, while on the test panels, maximum diameters of 25, 19, 25, and 22 mm were recorded in 8, 4, 8, and 4 months, respectively. Corophium tubes up to 25 mm long occurred on the first panel in both the control and test series, there being approximately 200 tubes on each.

f. Mollusca (nonboring mollusks). Anomia (jingle-shells) also occurred with considerable frequency on the panels at all four locations, although the number on any panel was generally few, and it exceeded 46 only twice. At the Timber Wharf, they showed up on 14 of the 41 control panels and on 15 of the 48 test panels. At the "1010 Wharf", they were on 23 of the 41 control panels and on 38 of the 48 test panels. One of the control panels was 60% encrusted. At the DE Wharf, they appeared on 17 of the 41 control panels and on 37 of the 48 test panels. At the Fuel Oil Pier, they occurred on 21 of the 41 control panels and on 40 of the 48 test panels. Ostrea (oysters) occurred in small numbers on occasional test panels at all locations. They were on six at the Timber Wharf, on seven at the "1010 Wharf", on five at the DE Wharf, and on seven at the Fuel Oil Pier. Maximum diameters of 18, 45, 20, and 30 mm were recorded in 5, 8, 7, and 4 months, respectively.

g. Chordata (tunicates). Tunicates occurred with considerable frequency at all locations. They were on 4 of the 41 control panels and on 19 of the 48 test panels at the Timber Wharf, on 13 of the 41 control panels and 36 of the 48 test panels at the "1010 Wharf", on 6 of the 41 control panels and 33 of the 48 test panels at the DE Wharf, and on 4 of the 41 control panels and 17 of the 48 test panels at the Fuel Oil Pier. Botryllus schlosseri occurred frequently, but Molgula and Ciona were also identified.

#### A48.05 Summary and Conclusions

1. Installation. Four test boards of the panel type installed at different locations at the Pearl Harbor Naval Shipyard at Pearl Harbor, Hawaii, on July 3 and 4, 1944, are still being operated. The results of these tests have been summarized to the end of 1947.

#### 2. Test Results.

a. Borers. Teredinidae were very active at all locations throughout the period covered by the tests, the breeding season being continuous and the attacks extremely destructive at each location, with panels becoming filled or riddled within 2 or 3 months. Limnoria also showed more or less activity at all locations, but the severity of the attack varied from year to year and at different locations. At the Timber Wharf, the attacks attained peak ratings of medium heavy in 1945, 1946, and 1947. At the "1010 Wharf", they attained peak ratings of medium heavy in 1945 and 1946 and very heavy in 1947. At the DE Wharf, they attained peak ratings of slight in 1945 and 1946 and very heavy in 1947. At the Fuel Oil Pier, they attained peak ratings of slight in 1945, 1946, and 1947. Pholadidae likewise showed more or less activity at all locations, varying slightly from year to year. At the Timber Wharf, the attacks rated very heavy in 1945, moderate in 1946, and none in 1947. At the "1010 Wharf", they rated very heavy in 1945 and 1946 and slight in 1947. At the DE Wharf, they rated very heavy in 1944 and 1946 and heavy in 1945 and 1947. At the Fuel Oil Pier, they rated very heavy in 1944 and 1945 and medium heavy in 1946 and 1947.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 7 phyla contributed to the fouling of the panels. The phyla comprised sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles and Corophium, jingle-shells and oysters, and tunicates. Of these organisms, serpulid worms and barnacles occurred with the greatest frequency and abundance; hydroids, jingle-shells, and filamentous Bryozoa each occurred with progressively less frequency; while encrusting Bryozoa occurred frequently only at the Timber Wharf. The occurrence of the others, as well as the algae, was merely sporadic or occasional.

3. Recent Addenda. There was a very heavy attack of Teredinidae on the board at the Timber Wharf in both 1948 and 1949. The Limnoria attack was moderate in 1948 and only slight in 1949 at this location. At the board near the "1010 Wharf", the attack by Teredinidae was very heavy in both 1948 and 1949. Limnoria were also very heavy here both years. The test board at the DE Wharf was attacked very heavily by Teredinidae in both 1948 and 1949. The Limnoria attack here rated very heavy in 1948 and medium heavy the following year. There was a slight attack by Pholads (Hiata and Martesia) in 1948 but none appeared here in 1949. These Pholads appeared as traces on the board at the "1010 Wharf" both years. The attack from Teredinidae sets was very heavy in both 1948 and 1949 at the Fuel Oil Pier. Limnoria rated slight at this location both years. A slight attack of Pholads (Hiata and Martesia) appeared on the board at the Fuel Oil Pier in 1948. In 1949, the appearance of Pholads rated as a mere trace.

## PALMYRA ISLAND -- U. S. NAVAL AIR STATION

A49.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the U. S. Naval Air Station on Palmyra, Territory of Hawaii, from December 20, 1945 until January 19, 1947, when it was discontinued because of the contemplated inactivation of this Station. Palmyra Island is located in the Central Pacific Islands, south of the Hawaiian Islands and Northwest of Fanning and Christmas Islands at (approximate) latitude 6° N and longitude 162° W. No information is available as to the location of the test board at this Station, which was designated by the symbol USNPI-1.

After the middle of 1946, there was considerable confusion with regard to the length of time that some of the panels were submerged because of their removal in improper order.

A49.02 Hydrographic Data

The depth of water where this test board was installed was 15 ft; the tidal range was given as  $3\frac{1}{2}$  ft; the current velocity was not recorded. The temperature of the water at the time of installation was 80° F. With regard to pollution, it was merely stated that the water was clear, so apparently no appreciable pollution existed.

A49.03 Marine Borers

1. Teredinidae. Teredinidae were very active at this location throughout the brief period covered by the test. They occurred in all the control panels, ranging from minute pits or embryonic specimens up to those 55 mm in length in one panel which had been inadvertently left submerged for two months. It is clearly evident that the breeding season at this location is continuous. Teredinidae occurred in all the test panels, and 2 were 75% filled after having been submerged for 4 months, with specimens in one panel up to 230 mm in length. No determination was made of the species involved. The attack at this location rated very heavy in 1946.

2. Limnoria. Limnoria were active and extremely abundant throughout the period covered by the test. They occurred in all the control panels and in unusually large numbers in most of them, there being some 15,000 tunnels recorded in one panel submerged from May 20 to June 18, 1946. In the test panels, there was a rapid increase in the number of Limnoria tunnels from the beginning of the test, with a peak

in May and June of 1946, when it was estimated that 12,000 tunnels occurred in panels that had been submerged for 5 and 6 months, respectively. After this time, the Limnoria population diminished rapidly and then increased again, until 4,600 tunnels were recorded in the panel removed on December 20, 1946, and 3,300 in the one panel removed on January 19, 1947. However, the period of submergence of these 2 panels was not known because of failure to remove them in the proper order. It is plainly apparent from this brief test that the Limnoria attack at this location was extremely severe in 1946.

3. Pholadidae. No Pholadidae were recorded at this location.

#### A49.04 Fouling Agents

1. Silt. Silt occurred as traces or light deposits on all the panels, both control and test.

2. Invertebrate animal phyla.

- a. Coelenterata (hydroids). Hydroids occurred as traces or light growths on 6 of the 12 control panels and on 10 of the 14 test panels. None was identified.

- b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on 6 of the 12 control panels and on 11 of the 14 test panels. The identity of these Bryozoa was not determined. Filamentous Bryozoa occurred more or less abundantly on 7 of the 12 control panels and on 10 of the 14 test panels. Bugula neritina was the only form identified.

- c. Annelida (marine worms). Serpulid (Serpula) tubes occurred, often in considerable numbers, on 3 of the 12 control panels and on 10 of the 14 test panels. The first of the test panels had an average of 35-40 tubes per sq in. (5,280).

- d. Mollusca (mollusks). A trace of Anomia (jingle-shells) occurred on a single control panel and on 2 of the test panels.

#### A49.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Air Station on Palmyra Island, Territory of Hawaii, from December 20, 1945 until its discontinuance on January 19, 1947, to determine the identity and prevalence of marine borers and fouling organisms at this location.

## 2. Test Results.

a. Borers. Teredinidae were very active throughout the brief period covered by the test, and it is clearly apparent that the breeding season is continuous throughout the year. The attack rated very heavy in 1946. Limnoria also were active and extremely abundant throughout the period covered by the test, occurring in exceptionally large numbers in the control panels. The attack was extremely severe in 1946. No Pholadidae were recorded at this location.

b. Fouling Organisms. Silt and invertebrate animals belonging to 4 phyla contributed to fouling of the panels. The phyla comprised hydroids, encrusting and filamentous Bryozoa, serpulid worms, and jingle-shells. Hydroids, encrusting and filamentous Bryozoa, and serpulid worms occurred with great frequency, while the occurrence of the jingle-shells was merely very occasional. The test was unusual in that the heretofore ubiquitous barnacles and tunicates were absent.

The operation of this test board was not continued long enough to provide conclusive information on the breeding habits and development of the marine borers and fouling organisms at this location, but it does show the general trend.

## Section 50

### WAKE ISLAND -- U. S. NAVAL AIR BASE

#### A50.01 Location of Test Stations and Test Boards

Test boards of the panel type were operated by the 85th Naval Construction Battalion at two locations on Wake Atoll from January 10, 1946 to June 10, 1947, when their operation was terminated because of the inactivation of this Base. The Pan-American Airways, which is now controlling operations on Wake Island, have been requested to continue the operation of the test boards, but no further panels have been received.

Wake Atoll consists of three islands: Wake, Wilkes, and Peale. Information was given on January 16, 1946, that the channel between Wake and Wilkes Islands had been closed recently by a causeway, forming a boat basin. Prior to this, the current caused by tide and wind had varied from 0 to 7 knots. Since then, only a moderate current is caused by the inflow and outflow of the tides. On the Wilkes side of this channel, opposite the location of Test Board No. 1 (designated as USNWI-1), there is an old dock made of wood cribbing, which was built at least 5 years prior to the above date. The action of marine borers was reported to be very noticeable in this cribbing.

The islands of Wake and Peale are connected by a bridge on steel piling, and below the bridge there is a water-level concrete causeway. The current in the channel varies with tide and wind from 0 to 5 knots, the causeway acting something like a weir. Test Board No. 2, designated as USNWI-2, is located near this point.

In the lagoon, which is not navigable and has coral formations almost awash at low tide, there is a sunken dredge at the location of this test board. The wooden wales of this dredge also showed considerable marine borer activity.

It was not possible to comply with the request that the test boards preferably be installed adjacent to, or in the vicinity of, untreated piling, as all the piling in the boat basin is, and will continue to be, of steel. However, close to Test Board No. 1 there were camels made of untreated wood in front of a bulkhead of steel sheet piling.

#### A50.02 Hydrographic Data

The depth of water where the test boards were installed was 18 ft at location No. 1 and 11 ft at location No. 2. The range of

tide was 2.5 ft, and the strength of the current as determined by tidal flow was approximately one knot. The temperature of the water at the time of installation was 70° F. There was said to be no pollution.

#### A50.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo sp., were extremely active and destructive at both locations, rating very heavy at the second location and heavier yet at the first. They occurred in all the control panels received from both locations, except the first panel of Test Board No. 2, which clearly indicated that they were breeding throughout the year. While many of the control panels from both test boards showed only pits or minute specimens, tunnels up to 70 mm in length were recorded in a panel of the board at the second location. One control panel which had been exposed from October 10 to November 10, 1946, at the first location was riddled, and one at the second location that had been exposed from January 10 to February 11, 1947, was filled.

All five test panels that were removed during the months of May to November (December panel was lost), after 4, 5, 6, 7, and 8 months' exposure, respectively, at the first location were either filled or riddled, with some specimens up to 190 mm in length. At the second location, all the test panels that were removed from August to December after 7 or 8 months' exposure, were more or less filled, with specimens running up to 220 mm in length. It thus appears that the period of most active growth ranges from May to December.

2. Limnoria. Limnoria also were active at both locations throughout the period for which the test boards were operated, occurring in all panels received, both control and test, except in the first panel of the control series at the second location. At the first location, the attack in the control panel submerged from October 10 to November 12, 1946, was exceptionally severe and rated medium heavy. At the second location, the attack was exceptionally severe in 2 of the control panels, rating heavy in one panel submerged from January 10 to February 11, 1947, and medium heavy in one inadvertently exposed for two months from April 10 to June 10, 1947. Such outstanding attacks in control panels demonstrate the ability of Limnoria to destroy wood very rapidly in comparatively short periods.

In the test panels, the Limnoria population fluctuated within certain limits but, in general, maintained a fairly high level, with the maximum attack at both locations ranging from the lower limit of the heavy rating in 1946 to well up in the same rating in 1947.



3. Pholadidae. No Pholadidae were recorded at either location.

#### A50.04 Fouling Agents

1. Silt. Deposits of silt, ranging from traces to light or sometimes medium, occurred on all the panels, both control and test, at both locations.

2. Algae. Algae occurred as traces to light growths on 5 of the 14 control panels and on 6 of the 15 test panels received from location No. 1. At the second location, they were more prevalent, occurring as traces to light or rarely moderate growths on 13 of the 16 control panels and 12 of the 16 test panels, one of the test panels being 40% covered. These growths were mostly green, although red and brown algae were also noted.

#### 3. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on 4 of the 14 control panels and on 7 of the 15 test panels received from location No. 1. At the second location, they were more widely prevalent, occurring on 9 of the 16 control panels and on 12 of the 16 test panels. However, they were limited to traces and light growths. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Traces of encrusting Bryozoa occurred on 2 control panels and on only one test panel at the first location. At the second location, they occurred only on a single test panel. Traces of filamentous Bryozoa occurred on only one each of the control and test panels at the first location, and none were recorded at the second location.

c. Annelida (annelid worms). Serpulid worms occurred more or less abundantly on 8 of the 13 control panels and on 11 of the test panels at the first location, some of the latter being from 25% to 50% covered. At the second location, they occurred only on 4 of the 16 test panels. Serpula and Spirorbia were present at both locations.

d. Mollusca (nonboring mollusks). A single specimen of Ostrea (oysters) was recorded on one of the test panels from the second location.

e. Chordata (tunicates). A few colonies of Botryllus schlosseri occurred on only a single panel of the control series at the first location.

## A50.05 Summary and Conclusions

1. Installation. Test boards of the panel type were operated at two locations on Wake Atoll from January 10, 1946 to June 10, 1947, to determine the identity and prevalence of marine borers and fouling agents.

### 2. Test Results.

a. Borers. Teredinidae were extremely active and destructive at both locations, and breeding occurred continuously throughout the year. The attack rated very heavy at both locations and especially so at the first location. Limnoria also were active at both locations throughout the year, the attack rating heavy. No Pholadidae were recorded at either location.

b. Fouling Organisms. Silt, algae, and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The phyla comprised hydroids, encrusting and filamentous Bryozoa, serpulid worms, oysters, and tunicates. Silt occurred regularly on all the panels at both locations. Algae occurred on most of the panels at location No. 2 but only sporadically at location No. 1. Hydroids and encrusting Bryozoa occurred frequently at location No. 2 but only sporadically at location No. 1. Serpulid worms occurred fairly frequently at location No. 1 but only occasionally at location No. 2. The occurrence of the other organisms was purely sporadic or occasional.

## Section 51

### ENIWETOK ATOLL, MARSHALL ISLANDS -- 592D NAVAL CONSTRUCTION BATTALION MAINTENANCE UNIT

#### A51.01 Location of the Test Station and Test Board

A test board of the panel type was operated by the 592d Naval Construction Battalion Maintenance Unit at Eniwetok Atoll, Marshall Islands, from March 11 to August 11, 1946, when it was discontinued as a result of the cessation of military activity at this location. This test board was designated by the symbol USNAT-1. No information was given with regard to its exact location.

#### A51.02 Hydrographic Data

The depth of water at the location where the test board was installed was 20 ft; the tidal range was 4 ft; the velocity of the current was about 2 knots. The temperature of the water at the time of installation was 82° F. The water was relatively free from pollution.

#### A51.03 Marine Borers

1. Teredinidae. Teredinidae (no determinations made) were active throughout the brief period of the test. They occurred in 2 of the 4 control panels that were received. One of these panels contained only 12 specimens, no specimen was more than 15 mm in length, and the other panel had only seven juvenile forms. The breeding season at this location is probably continuous. Teredinidae also occurred in all 4 of the test panels received. The test panel removed at the end of one month contained 3 specimens up to 10 mm long; the panel removed at the end of 3 months was filled with specimens up to 130 mm long; the panel removed at the end of 4 months was half filled with specimens up to 45 mm long; and the panel removed at the end of 5 months was filled with specimens up to 58 mm long and also contained many stenomorphs. Although the test was continued for only 5 months, and the second one of the test panels and its accompanying control panel were lost, it is apparent that the attack was very heavy.

2. Limnoria. Limnoria were very active at this location, and there was a rapid increase in numbers up to the time the test was terminated, thus indicating that if it had been continued longer, the attack would have been much heavier. In the control panels, the number of Limnoria tunnels in the 4 received was 6, 10, 42, and 660, respectively. No Limnoria were recorded in the first test panel submerged. The second panel was lost, and there were 85, 75, and 2,600

tunnels, respectively, in panels submerged for 3, 4, and 5 months. The Limnoria attack at this location was rated as moderate on the strength of the maximum number of tunnels recorded, but undoubtedly it would have been much heavier had the test been conducted longer.

3. Pholadidae. No Pholadidae were recorded at this location.

#### A51.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series, the deposits ranging from traces to moderate in each series.

2. Algae. A trace to a light growth of green algae occurred on the first 2 control panels and on the first 2 test panels received.

3. Invertebrate animal phyla.

a. Coelenterata (hydroids): Hydroids occurred as traces on 3 of the 4 control panels and as traces to light growths on 3 of the 4 test panels received.

b. Annelida (marine worms). A trace of serpulid (Serpula) tubes occurred on one control panel and on 2 test panels.

#### A51.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated by the 592d Naval Construction Battalion Maintenance Unit at Eniwetok Atoll, Marshall Islands, from March to August in 1946, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

2. Test Results.

a. Borers. Teredinidae occurred in destructive numbers, and the severity of the attack was rated as very heavy. The breeding season is probably continuous. Limnoria also were very active, and the attack rated as moderate, although increasing rapidly at the time the operation of the test board was discontinued. No Pholads were recorded at this location.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 2 phyla contributed to fouling of the panels. The phyla were hydroids and serpulid worms. Hydroids occurred with the greatest frequency, and serpulid worms and green algae occurred as infrequent traces.

## MANUS ISLAND, ADMIRALTY ISLANDS -- UNIDENTIFIED NAVAL BASE

A52.01 Location of the Test Station and Test Board

A test board of the panel type was operated at an unidentified Naval Base on Manus Island, Admiralty Islands, from February 19 to October 2, 1946, when it was discontinued because of the inactivation of this Base. No information was given as to the location of this test board, designated as USNY-1, other than that it was at Murzim Pier. It was reported that no marine borer activity had been evident in this area within the past two years.

A52.02 Hydrographic Data

The depth of water where the test board was installed was 10 ft. The tidal range was given as follows: mean, 1.4 ft; diurnal, 1.7 ft; and spring, 3.0 ft. There was no current. The temperature of the water at the time the board was installed was 70° F. With regard to pollution it was stated: "Ten colonies per culture plate; acid- and gas-forming bacteria were present."

A52.03 Marine Borers

1. Teredinidae. The duration of this test was so brief that only 6 sets of panels were removed, and the fourth control panel never was received. Teredinidae, including Bankia sp. and Teredo (Lyrodus) sp., occurred in 5 control panels. The first panel had only 16 minute pits; while the second, submerged for one month, contained 210 specimens, some of which were as much as 75 mm long. The third panel, submerged for 2 months by mistake, was filled with specimens up to 85 mm long. The fifth panel, also submerged for 2 months by mistake, contained only 4 specimens, ranging up to 30 mm long, and the sixth contained 50 specimens up to 7 mm long.

The first one of the test panels, submerged for one month, showed only 36 minute pits. The second panel, submerged for 2 months, was filled with specimens up to 105 mm long. The third and fourth, each submerged for 4 months, were both riddled with specimens up to 180 mm long. The fifth, submerged for 6 months, was riddled with specimens up to 230 mm long. While the duration of the test was entirely too short to afford an accurate picture of the attack by Teredinidae, it clearly shows that they were active throughout the period covered by the test, apparently starting to breed about the middle of February and rapidly becoming destructive. The breeding season at this location is probably continuous. The attack rated very heavy, with panels becoming filled or riddled within 2 or 3 months.

2. Limnoria. Limnoria were active in all the panels throughout the period of the test, and the attack rapidly became destructive. In the last control panel submerged for less than a month (from August 10 to September 2), the attack rated slightly above moderate. In the test panels, the Limnoria population rose rapidly, attaining a rating of heavy in a panel removed August 10 after having been submerged for 6 months, although somewhat lower in the last panel.

3. Pholadidae. No Pholadidae were recorded at this location.

#### A52.04 Fouling Agents

1. Silt. Silt occurred on all the panels, both control and test, ranging from traces to light deposits.

2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on all the panels, both control and test, ranging from traces to light deposits. Tubularia was the only form identified.

b. Bryozoa (encrusting). Encrusting Bryozoa occurred on 3 of the 5 control panels and on 4 of the 6 test panels. They were mostly few in number. Electra monostachys was determined in one case.

c. Annelida (annelid worms). Serpulid (Serpula) worms occurred on one of the control panels and on 4 of the test panels. They were few in number in 2 of the latter, but the other 2 test panels contained 50 to 65 tubes, respectively.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred on the first 3 control panels and on the first 4 test panels, the greatest number on any single panel being 25 barnacles. On the control panels, the maximum diameter of the specimens was 10 mm, and on the test panels, the maximum was 15 mm on one panel exposed for 4 months.

e. Mollusca (nonboring mollusks). A dozen juvenile specimens of Mytilus (mussels) occurred on a single control panel.

#### A52.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at an unidentified Naval Base on Manus Island, Admiralty Islands, from February 10 until its discontinuance after October 2, 1946.

## 2. Test Results.

a. Borers. Teredinidae were active in all the panels throughout the brief period of the test, the breeding season apparently being continuous. The attack rated very heavy in panels exposed only 4 months. Limnoria also were active in all the panels throughout the test, the attack rapidly becoming destructive and rating heavy. No Pholads were recorded at this location.

b. Fouling Organisms. Silt and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The invertebrates comprised hydroids, encrusting Bryozoa, serpulid worms, barnacles, and mussels. Silt and hydroids occurred regularly on all the panels. Encrusting Bryozoa, serpulid worms, and barnacles occurred less frequently, and mussels only once.

The operation of the test board was not continued long enough to provide conclusive information on the breeding habits and development of the marine borers and fouling organisms at this location, but the conclusions reached from its study show the general trend.

## Section 53

### ESPIRITU SANTO ISLAND, NEW HEBRIDES -- U. S. NAVAL ADVANCED BASE

#### A53.01 Location of the Test Station and Test Boards

Four test boards of the panel type were installed August 10, 1944, at different locations at the U. S. Naval Advanced Base Depot on Espiritu Santo Island, New Hebrides. Because of the varying conditions, four representative locations were selected. Two of these locations were in Segond Channel, one in Pallukulo Bay, and one in Turtle Bay, but the exact locations were not disclosed for security reasons. It appears from correspondence, however, that Station No. 2 was on Aore Island, which is separated from Espiritu Santo Island by Segond Channel. The test boards at Stations 2 and 4 were missing on the inspection date in October 1945, apparently having been carried away during a storm. The curtailment of military activity at that time made it necessary to discontinue the operation of the boards at these stations, and the operation of those boards at Stations 1 and 3 was discontinued after January 10, 1946. These test boards were designated by the symbols USNXX-1, 2, 3, and 4.

#### A53.02 Hydrographic Data

1. Station No. 1. The test board at this location was submerged in water 29 ft deep where the tidal range was 5 ft and the current fairly slow. The water was clear and clean at each of these locations and was recorded as having a temperature of 78° F at the time of installation. The test board was located 3 ft from treated piling.

2. Station No. 2. The test board at this location was submerged in water 28 ft deep where the tidal range was 5 ft and the current fairly slow. It was located 5 ft from treated piling.

3. Station No. 3. The test board at this location was submerged in water 28 ft deep where the tidal range was 5 ft and the current fairly slow. It was located 10 ft from treated piling.

4. Station No. 4. The test board at this location was submerged in water 15 ft deep where the tidal range was 4 ft and the current fairly slow. It was located near the pontoon dock.

#### A53.03 Marine Borers

1. Teredinidae. Teredinidae were extremely active and destructive throughout the period of the test, occurring in every control and test panel at each of the four locations. They were so destructive that it was requested in November 1944 that all panels on the test boards be



removed and replaced with panels 2 inches thick. This change was made on January 10, 1945. In November 1945 it was requested that the panels on the test boards be removed and replaced by a new series to be operated on a 4-month basis instead of on the 8-month basis which was being employed. The panels on the test boards which were still being operated at Stations 2 and 4 were removed on January 10, 1946, and the operation of these boards was discontinued at this time.

In many of the control panels at each location, Teredinidae were embryonic, but they ranged up to 43 mm, 120 mm, 40 mm, and 12 mm in length at locations 1, 2, 3, and 4, respectively. The maximum number recorded in any one of these panels was 660 up to 12 mm long at location No. 1, approximately 4,000 up to 15 mm long at location No. 2, approximately 1,000 up to 24 mm long at location No. 3, and 660 up to 10 mm long at location No. 4.

Most of the test panels at each location were either filled or more or less completely riddled. They became riddled when submerged for as brief a period as 3 months. Maximum lengths of 280 mm, 325 mm, 320 mm, and 510 mm were recorded at locations 1, 2, 3, and 4, respectively. An unusual number of species was recorded on panels from these locations. Those species identified included Bankia hawaiiensis, Teredo (Lyrodus) diegensis, T. (Lyrodus) sp., T. disconus, T. fulleri, T. gregoryi, T. milleri, T. trulliformis, T. (Psiloteredo) sp., T. (Teredora) sp., and Teredo sp. The attack rated very heavy at all four locations.

2. Limnoria. Limnoria were active throughout the period of the test, occurring in all the panels, both control and test, at locations 3 and 4 and in nearly all of both types at the other two locations. The maximum attack rated medium heavy at locations 1 and 2 and heavy at the other two locations.

3. Pholadidae. No Pholadidae were recorded at any of these locations.

#### A53.04 Fouling Agents

1. Silt. Silt occurred on all the panels, both control and test, at each of the four locations; nearly all the deposits ranged from traces to light.

2. Algae. Green algae occurred on only 2 control panels at location No. 1, on one control and 2 test panels at location No. 2, on 5 control panels and 9 test panels at location No. 3, and on 8 control and 10 test panels at location No. 4. The growths were mostly traces but were occasionally light.

### 3. Invertebrate animal phyla.

a. Porifera (sponges). Ten colonies of an encrusting sponge were recorded on a single test panel at location No. 1, but none whatever occurred at the other locations.

b. Coelenterata (hydroids). Hydroids, ranging from traces to occasionally light growths, occurred on nearly all the panels, both control and test, at all four locations.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred quite frequently at all four locations, being recorded on 20 of a combined total of 58 control panels and on 39 of a combined total of 72 test panels. The number of colonies per panel ranged from one to 50. Cryptosula pallasiana, Cryptosula sp., Electra., and Holoporella sp. were identified. Filamentous Bryozoa occurred on 6 control panels and on 5 test panels at location No. 1, and on one panel of each type at location No. 2, but did not occur on any of the panels at the other two locations. The number of colonies on any one panel ranged from 1 to 24. Bugula sp. was the only identification.

d. Annelida (annelid worms). Serpulid (Serpula) worms occurred quite frequently on panels, both test and control, at locations 1, 2, and 3, but only on 2 test panels at the other location. They occurred on 15 of a combined total of 58 control panels and on 49 of a combined total of 72 test panels, ranging from a trace to numerous. At location No. 3, six test panels removed consecutively were covered.

e. Mollusca (nonboring mollusks). A trace of Ostrea (oysters) was recorded on one of the test panels at location No. 4. The maximum diameter recorded was 35 mm. A trace of Anomia (jingle-shells) was recorded on a single test panel at location No. 2 and on 2 test panels at location No. 4. The maximum size attained was 40 mm in diameter.

f. Chordata (tunicates). Botryllus schlosseri was recorded on a single control panel and a single test panel at location No. 2, there being one and 10 colonies, respectively, at these panels.

#### A53.05 Summary and Conclusions

1. Installation. Test boards of the panel type were operated at four locations at the U. S. Naval Advanced Base at Espiritu Santo Island, New Hebrides, to determine the identity and prevalence of marine borers and fouling agents. The boards were installed on August 10, 1944; two boards were operated until September 10, 1945, and the other two until January 10, 1946.

## 2. Test Results.

a. Borers. Teredinidae were extremely active and destructive throughout the period of the test, occurring in every panel, both control and test, at each of the four locations, with the breeding season extending throughout the year. Test panels at each location were riddled when submerged for as brief a period as 3 months. The attack rated very heavy at all four locations. Limnoria also were active throughout the period of the test, occurring in all the panels, both control and test, at locations 3 and 4 and in nearly all of both types at the other two locations. The maximum attack rated medium heavy at locations 1 and 2 and heavy at the other two locations. No Pholads were recorded at any of these locations.

b. Fouling Organisms. Silt, green algae, and invertebrate animals belonging to 6 phyla contributed to fouling of the panels. The phyla were encrusting sponges, hydroids, encrusting and filamentous Bryozoa, annelid worms, nonboring mollusks, and tunicates. Silt occurred on all the panels, both control and test, at each of the four locations. Hydroids and encrusting Bryozoa occurred quite frequently at all four locations and green algae somewhat less frequently. Serpulid worms occurred quite often at locations 1, 2, and 3 but were scarce at the other location. The filamentous Bryozoa occurred sporadically at locations 1 and 2 but not at all at the others. The occurrence of the other organisms was largely occasional.

## Section 54

### NOUMEA, NEW CALEDONIA -- U. S. NAVAL ADVANCED BASE

#### A54.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the U. S. Naval Advanced Base at Noumea, New Caledonia, from July 19, 1944 to May 28, 1946. No details were given as to the exact location of this test board, which was designated by the symbol USNNC-1. Its operation was discontinued with the cessation of military activity at this location. U. S. Naval Activities at Noumea were placed in a caretaker status in June 1946 and were disestablished in May 1947.

#### A54.02 Hydrographic Data

The depth of water where the test board was installed was 32 ft at mean low water; the tidal range averaged 4.5 ft; the velocity of the current was not more than one knot. The temperature of the water was given as 68° F to 72° F, but it is not clear as to just what portion of the year this applied, or whether it is the range for the year. The water was reported to be polluted by sewers of the City of Noumea and by ships tied up at the piers.

#### A54.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo (Cornuteredo) medilobata and T. (Lyrodus) sp., occurred sporadically in 5 of the 22 control panels, but all specimens were embryonic or minute; the maximum number recorded in any one panel was 15 specimens. The breeding season extends from the middle of July to the middle of March. Teredinidae also occurred rather sporadically in 13 of the 22 test panels, but mostly in small numbers; in fact, the number exceeded 8 in only 2 panels. One of these panels had from 80-100 specimens, ranging from embryonic to 10 mm in length. Panels removed from February to March of 1945, after 8 months' submergence, had tunnels from 60-180 mm in length, while the greatest length recorded was in another panel with the same period of submergence, removed November 27. The maximum attack by Teredinidae at this location was considered to rate as moderate.

2. Limnoria. Limnoria occurred with great regularity and abundance at this location. There was only a single control panel where it was not recorded, and in one panel there was an average of 15 tunnels per sq in. (1,980 in all). From the time the test board was submerged in July 1944 there was, in general, a gradual increase in the Limnoria population until a peak rating of very heavy was attained

in an 8-month panel removed in May 1945. After this, the number of tunnels fell abruptly and remained fairly low through October 1945, and then suddenly attained a high peak, with never less than 75, and mostly 90, tunnels per sq in. from then until the termination of the test at the end of May 1946. The Limnoria attack thus rated very heavy in both 1945 and 1946.

3. Pholadidae. No Pholadidae were recorded at this location.

#### A54.04 Fouling Agents

1. Silt. Traces of silt occurred on all the panels except one of the controls. On the control panels, there were mostly traces but sometimes light deposits; while on the test panels, silt mostly ranged from traces to light, but sometimes moderate, and once heavy.

2. Invertebrate animal phyla.

a. Porifera (sponges). Encrusting sponges occurred on 9 of the 22 control panels and on 11 of the 22 test panels. On the test panels, it occurred on all except one of those panels removed from November 20, 1944 to October 20, 1945. While these panels were mostly limited to occasional colonies, there were as many as 50 on a test panel, and 2 control panels were recorded as 25% and 50% covered, respectively.

b. Coelenterata (hydroids). Hydroids occurred on most of the panels, but they were absent on the control panels removed after October 1945 and also on the test panels removed during the months from December 1945 through April 1946. They rated as traces on the control panels and as traces, but sometimes light, on the test panels.

c. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on all the control panels and on all except one test panel. Nine test panels were from 25% to 80% covered, and even one of the control panels was 75% covered. In most cases, the organism was identified as Cryptosula pallasiana or as Cryptosula sp., but Hippodina feegeensis and Watersipora cucullata also were identified. Filamentous Bryozoa were recorded on 3 control panels and on 2 test panels, but mostly as traces.

d. Annelida (annelid worms). Serpulid (Serpula) tubes occurred more or less abundantly on all but 3 of the 22 control panels and on all of the test panels. One control panel was 5% covered, and one test panel was 12% covered. The maximum length of the tubes recorded on the control panels was 40 mm, while the maximum tube length on the test panels was 60 mm.

e. Arthropoda (crustaceans). Balanus (barnacles) occurred more or less abundantly on only 3 of the 22 control panels and on all the test panels that were removed before October 20, 1945, but only as minute traces on 2 of the 7 test panels removed thereafter, although these panels had been submerged for 8 months. Seven test panels submerged from 3 to 8 months were from 40% to 95% covered. The maximum diameter recorded on any of the control panels was 6 mm, while on the test panels, a maximum diameter of 16 mm was recorded on a panel submerged for 8 months.

f. Mollusca (nonboring mollusks). A trace of Anomia (jingle-shells) was recorded on 3 control panels and on only a single one of the test panels. A single specimen of the family Pterididae was also found on one of the test panels.

g. Chordata (tunicates). Tunicates were recorded on 2 control panels and on 2 test panels. They occurred as mere traces except on one of the test panels, which was 10% covered. In two cases the organism was identified as Botryllus schlosseri.

#### A54.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Advanced Base at Noumea, New Caledonia, from July 19, 1944 until its discontinuance after May 28, 1946, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

#### 2. Test Results.

a. Borers. Teredinidae occurred rather sporadically, and the attack appeared to rate only as moderate. The breeding season extended from the middle of July to the middle of March. Limnoria, however, were very abundant and very destructive, and the attack rated as very heavy in both 1945 and 1946. No Pholads were recorded at this location.

b. Fouling Organisms. Silt and invertebrate animals belonging to 7 phyla contributed to fouling of the panels. The phyla comprised encrusting sponges, hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, jingle-shells, and tunicates. The hydroids, encrusting Bryozoa, serpulid worms, and barnacles all occurred with great frequency, the encrusting sponges with less frequency, while the occurrence of the other organisms was purely sporadic or occasional.

## OKINAWA, SOUTHWESTERN ISLANDS OF JAPAN -- U. S. PACIFIC FLEET SECTION BASE

A55.01 Location of the Test Station and Test Board

A test board of the panel type was installed at the U. S. Pacific Fleet Section Base at Okinawa, Southwestern Islands of Japan, on February 6, and was operated until September 2, 1946, after which date the test board, together with the decking facilities to which it was attached, were carried away during a storm. The failure to install another test board was probably because of the decommissioning of this Base. This test board, which was designated by the symbol USNO-1, was submerged near the base of the Katchin Hanto Peninsula in Buckner Bay.

A55.02 Hydrographic Data

The depth of water where the test board was installed was 20 ft below mean low water. The daily range of tide for February 1946 varied from 0.5 to 6.9 ft. The strength of current was not measured but was estimated as 3 to 5 knots. The board was secured to a pontoon dock at the edge of a tidal channel 100 ft wide, in clear and constantly changing water. Several small ships that discharged their waste into the bay were usually tied up to the dock. The temperature of the water during February 1946 averaged 68° F. The board was in the vicinity of treated piling.

A55.03 Marine Borers

1. Teredinidae. While the operation of the test board at this location was discontinued shortly after Teredinidae became active, it was clearly apparent from their extremely rapid development that they were very destructive, and the attack was rated as very heavy. They appeared to begin breeding very slowly early in April and rapidly from June through August. It is quite likely, however, that a more extensive test would show the breeding season to be continuous at this location. The control panel submerged during June was one-third filled with specimens up to 68 mm long; the one submerged during July had only 5 minute pits; while the one submerged during August was 85% filled with juvenile specimens. Test panels submerged on February 6 and removed 5, 6, and 7 months later were 50% filled with specimens up to 60 mm, 75% filled with specimens up to 125 mm, and filled with specimens up to 222 mm long, respectively.

2. Limnoria. Limnoria did not show any sign of development until August, and only a trace was recorded during that month. The loss of the test board and discontinuance of the test made it impossible to follow their further development.

#### A55.04 Fouling Agents

1. Silt. Silt occurred on all the panels of both the control and test series, the deposits ranging from traces to mostly light.

2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred on the last 4 of the 7 control panels and on the first and the last 4 of the 7 test panels. They ranged from traces to light growths. Tubularia was the only form identified.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred on only one of the control panels and on 2 of the test panels. Filamentous Bryozoa occurred on the first 2 of the control panels and on the first 3 of the test panels.

c. Annelida (annelid worms). A trace of serpulid (Serpula) tubes occurred on 2 of the 7 test panels.

#### A55.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Pacific Fleet Section Base at Okinawa, Southwestern Islands of Japan, during the brief period from February 6 to September 2, 1946, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

2. Test Results.

a. Borers. Teredinidae developed with great rapidity, and their tunnels soon filled the panels more or less completely; the attack rated very heavy. They appeared to begin to breed early in April and rapidly from June through August, but a more extensive test would probably show the breeding season to be continuous. Limnoria did not show any signs of development until August, and only a trace was recorded during this month; but the loss of the test board and discontinuance of the test made it impossible to follow their further development.

b. Fouling Organisms. Silt and invertebrate animals belonging to 3 phyla contributed to fouling of the panels. The phyla comprised hydroids, encrusting and filamentous Bryozoa, and



serpulid worms. Of these organisms, hydroids occurred most frequently, filamentous Bryozoa occurred less frequently, and encrusting Bryozoa and serpulid worms occurred still less frequently.

The operation of the test board was not continued long enough to provide conclusive information on the breeding habits and development of the marine borers and fouling organisms at this location, but the results obtained show the general trend.

## BRISBANE, AUSTRALIA -- U. S. NAVAL OPERATING BASE

A56.01 Location of the Test Station and Test Board

A test board of the panel type was operated at the U. S. Naval Operating Base at Brisbane, Australia, from July 1, 1944 to January 3, 1945, when the board was discontinued because the personnel handling the installation were assigned to other activities and other locations, and the Base no longer maintained or operated waterfront facilities. The test board, designated by the symbol USNBA-1, was installed at the upstream end of the wharf at the Colonial Sugar Refinery Co., Ltd., in the Brisbane River, approximately 9 miles from Moreton Bay and 20 miles from the open sea.

A56.02 Hydrographic Data

The depth of water at the location where the test board was installed was 18 ft at low tide. There was an average tidal range of 6 ft and a maximum of  $7\frac{1}{2}$  ft. The maximum strength of the current was 3 knots during ebb and flow tide. The mean temperature of the water was given as 70° F. The degree of pollution was considered inconsequential. It was stated that there was an average of 50 vessels in the river but no city sewage. The water was reported to be muddy at all times.

A56.03 Marine Borers

1. Teredinidae. Teredinidae, including Bankia (Nausitora) sp. and Teredo sp., were active from September to the end of 1944, when the test was discontinued. They occurred as embryonic specimens in 3 of the 6 control panels, the last 2 panels not being received. The breeding season extends from September to at least December, and probably longer. Teredinidae also occurred in the last 6 of the 8 test panels, which had been submerged from 3 to 8 months, respectively. The maximum lengths recorded in these panels ranged from 8 mm in 3 months, 10 mm in 4 months, 25 mm in 5 months, to 75 mm in 6 months. The maximum number recorded was from 250-300 up to 75 mm long in a panel submerged for 6 months. While this test was not conducted long enough to provide conclusive information regarding the breeding season and the development of marine borers and fouling organisms at this location, it is certain that Teredinidae were present in destructive numbers and, accordingly, the attack was rated as very heavy.

2. Limnoria. No Limnoria or other crustacean borers and no Pholadidae were found in any of the panels.

## A56.04 Fouling Agents

1. Silt. Silt occurred as light deposits on all the control panels and as light to moderate deposits on all the test panels.

### 2. Invertebrate animal phyla.

a. Coelenterata (hydroids). Hydroids occurred as traces on all the control panels received except the last one, and as traces to light growths on all of the 8 test panels, which had been submerged for periods ranging from 1 to 7 months.

b. Bryozoa (encrusting and filamentous). Encrusting Bryozoa occurred more or less abundantly on 2 of the 6 control panels and on the first 6 of the 8 test panels. Electra sp. was the only one identified. Scattered colonies of filamentous Bryozoa (Bugula sp.) occurred on a single panel of both the control and test series.

c. Annelida (annelid worms). Serpulid (Serpula) tubes occurred on the last 2 of the control panels and on 2 of the test panels. They were few in number on all but the last one of the control panels, where tubes up to 30 mm in length covered 80% of the surface.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred more or less abundantly on 4 of the 6 control panels and on all 8 test panels. They attained maximum diameters of 12 mm in one month on a control panel and 22 mm on one of the test panels submerged for 4 months. On 2 of the test panels they covered 50% and 75%, respectively, of the surface.

e. Mollusca (nonboring mollusks). Mytilus (mussels) did not occur on any of the control panels but developed in great abundance on 5 of the 8 test panels which had been submerged from 3 to nearly 7 months. The maximum length recorded was 22 mm on a panel submerged for 5 months. On one of the test panels submerged for 6 months, 40% of the surface was covered; and on the last two, which had been submerged from 6 to 7 months, 90% of the surfaces were covered.

## A56.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated at the U. S. Naval Operating Base at Brisbane, Australia, during the last half of 1944, to determine the identity and prevalence of marine borers and fouling organisms occurring at this location.

## 2. Test Results.

a. Borers. Teredinidae occurred in destructive numbers and the maximum severity of attack was rated as very heavy. The breeding season extends from September to at least December, and probably longer. No Limnoria or other crustacean borers and no Pholadidae occurred in any of the panels.

b. Fouling Organisms. Silt and invertebrate animals belonging to 5 phyla contributed to fouling of the panels. The latter comprised hydroids, encrusting and filamentous Bryozoa, serpulid worms, barnacles, and mussels. The hydroids and barnacles occurred most frequently, the encrusting Bryozoa occurred less frequently, while the occurrence of the others was purely sporadic or occasional.

The operation of the test board was not continued long enough to provide conclusive information on the breeding habits and development of marine borers and fouling organisms at this location, but the test does show the general trend.

## AUCKLAND, NEW ZEALAND -- U. S. NAVAL BASE

A57.01 Location of the Test Station and Test Board

A test board of the panel type was installed September 16, 1944, adjacent to concrete piles at the end of Kings Wharf in Waitemata Harbor at Auckland, New Zealand. This board was operated until November 16, 1944, when this Base was decommissioned, interrupting the test after 2 test panels and the accompanying control panels had been sent for examination. It was designated by the symbol USNNZ-1.

On July 14, 1945, a new and more appropriate location was selected, and the second test board was installed adjacent to both wood and concrete piling at the end of the Export Wharf in the same harbor. This was done through the cooperation of the U. S. Joint Purchasing Board Public Works Department, Millars Yard, the Strand, Auckland. The operation of this test board was discontinued with the forwarding of the last set of panels on December 15, 1945.

A57.02 Hydrographic Data

The first test board was submerged in water from 20 to 30 ft deep where the tidal range was 12 ft and the current was negligible. The temperature of the water at the time of installation was 55° F. There was very little sewage and silt to pollute the water.

The second board was submerged in water from 25 to 35 ft deep where the tidal range was 10 ft and the strength of the current was only tidal. The temperature of the water at the time of installation was 55° F. The pollution here was reported to be negligible.

A57.03 Marine Borers

1. Teredinidae. Teredinidae, including Teredo sp., showed considerable activity on the panels at both locations, but in neither the 2-month period during which the first test board was operated nor the 6-month period during which the second test board was operated did they develop beyond the embryonic or minute stages in either the control or test panels. They occurred in both the control panels from the first location and in the first 3 of the 6 panels from the second location, but the greatest number in any one panel from either location did not exceed 15. The breeding season extended from the middle of June through October and probably longer. All the test panels except the first one from the first location showed Teredinidae, the maximum

number recorded from the panel submerged for 6 months being 500 of embryonic size. The maximum attack was rated as moderate, but largely on the basis of numbers rather than size or damage to panels. The changing of the test board locations and the brief period for which either was operated make it difficult to accurately evaluate the damage from Teredinidae in this harbor.

2. Limnoria. No evidence of Limnoria occurred in any of the control panels from either location. No forms occurred in either of the 2 test panels from the first location, and only mere traces occurred in 4 of the 6 test panels from the second location.

3. Pholadidae. No Pholadidae were recorded from either location.

#### A57.04 Fouling Agents

1. Silt. All of both the control and test panels showed traces of silt except one of each which showed light deposits.

2. Invertebrate animal phyla.

a. Coelenterata (hydroids). All except the last 2 of the control panels from the second location and all the test panels from both locations showed hydroids. These hydroids were limited to traces in most cases, but some showed light growths. Tubularia was the only form identified.

b. Bryozoa (filamentous). A trace of a filamentous Bryozoa was recorded on a single one of the test panels.

c. Annelida (annelid worms). A trace of serpulid (Serpula) tubes was recorded on a single one of the test panels.

d. Arthropoda (crustaceans). Balanus (barnacles) occurred more or less frequently on all of both the control and test panels from both locations, but all specimens remained very small. The maximum size recorded on any of the control panels was only 2 mm in diameter, while the maximum size on any of the test panels was 5 mm in diameter in 2 panels submerged for 4 and 5 months, respectively.

#### A57.05 Summary and Conclusions

1. Installation. A test board of the panel type was operated for brief periods at two locations in Waitemata Harbor at Auckland, New Zealand, between September 16, 1944 and December 15, 1945, to determine the identity and prevalence of marine borers and fouling agents occurring at this location.

## 2. Test Results.

a. Borers. Teredinidae were fairly active, especially in the test panels, almost throughout the duration of the test, but none developed beyond the embryonic or minute stages. The attack was rated as moderate, chiefly on the strength of the number of individuals present. The changing of the test board locations, and the brief period for which either was operated, make it difficult to evaluate accurately the damage from Teredinidae or the full breeding season in this harbor. The breeding season extended at least from June through October and probably longer. Limnoria was recorded as only a trace, and no Pholads were observed.

b. Fouling Organisms. Silt and invertebrate animals belonging to 4 phyla contributed to fouling of the panels. The latter comprised hydroids, filamentous Bryozoa, serpulid worms, and barnacles. The hydroids and barnacles occurred with great frequency and regularity, but the others were represented only as mere traces.





P A R T B  
TABULAR SUMMARIES OF MARINE BORER DATA  
FROM 160 HARBORS  
IN THE  
ATLANTIC OCEAN,  
PACIFIC OCEAN,  
AND  
MEDITERRANEAN AREA

MOLLUSCAN BORERS					CRUSTACEAN BORERS								
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDIDAE			LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	

NEWFOUNDLAND

ATLANTIC OCEAN

Lomond	Bowater's Newfoundland Pulp & Paper Mills, Ltd.	Lomond wharf	IP-N-0 Spec.	1943	Tr.	11	Teredo navalis and T. dilatata?	0	11		S	11	
"	"	"	IP-N Spec.	1944	M	5	Teredo navalis	0	12		S	12	
"	"	"	IP-N Spec.	1945	H	6	Teredo navalis	0	11		S	11	
"	"	"	IP-N Spec.	1946	Tr.	7	Teredo navalis	0	7		M	7	
Corner Brook	International Power & Paper Co. of Newfoundland, Ltd. (became Bowater's Newfoundland Pulp & Paper Mills, Ltd. in 1939)	Clarke and Mill wharves	IP-A-C Spec.	1936	0	5		0	5		Tr.	5	
"	"	Clarke, Mill and Town wharves	IP-A-M Spec.	1937	VH	5	Teredo navalis and T. dilatata?	0	8		S	8	
"	"	"	IP-A-Y Spec.	1938	M	5	Teredo navalis	0	8		S	5	
"	"	"	IP-A-Y Spec.	1939	Tr.	4	Teredo navalis and T. megotara	0	12		M	12	
"	"	"	IP-A-Y Spec.	1940	H	7	Teredo navalis	0	11		Tr.	11	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	CO-OPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

NEWFOUNDLAND, continued

Corner Brook	Bowater's Newfoundland Pulp & Paper Mills, Ltd.	Clarke, Mill and Town wharves	IP-A-Y Spec.	1941	Tr.	11	Teredo navalis	0	11	M	7
"	"	"	IP-A-Y Spec.	1942	S	11	Teredo navalis	0	11	Tr.	3
"	"	"	IP-A-Y Spec.	1943	S	11	Teredo navalis	0	11	ME	11
"	"	"	IP-B, E and K Spec.	1944	M	5	Teredo navalis and T. dilatata	0	11	S	11
"	"	"	IP-B, E and K Spec.	1945	H	6	Teredo navalis	0	6	S	5
"	"	"	IP-B, E and K Spec.	1946	M	7	Teredo navalis	0	7	M	5
"	"	"	"	1948	0					Tr.	
Argentia	U.S. Naval Operating Base	South end of Fleet Dock	USNA-1 Panel	1944 to 1947	Tr.	8	Teredo navalis	0	8	M	8
"	"	"	"	1948	Tr.					Tr.	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS					
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDIDAE			LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	

NOVA SCOTIA

Halifax	Foundation Maritime Limited		FMI-1 Spec.	1943 to 1944	0	7		0	7		MH	7	
Liverpool	Mersey Paper Co.		MFC-A-L Spec.	1936 to 1938	0	8		0	8		MH	8	
"	"		MFC-A-L Spec.	1939	0	8½		0	8½		VH	8½	
"	"		MFC-A-L Spec.	1940	0	9½		0	9½		H	8½	
"	"		MFC-A-L Spec.	1941	0	9		0	9		H	7½	
"	"		MFC-A-L Spec.	1942	Tr.	9	Teredo navalis	0	9		MH	7½	
"	"		MFC-A-L Spec.	1943	S	7	Teredo navalis	0	7		MH	7	
"	"		MFC-A-L Block	1944	0	6		0	6		S	5	
"	"		MFC-A-L Block and Spec.	1945	0	9		0	9		MH	7	



MOLLUSCAN BORERS						CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDIDAE		LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	

**NEW BRUNSWICK**

St. John	Atlantic Sugar Refineries, Ltd.	Kennedy Slip	ASR-1 Spec.	1935 to 1936	0	7½		0	7½	Tr.	7½	
"	"	Cooperage Wharf, N.W. corner	ASR-2 Spec.	1935 to 1938	0	9		0	9	Tr.	9	
<u>MAINE</u>												
Calais	Maine Central R.R.	St. Croix River	MC-1 Block	1934 to 1941	0	8		0	8	0	8	
Eastport	Maine Central R.R.		MC-2 Block	1934 to 1943	0	8		0	8	M	8	
"	"		MC-2 Spec.	1935	0	5		0	5	S	5	
East Machias Machias - port	Maine State Highway Commission	Machias River between East Machias and Machias-port	MSH-5 Block and panel	1935 to 1947	0	8	Teredo	0	8	Tr.	8	
Machias	Maine Central R.R.	Dr. Longfellow's Wharf	MC-8 Block	1934 to 1943	0	8		0	8	0	8	
Jonesport	"	O.W. & B.S. Look's Wharf	MC-9 Block	1942 to 1943	0	8		0	8	Tr.	8	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE			MONTHS TO ATTAIN

MAINE, continued

Hancock-Sullivan	Maine State Highway Commission	Hancock-Sullivan Bridge over Taunton River	MSH-4 Block	1935	0	7			0	7			
Mt. Desert Ferry	Maine Central R. R.		MC-3 Block	1934 to 1938	0	8			S	8			
Bar Harbor	U.S. Naval Section Base		USNRH-1 Panel	1944	0	3			Tr.	3			
Southwest Harbor	U.S. Coast Guard Depot		USNSM-1 Panel	1944 to 1947	0	8			M	8			
Bangor	Maine Central R. R.	High Head	MC-4 Block	1934 to 1935	0	8			0	8			
Bucksport	Maine State Highway Commission	Verona Bridge	MSH-3 Block and Panel	1935 to 1947	0	8			0	8			
Searsport	Bangor and Aroostook R. R.	Penobscot Coal & Wharf Co. wharf	BAR-1 Block and Panel	1934 to 1945	S	9½		Teredo	0	9½		M	8
"	"	"	BAR-1 Spec.	1935 to 1937	S	6		Teredo	0	6		ME	6
"	"	Bangor and Aroostook R.R. Wharf	BAR-2 Block and Panel	1940 to 1947	S	9		Teredo	0	17		ME	9

		MOLLUSCAN BORERS						CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDAE			LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN
MAINE, continued												
Rockland	Maine Central R.R.	Wharf owned by R. E. Thurston	MC-7 Block	1934 to 1942	0	8		0	8		H	8
Thomaston	Maine State Highway Commission	Wadsworth St. Bridge, Georges River	MSH-2 Block and Panel	1935 to 1947	VH	24?	Teredo navalis	0	24?		Tr.	15
Wiscasset	Maine Central R.R.	Sheepsfoot River Bridge	MC-6 Block	1934 to 1947	Tr.	8		0	11		H	8
Booth Bay Harbor	U.S. Bureau of Fisheries	Wharf on N.E. end of McKown Point	---	1936	0	2		0	2		S	2
Bath	Maine Central R.R.	South of Track No. 15	MC-5 Block	1934 to 1943	0	8		0	8		Tr.	4
Portland	U.S. Naval Station	Naval Supply Pier, Bay	USNP-1 Panel	1944 to 1947	0	15		0	15		ME	9
"	Pan American Petroleum & Transport Co.	N. end of wharf facing tunnel	PAP-2 Spec.	1936 to 1942	S	8	Teredo	0	12		H	8
"	Portland Terminal Co.	Railroad Bridge	PT-1 Block and Panel	1934 to 1947	Tr.	8	Teredo	0	9		H	8
"	"	Wharf No. 4	PT-2 Block and Panel	1934 to 1947	Tr.	8	Teredo	0	8		VH	8



				MOLLUSCAN BORERS				CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE		MONTHS TO ATTAIN
MAINE, continued												
Portland	Portland Terminal Co.	Wharf No. 4	PT-2 Spec.	1935	0	3		0	3	VH	3	
"	"	Wharf No. 3	PT-3 Block	1934 to 1947*	Tr.	8	Teredo	0	9	H	8	
"	"	Wharf No. 1	PT-4 Block	1934 to 1947	0	8		0	8	VH	2	
"	"	Wharf No. 2	PT-5 Block	1934 to 1947	Tr.	8	Teredo	0	9	H	9	
"	"	"	PT-5 Spec.	1935	0	5		0	5	H	5	
"	"	E. end of Wharf No. 3	PT-6 Block	1934 to 1947	Tr.	8	Teredo navalis	0	9	H	9	
Scarboro Beach	Boston & Maine R.R.	Br. 106.72 (old 117), north end of upriver side	BM-17 Block	1934 to 1947	0	9		0	9	Tr.	8	
York	"	Sewall's Bridge, York River	MSH-1 Block and Panel	1935 to 1947	Tr.	11	Teredo	0	19	M	11	
"	"	Sewall's Bridge, York River	MSH-1 Spec.	1935	0	2		0	2	Tr.	2	

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN

NEW HAMPSHIRE

Portsmouth	Portsmouth Naval Shipyard	Outboard end of Berth No. 16	USNNE-1 Panel	1944 to 1947	S	8	Teredo navalis	0	12	M	8
"	"	Inboard end of Berth No. 11	USNNE-2 Panel	1944 to 1947	S	8	Teredo navalis	0	11	M	8
"	Boston & Maine R.R.	S. end of Bridge No. 70	BM-14 Block	1934 to 1940	0	8		0	8	H	8
"	"	"	BM-14 Spec.	1935	0	5		0	5	Tr.	5
"	"	N. end of Bridge No. 70	BM-15 Block	1934 to 1947	Tr.	8	Teredo	0	8	H	8
"	"	Concord Wharf	BM-18 Block	1941 to 1942	0	8		0	8	S	8
Hampton Beach	State of New Hampshire	Hampton River Toll Bridge, S. side	CNE-1 Block	1934 to 1937	Tr.	8	Teredo	0	8	Tr.	8
"	"	Hampton River Toll Bridge, N. side	CNE-2 Block	1934 to 1937	0	8		0	8	Tr.	8

					MOLLUSCAN BORERS					CRUSTACEAN BORERS		
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE			LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		

MASSACHUSETTS

Newburyport	Boston & Maine R.R.	Bridge No. 50	BM-13 Block	1934 to 1941	0	8		0	8		0	8
"	New England Power Service Co.	Haverhill Electric Co.	NEPN-1 & 2	1940	0	6		0	6		0	6
"	"	"	NEPN Spec.	1941	0	6		0	6		0	6
"	"	"	NEPN Spec.	1942	0	5		0	5		0	5
"	"	"	NEPN Spec.	1943	0	5		0	5		0	5
"	"	"	NEPN Spec.	1944	0	4		0	4		0	4
Gloucester	Commonwealth of Massachusetts	State Pier	CM-15 Block	1939 to 1941	0	8		0	8		S	8
"	Boston & Maine R.R.	Bridge No. 203	BM-12A Block	1934 to 1947	0	8		0	8		M	8
"	Essex Co., Office of County Engineer	Richard Blyman Bridge	EC-1 Block	1938	Tr.	8	Teredo navalis and T. megotara?	0	8		S	8
"	New England Power Service Co.	Gloucester Electric Co.	NEPG-1,2,3 Spec.	1940	0	7		0	7		S	7
"	"	"	NEPG Spec.	1941	0	6		0	6		S	6

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN

MASSACHUSETTS, continued

Gloucester	New England Power Service Co.	Gloucester Electric Co.	MEPG Spec.	1942	0	5		0	5		M	5
"	"	"	MEPG Spec.	1943	0	5		0	5		S	5
"	"	"	MEPG Spec.	1944	0	5		0	5		Tr.	5
"	"	"	MEPG Spec.	1945	0	5		0	5		Tr.	5
"	"	"	MEPG Spec.	1946	0	5		0	5		0	5
Manchester	Boston & Maine R.R.	Bridge No. 25.06	BM-19 Block	1941 to 1943	0	8		0	8		S	8
Beverly	"	Bridge No. 32, Beverly Harbor	BM-12 Block	1934 to 1947	0	9		0	9		MH	8
"	"	Beverly Drawbridge No. 32	BM-12B Block	1947	0	2		0	2		0	2
"	Gulf Oil Co.	Gulf Oil Co. wharf	G-1 Spec.	1938 to 1947	S	7	Teredo	0	22		VH	13
"	New England Power Service Co.	Beverly Gas	MEPB-2,3,4 Spec.	1940	0	6		0	6		Tr.	6
"	"	"	MEPB Spec.	1941	0	7		0	7		M	7
"	"	"	MEPB Spec.	1942	Tr.	6	Teredo	0	6		Tr.	6

Chelura present in 1945

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDAE		LIMNORIA	MISCELLANEOUS	
					MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN		DEGREE	MONTHS TO ATTAIN

MASSACHUSETTS, continued

Beverly	New England Power Service & Electric Co.	Beverly Gas Electric Co.	NEPB Spec.	1943	0	6		0	6	S	6
"	"	"	NEPB Spec.	1944	0	5		0	5	Tr.	5
"	"	"	NEPB Spec.	1945	0	5		0	5	Tr.	5
"	"	"	NEPB Spec.	1946	0	4		0	4	S	4
Salem (Beverly Plant)	New England Coal & Coke Co.		MG-7 Block	1935 to 1947	M	8	Teredo navalis	0	10	ME	8
Salem	New England Power Service & Electric Co.	Salem Electric Light Co.	NEPSE-1,2,3	1940	VH	7		0	7	ME	7
"	"	"	NEPSE Spec.	1941	0	6		0	6	VH	6
"	"	"	NEPSE Spec.	1942	S	6	Teredo	0	6	ME	6
"	"	"	NEPSE Spec.	1943	Tr.	6	Teredo	0	6	VH	6
"	"	"	NEPSE Spec.	1944	0	5		0	5	VH	5
"	"	"	NEPSE Spec.	1945	0	5		0	5	VH	5
"	"	"	NEPSE Spec.	1946	0	4		0	4	H	4
"	"	Salem Gas Light Co.	NEPSE-1,2,3	1940	0	7		0	7	S	7

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS		
					TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE

MASSACHUSETTS, continued

Salem	New England Power Service Co.	Salem Gas Light Co.	MEPSG Spec.	1941	0	7		0	7		H	7
"	"	"	MEPSG Spec.	1942	0	5		0	5		H	5
"	"	"	MEPSG Spec.	1943	0	5		0	5		ME	5
"	"	"	MEPSG Spec.	1944	0	4		0	4		Tr.	4
"	"	"	MEPSG Spec.	1945	0	5		0	5		0	5
"	"	"	MEPSG Spec.	1946	0	5		0	5		S	5
"	"	Salem Terminal Corporation	MEPST-1,2,3	1940	0	6½		0	6½		ME	6½
"	"	"	MEPST Spec.	1941	0	7		0	7		M	7
"	"	"	MEPST Spec.	1942	S	5	Teredo	0	5		M	5
"	"	"	MEPST Spec.	1943	Tr.	6	Teredo	0	6		ME	6
"	"	"	MEPST Spec.	1944	0	5		0	5		ME	5
"	"	"	MEPST Spec.	1945	0	5		0	5		M	5
"	"	"	MEPST Spec.	1946	0	5		0	5		ME	6

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS		
					TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE

MASSACHUSETTS, continued

Lynn	Essex County, Office of County Engineer near	Fox Hill Bridge over Saugus River	EC-2 Block	1938 to 1943	Tr.	8	Teredo navalis	0	8	H	8
"	General Electric Co.	Saugus River, 600 ft. N. of B. & M. R.R. Bridge	GE-1 Block and Spec.	1934 to 1939	S	36?	Teredo navalis	0	36?	ME	36? (Board lost long time)
"	Lynn Gas & Electric Co.		LG-1 Spec.	1938	0	6		0	6	Tr.	6
West Lynn	Commonwealth of Massachusetts, Dept. of Public Works	Lampert's Coal Wharf	CM-16 Block	1939 to 1941	0	8		0	8	M	8
Revere	Boston & Maine R.R.	Bridge No. 14	BM-11A Block	1934	0	6		0	6	0	6
Revere	New England Power Service Co.	Suburban Gas & Electric Co.	NEPR Spec.	1940	0	7		0	7	ME	7
"	"	"	NEPR Spec.	1941	0	7		0	7	ME	7
Boston (Chelsea)	Boston Edison Co.	Meridian St. Bridge	EE-8 Block and Panel	1935 to 1947	0	9		0	9	ME	8
"	"	Chelsea St. Bridge, North Draw	EE-9 Block and Panel	1935 to 1947	0	8		0	8	H	8

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN

MASSACHUSETTS, continued

Boston (Everett)	Barrett Co.	Shipping Wharf	MG-1 Block	1935 to 1936	0	8		0	8		Tr.	8
"	Massachusetts Gas Co.'s Coke Works	Coal Wharf Island End River	MG-2 Block	1935 to 1936	0	8		0	8		S	8
"	"	"	MG-2A Block	1936	0	8		0	8		0	8
"	Beacon Oil Co.	Wharf, Mystic River	MG-3 and 3A Block	1935 to 1940	0	8		0	8		S	8
"	"	"	MG-3A Block	1936 to 1940	0	8		0	8		S	8
"	Massachusetts Gas Co.'s Blast Furnace	Mystic Wharf, Mystic River	MG-4 Block	1935 to 1947	0	8		0	8		M	8
Boston (Charlestown)	Boston Edison Co.	Chelsea St. Bridge, S. end	EE-10 Block and Panel	1935 to 1947	0	8		0	8		ME	8
"	"	Alford St. Bridge	EE-11 Block	1935 to 1936	0	8		0	8		Tr.	8
"	New England Coke & Coal Co.	Coal Wharf Mystic River	MG-5 Block	1935 to 1947	0	8		0	8		S	8
"	Boston & Maine R.R.	Charles River	EM-1 Block	1934 to 1936	0	8		0	8		0	8
"	"	Charles River Bridge, West end S. Fender	EM-2 Block	1934 to 1947	0	8		0	8		ME	8



				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	MONTHS TO ATTAIN			DEGREE
Boston (Charles-town)	Boston & Maine R.R.	Charles River Bridge, N. End	BM-2 Spec.	1935 to 1936	0	8			0	S	8
"	"	Charles River Bridge, East Walk	BM-3 Block	1934 to 1947	0	8			0	M	8
"	"	Yard No. 13 along sea-wall	BM-4 Block	1934 to 1947	0	8			0	Tr.	8
"	"	Hoosac Tunnel Docks, Pier No. 41	BM-5 Block	1934 to 1944	0	8			0	ME	8
"	"	"	BM-5 Spec.	1935 to 1944	0	5			0	VH	5
"	"	Hoosac Tunnel Docks, Pier No. 46	BM-6 Block	1934 to 1943	0	8			0	ME	8
"	"	Hoosac Tunnel Docks, Pier No. 44	BM-7 Block	1934 to 1943	0	8			0	H	8
"	"	"	BM-7A Block	1934 to 1943	0	8			0	ME	8
Boston	Boston Naval Shipyard	Pier No. 9 Navy Yard	USNB-1 Panel	1944 to 1947	0	8			0	H	8

MASSACHUSETTS, continued

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

MASSACHUSETTS, continued

Boston (Charlestown)	Boston & Maine R.R.	House No. 46, junction of S.Channel with Boston Harbor	BM-8 Block	1934 to 1947	0	8	0	8	0	8	H	8
"	"	"	BM-8 Spec.	1935 to 1947	0	5	0	5	0	5	VH	5
"	"	House No. 49, Mystic River	BM-9 Block	1934 to 1947	0	8	0	8	0	8	MH	8
"	"	E. end of Wharf, Mystic River	BM-10 Block	1934 to 1947	0	8	0	8	0	8	MH	8
"	"	W. end of long wharf, Mystic River	BM-11 Block	1934 to 1947	0	8	0	8	0	8	MH	8
"	Wiggin Terminals, Inc.	Lumber Terminal, Mystic River	WT-1 Block	1935 to 1947	0	10	0	10	0	10	MH	9
"	"	Warehouse Terminal, Mystic River	WT-2 Block	1935 to 1947	0	14	0	14	0	14	MH	9
"	Boston Edison Co.	Charlestown Bridge	EE-7 Block and Panel	1935 to 1947	0	8	0	8	0	8	MH	8

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

MASSACHUSETTS, continued

Boston	Seaboard Construction Co.	India Wharf, N.E. Corner	SB-1 Block	1936 to 1938	0	15		0	15	VH	15
"	"	India Wharf, S.E. Corner	SB-2 Block	1934 to 1935	0	7½		0	7½	VH	7½
"	"	Central Wharf, East end	SB-3 Block	1934 to 1935	0	7½		0	7½	VH	7½
"	"	Central Wharf, North side	SB-4 Block	1934 to 1935	0	7½		0	7½	VH	7½
"	"	Central Wharf, N.E. Corner	SB-5 Block	1934 to 1935	0	7½		0	7½	VH	7½
"	"	Central Wharf, S.E. Corner	SB-6 Block	1934 to 1935	0	7½		0	7½	VH	7½
Boston (East)	Mystic Steamship Repair Yard	South Pier East Boston Yard	MJ-6 Block	1935 to 1947	0	8		0	8	MH	8
"	Bethlehem Shipbuilding Corporation	Atlantic Yard, Pier No. 3	BS-10 Spec.	1936 to 1938	0	12		0	12	VH	12
"	"	Atlantic Yard, Pier No. 4	BS-11 Spec.	1936 to 1938	0	12		0	12	VH	12
"	"	Atlantic Yard, Pier No. 5	BS-12 Spec.	1936 to 1938	Tr.	21	Teredo navalis	0	21	VH	12

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	

MASSACHUSETTS, continued

Boston (East)	Bethlehem Shipbuilding Corporation	Atlantic Yard, Pier No. 6	BS-14 (14-A) Block	1944 to 1947	0	8	0	0	0	0	0	0	8	MH		
"	"	"	BS-14 Spec.	1944 to 1945	0	8	0	0	0	0	0	0	8	VH		
"	"	"	BS-14B Block	1946 to 1947	0	8	0	0	0	0	0	0	8	Tr.		
"	Boston Naval Shipyard	Lookwood Basin	USNB-3 Panel	1944 to 1947	0	8	0	0	0	0	0	0	8	H		
"	Commonwealth of Massachusetts	Pier No. 1	CM-3 Block	1934 to 1944	0	10	0	0	0	0	0	0	10	VH		
"	Bethlehem Shipbuilding Corporation	Simpson Plant, inner end of Pier No. 1	BS-6 Spec.	1936 to 1940	0	12	0	0	0	0	0	0	12	VH		
"	"	Simpson Plant, outer end of Pier No. 1	BS-7 Spec.	1936 to 1940	0	12	0	0	0	0	0	0	12	VH		
"	"	Simpson Plant, Pier No. 2	BS-8 Spec.	1936 to 1940	0	12	0	0	0	0	0	0	12	VH		
"	"	Simpson Plant, Dry-Dock, No. 4	BS-9 Spec.	1936 to 1940	0	12	0	0	0	0	0	0	12	VH		A single specimen Chelura found in 1939.

				MOLLUSCAN BORERS				CRUSTACEAN BORERS					
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		DEGREE	MONTHS TO ATTAIN	LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	FORMS IDENTIFIED			DEGREE	MONTHS TO ATTAIN	

MASSACHUSETTS, continued

Boston (East)	Bethlehem Shipbuilding Corporation	Simpson Plant Donnelly Dock, inner end	BS-13 Spec.	1937 to 1940	Tr.	12	Teredo	0	12	VH	12	
"	"	Simpson Plant, New Pier No. 1	BS-15 (15-A) Block	1944 to 1947	0	8		0	8	M	8	
"	"	Simpson Plant, New Pier No. 1	BS-15 Spec.	1944 to 1945	0	8		0	8	VH	8	
"	"	Simpson Plant, New Pier No. 1	BS-15B Block	1946 to 1947	0	8		0	8	M	8	
Boston (South)	Boston Edison Co.	Dover St. Bridge	EE-14 Block	1935 to 1936	0	8		0	8	0	8	
"	Boston Naval Shipyard	Pier No. 7 U.S. Naval Drydocks	USNB-2 Panel	1944 to 1947	0	8		0	8	H	8	
"	"	East Jetty U.S. Naval Drydock	USNB-4 Panel	1946 to 1947	0	8		0	8	ME	8	
"	U.S. Army Base		USA-1 Block	1934 to 1935	0	5		0	5	VH	5	
"	"		USA-2 Block	1934 to 1935	0	5		0	5	VH	5	
"	"		USA-3 Block	1934 to 1935	0	8		0	8	VH	8	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE		MONTHS TO ATTAIN	DEGREE

MASSACHUSETTS, continued

Boston (South)	U.S. Army Base		USA-3 Spec.	1935	0	1	0	1		VH	1
"	"	Location No. 1	AB-1 Panel	1945 to 1946	0	10	0	10		ME	10
"	"	Location No. 2	AB-2 Panel	1945 to 1946	0	10	0	10		ME	10
"	"	Location No. 3	AB-3 Panel	1945 to 1946	0	10	0	10		ME	10
"	"	Location No. 4	AB-4 Panel	1945 to 1946	0	10	0	10		H	10
"	"	Location No. 5	AB-5 Panel	1945 to 1946	0	8	0	8		H	3
"	"	Location No. 6	AB-6 Panel	1945 to 1946	0	8	0	8		ME	7
"	Boston Port Authority	Castle Island Wharf, Location No. 7	CI-1 Panel	1945 to 1947	0	15	0	15		ME	12
"	"	Castle Island Wharf, Location No. 8	CI-2 Panel	1945 to 1947	0	16	0	16		ME	7
"	"	Castle Island Wharf, Location No. 9	CI-3 Panel	1945 to 1947	0	14	0	14		ME	12

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS						CRUSTACEAN BORERS						
					TEREDINIDAE			PHOLADIDAE			DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	LIMNORIA	DEGREE	MONTHS TO ATTAIN	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED							

MASSACHUSETTS, continued

Boston (South)	Boston Port Authority	Castle Island Wharf, Location No. 10	CI-4 Panel	1945 to 1947	0	15	0	0	15	0	0	14	ME	14	
"	"	Castle Island Wharf, Location No. 11	CI-5 Panel	1945 to 1947	0	14	0	0	14	0	0	14	VH	12	
"	"	Castle Island Wharf, Location No. 12	CI-6 Panel	1945 to 1947	0	14	0	0	14	0	0	14	ME	14	
"	Boston Edison Co.	I. St. Station	EE-1-3 Block and Panel	1935 to 1947	S	8	0	0	9	0	0	9	VH	9	Chelura very abundant from 1935 to 1942 and in 1945, sometimes outnumbering Limnoria.
"	N.Y., N.H. & Hartford R. R.	Atlas Stores Wharf, Fort Point Channel	NH-1 Block	1934 to 1947	0	9	0	0	9	0	0	9	ME	8	
"	"	Fort Point Channel	NH-2 Block	1934 to 1947	0	8	0	0	8	0	0	8	M	8	
"	"	Pier No. 1	NH-3 Block	1934 to 1947	0	9	0	0	9	0	0	9	VH	8	

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS						CRUSTACEAN BORERS		
					TEREDINIDAE			PHOLADIDAE			LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED			

MASSACHUSETTS, continued

Boston (South)	N. Y., N. H. & Hartford R. R.	Pier No. 4	NE-4 Block	1934 to 1947	0	9	0	0	9	VH	8	
"	Commonwealth of Massachusetts, Dept. of Public Works	Pier No. 5	CM-2 Block	1934 to 1944	0	12	0	0	12	VH	8	
"	"	"	CM-2 Spec.	1935	0	3	0	0	3	VH	3	
"	City of Boston, Public Works Dept.	Fort Hill Wharf	CB-1 Block	1935	0	5	0	0	5	Tr.	5	
"	"	"	CB-1 Spec.	1935 to 1938	0	12	0	0	12	VH	12	
"	"	South Bay Albany St.	CB-2 Block	1935	0	5	0	0	5	0	5	
"	"	South Bay near lobster traps	CB-2 Spec.	1936 to 1937	0	7½	0	0	7½	H	7½	
"	Commonwealth of Massachusetts	State Wharf Roxbury Canal, So. Bay	CM-4 Block	1934 to 1944	0	9	0	0	9	Tr.	9	
Dorchester	City of Boston, Public Works Dept.	Victory Road Relief Station	CB-3 Block and Spec.	1935 to 1938	0	6	0	0	6	H	6	



				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

MASSACHUSETTS, continued

Neponset River	Boston Edison Co.	Neponset Bridge	EE-13 Block and Panel	1935 to 1947	0	8		0	8	Tr.	8	
"	N.Y., N.H., & Hartford R.R.	"	NH-5 Block	1934 to 1947	0	9		0	9	M	8	
"	"	"	NH-5 Spec.	1935 to 1946	Tr.	5		0	5	H	5	
Quincy	Bethlehem Shipbuilding Corporation	Fore River Plant, Pier No. 5	BS-1 Spec.	1936 to 1940	0	11		0	11	VH	8	Traces of Chelura occurred in 1938, 1939, and 1940.
"	"	"	BS-2 Spec.	1936 to 1940	Tr.	12	Teredo	0	15	VH	12	Chelura occurred as traces in 1938 and 1939 but became very abundant in 1940.
"	"	Fore River Plant, Pier No. 3	BS-3 Spec.	1936 to 1939	0	15		0	15	VH	15	Heavy Chelura were very abundant in 1937, 1938, and 1939.
"	"	Fore River Plant, Pier No. 2	BS-4 Spec.	1936 to 1939	0	15		0	15	VH	15	
"	"	Fore River Plant, near Pier No. 1	BS-5 Spec.	1936 to 1940	0	11		0	11	VH	11	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

MASSACHUSETTS, continued

Quincy	Bethlehem Shipbuilding Corporation	Pier No. 1	BS-16 Block	1944 to 1947	0	8	0	8	VH	8	Chelura numerous in 1945 and 1946.
"	"	"	BS-16 Spec.	1944 to 1945	0	4	0	4	H	2	
Quincy Point	Boston Edison Co.	Quincy Point Station Wharf	EE-12 Block	1935 to 1939	0	8	0	8	MH	8	
Quincy Point near Weymouth	Commonwealth of Massachusetts, Dept. of Public Works	Bridge over Fore River	CM-1 Block	1934 to 1942	0	10	0	10	VH	8	Few Chelura observed at end of 1941, but plentiful in Limnoria tunnels in 1942.
Hingham	Bethlehem Hingham Shipyard, Inc.		BSH-1 Block	1944 to 1945	0	11	0	11	0	11	
Weymouth	Boston Edison Co.	Weymouth-Fore River	EE-4-6 Block and Panel	1935 to 1947	0	9	0	9	VH	9	Chelura more or less abundant from 1937 through 1943.
Scituate	Commonwealth of Massachusetts, Dept. of Public Works	S.E. corner Town Wharf	CM-5 Block	1934 to 1942	MH	8	0	8½	H	8	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS					
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE			LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	
MASSACHUSETTS, continued													
Marshfield	N. Y., N. H. & Hartford R. R.	North River Bridge 19.03	NH-6 Block	1934 to 1939	Tr.	8	Teredo navalis	0	8		Tr.	8	
Plymouth	Commonwealth of Massachusetts, Dept. of Public Works		CM-13 Block	1935 to 1942	VH	8	Teredo navalis	0	10		VH	7	
Provincetown	"		CM-12 Block	1935 to 1941	VH	9	Teredo navalis	0	9		MH	8	Chelura abundant in 1935, 1939, 1940, and 1941.
Truro	N. Y., N. H., & Hartford R. R.		NH-7 Block	1934 to 1943	VH	7	Teredo navalis	0	9		Tr.	8	
Sandwich (Cape Cod Canal)	Commonwealth of Massachusetts, Dept. of Public Works	Fish Freezer Wharf at E. end of canal	CM-7 Block	1934 to 1942	VH	6	Teredo navalis	0	10		S	8	
Buzzards Bay	N. Y., N. H., & Hartford R. R.	West end of Canal	NH-8 Block	1934 to 1947	VH	4	Teredo navalis	0	8		Tr.	8	
Chatham	Commonwealth of Massachusetts, Dept. of Public Works	Chatham Bridge over Mitchell's River	CM-8 Block	1934 to 1942	VH	8	Teredo navalis	0	8½		MH	8	Few Chelura present in 1933 and 1937.
Hyannis	"		CM-9 Block	1934 to 1942	VH	5	Teredo navalis	0	9		M	9	Chelura fairly abundant in 1935 and early in 1942.

				MOLLUSCAN BORERS				CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS	
					MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN	DEGREE		FORMS IDENTIFIED
Hyannis	Commonwealth of Massachusetts, Dept. of Public Works		CM-9 Spec.	1935	VH	3	Teredo navalis	0	5	H	4	Chelura quite abundant in burrows of Limnoria.
Bourne	"	Cape Cod Pier	CM-6 Block	1934 to 1942	VH	3	Teredo navalis	0	9	Tr.	8	
Marion	"	Town Wharf	CM-10 Block	1934 to 1942	VH	7	Teredo navalis	0	9	S	9	
New Bedford	"	State Pier	CM-11 Block	1934 to 1942	VH	4	Teredo navalis	0	9	VH	7	Chelura abundant from 1935 through 1942 except for 1940.
"	"	"	CM-11 Spec.	1935	H	4	Teredo navalis	0	2	VH	2	Chelura present in considerable numbers.
Fall River	"	Slade's Ferry	CM-14 Block	1937 to 1942	VH	8	Teredo navalis	0	9	MH	8	
"	N.Y., N.H., & Hartford R.R.	Steamship Dock	NH-12 Block	1934 to 1936	VH	6	Teredo navalis	0	8	S	6	Trace of Chelura in 1935.
"	"	Baylies Wharf	NH-12 Spec. and Panel	1936 to 1947	VH	5	Teredo navalis	0	8	H	6	
"	New England Power Service Co.	Fall River Electric Light Co.	NEPR-1, 2, 3 Spec.	1940	VH	7	Teredo	0	7	VH	7	

MASSACHUSETTS, continued

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

MASSACHUSETTS, continued

Fall River	New England Power Service Co.	Fall River Electric Light Co.	NEPFR Spec.	1941	VH	7	Teredo	0	7	MH	7	
"	"	"	NEPFR Spec.	1942	Tr.	6	Teredo	0	6	VH	6	Chelura very abundant.
"	"	"	NEPFR Spec.	1943	H	6	Teredo	0	6	M	6	
"	"	"	NEPFR Spec.	1944	Tr.	5	Teredo	0	5	M	5	
"	"	"	NEPFR Spec.	1945	Tr.	5	Teredo	0	5	M	5	
"	"	"	NEPFR Spec.	1946	M	5	Teredo	0	5	S	5	
Woods Hole	N.Y., N.H., & Hartford R.R.		NH-9 Block and Panel	1934 to	VH	8	Teredo navalis	0	9	VH	8	Chelura abundant from 1935 to 1945.
"	"		NH-9 Spec.	1935 to 1946	VH	5	Teredo navalis	0	5	VH	5	Chelura abundant from 1936 to 1945.
Vineyard Haven	"		NH-26 Block to Spec. and Panel	1934 to 1945	VH	5	Teredo navalis	0	8	VH	8	Chelura more or less abundant from 1936 to 1945
Edgartown	Edgartown Yacht Club		EA-1 Block Spec. and Panel	1938 to 1947	M	11	Teredo navalis	0	11	VH	11	Chelura abundant from 1938 to 1945, being especially so in 1940.

					MOLLUSCAN BORERS					CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDIDAE			LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN		
Nantucket	N.Y., N.H., & Hartford R.R.		NH-25 Block	1934 to 1937	VH	7	Teredo navalis.	0	8		H	8	Chelura more or less abundant from 1935 to 1937.	
"	"		NH-25 Spec. and Panel	1936 to 1947	VH	4	Teredo navalis	0	8		H	4	Chelura abundant from 1936 to 1945 except for 1943.	
<u>RHODE ISLAND</u>														
Tiverton	N.Y., N.H., & Hartford R.R.	Bridge No. 45.34 over Sakonnet River	NH-11 Block	1934 to 1947	VH	5	Teredo navalis	0	9		S	8		
Warren	"	Hampden Meadows Bridge, Barrington River	NH-13 Block	1934 to 1935	M	6	Teredo navalis	0	6		0	6		
Providence (East)	"	India Point Drawbridge, Seekonk River	NH-14 Block Spec. and Panel	1934 to 1947	S	5	Teredo navalis	0	8		Tr.	1		
Providence	Pan American Petroleum & Transport Co.	N.W. corner of pier	PAP-1 Spec.	1936 to 1942	VH	5	Teredo navalis	0	6½		0	6½		
"	New England Power Service Co.	Narragansett Electric Co., Manchester St.	NEPPM-1,2,3	1940	0	6		0	6		0	6		

MASSACHUSETTS, continued

				MOLLUSCAN BORERS						CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDAE			LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	
RHODE ISLAND, continued													
Providence	New England	Narragansett Electric Co., Manchester St.	NEPPM Spec.	1941	0	6		0	6		0	6	
"	"	"	NEPPM Spec.	1942	0	6		0	6		0	6	
"	"	"	NEPPM Spec.	1943	0	6		0	6		0	6	
"	"	"	NEPPM Spec.	1944	0	5		0	5		0	5	
"	"	"	NEPPM Spec.	1945	0	5		0	5		0	5	
"	"	"	NEPPM Spec.	1946	0	5		0	5		0	5	
"	"	Narragansett Electric Co., South St.	NEPPS-1-4 Spec.	1940	0	14		0	14		0	14	
"	"	"	NEPPS Spec.	1941	0	6		0	6		0	6	
"	"	"	NEPPS Spec.	1942	0	6		0	6		0	6	
"	"	"	NEPPS Spec.	1943	0	6		0	6		0	6	
"	"	"	NEPPS Spec.	1944	0	5		0	5		0	5	
"	"	"	NEPPS Spec.	1945	0	5		0	5		0	5	
"	"	"	NEPPS Spec.	1946	0	5		0	5		0	5	

MOLLUSCAN BORERS										CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDAE			LIMNORIA		MISCELLANEOUS
					MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN		

RHODE ISLAND, continued

Newport	N. Y., N. H., & Hartford R.R.	East Prong of Narragansett Bay	NH-10 Block	1934 to 1941	8	Teredo navalis	0	9	H	9	Chelura more or less abundant from 1934 to 1941;	
<b>CONNECTICUT</b>												
Stonington	Atwood Machine Co.		CT-1 Spec.	1937 to 1940	8	Teredo navalis	0	8	H	8	Chelura abundant each year.	
Mystic	N. Y., N. H., & Hartford R.R.		NH-15 Block	1934 to 1947	8	Teredo navalis	0	8	H	8	Chelura more or less abundant from 1936 to 1946.	
Groton	U. S. Submarine Base		CT-2 Spec.	1937	8	Teredo navalis	0	9	VH	9		
South Groton	Electric Boat Co.		CT-3 Spec. & Panel	1937 to 1947	8	Teredo navalis	0	8	M	8	Chelura more or less abundant from 1937 to 1946.	
Allyn's Point (Thames River)	N. Y., N. H., & Hartford R.R.	East side of bay North of New London	NH-17 Spec.	1934 to	8	Teredo navalis	0	8	Tr.	8		
New London (north)	State of Connecticut		CT-4 Spec.	1937 to 1939	6	Teredo navalis	0	8	ME	8	Chelura numerous in 1938 and less so in 1939.	
New London	U. S. Naval Submarine Base		USNWL-1 Panel	1944 to 1947	4	Teredo navalis	0	8	Tr.	8		
"	Merritt-Chapman & Scott Corporation		CT-5 Spec.	1937 to 1938	8	Teredo navalis	0	9	VH	7	Chelura very abundant late in 1937.	



MOLLUSCAN BORERS				CRUSTACEAN BORERS								
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE		MONTHS TO ATTAIN
New London	Burr Yacht Basin		CT-25 Spec.	1940 to 1941	S	8	Teredo navalis	0	9	H	8	Chelura abundant both years.
"	N.Y., N.H., & Hartford R.R.	Shaw's Cove	NH-18 Block and panel	1934 to	S	8	Teredo navalis	0	16	VH	8	Chelura more or less abundant from 1935 through 1945.
"	"	"	NH-18 Spec.	1935 to 1946	H	5	Teredo navalis	0	5	VH	5	Chelura more or less abundant from 1935 to 1945 except for 1944.
Niantic	N.Y., N.H., & Hartford	Bridge No. 44.50	NH-19 Block	1934 to 1947	VH	8	Teredo navalis	0	16	M	8	Chelura abundant 1945.
Saybrook	"	Bridge No. 34.65 over Connecticut River	NH-16 Block Spec. and Panel	1934 to 1947	VH	5	Teredo navalis	0	8	Tr.	8	
"	Saybrook Dock		CT-6 Spec.	1937 to 1941	VH	8	Teredo navalis	0	8	0	8	
Guilford	N.Y., N.H., & Hartford R.R.		NH-20 Block	1934 to 1947	VH	8	Teredo navalis	0	8	0	8	
New Haven	"	Steamboat Wharf, Belle Dock	NH-21 Block Spec. and Panel	1935 to 1947	VH	5	Teredo navalis	0	8	ME	8	

CONNECTICUT, continued

MOLLUSCAN BORERS				CRUSTACEAN BORERS									
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDAE					
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED			

CONNECTICUT, continued

New Haven	City Wharf		CT-26 Spec.	1940	S	6	Teredo navalis	0	10		Tr.	6
New Haven (East)	Koppers Connecticut Coke Co.		CT-7 Spec.	1937	VH	7	Teredo navalis	0	7		0	7
"	T. A. D. Jones & Co.		CT-20 Spec.	1938 to 1941	VH	8½	Teredo navalis	0	9		S	7
New Haven (North)	Sperry & Jones		CT-8 Spec.	1937	0	8		0	8		Tr.	8
"	Long Wharf		CT-21 Spec.	1938 to 1940	Tr.	8½	Teredo navalis	0	8½		Tr.	8½
New Haven (West)	The American Oil Co.		CT-9 Spec.	1937 to 1938	0	13		0	13		Tr.	13
Devon	N. Y., N. H., & Hartford R.R.	Devon Bridge No. 48.50	NH-22 Block and Spec.	1934 to 1941	0	5		0	5		0	5
Bridgeport	"	Bridgeport Bridge No. 43.88	NH-23 Block, Spec. and Panel	1934 to 1947	S	7	Teredo navalis	0	8		Tr.	5
"	Stanley Works		CT-11 Spec.	1937 to 1947	VH	5	Teredo navalis	0	10		H	10
Bridgeport (East)	The American Oil Co.		CT-12 Spec.	1937 to 1940	S	8	Teredo navalis	0	12		Tr.	8

				MOLLUSCAN BORERS				CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDAE			LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN
CONNECTICUT, continued												
Bridgeport	Tydol Associated Oil Co.		CT-13 Spec.	1937 to 1940	0	9		0	9		Tr.	9
"	United Illuminating Co.		CT-22 Spec.	1938 to 1940	MH	12	Teredo navalis	0	12		MH	9
Bridgeport (Pleasure Beach Bridge)	City of Bridgeport		CT-24 Spec.	1938 to 1940	VH	9	Teredo navalis	0	12		Tr.	9
Norwalk (East)	Shore and Country Club		CT-15 Spec.	1937 to 1938	VH	5	Teredo navalis	0	10		0	10
Norwalk (West)	Gulf Oil Corporation		CT-16 Spec.	1937 to 1940	VH	7	Teredo navalis	0	12		Tr.	9
South Norwalk	N.Y., N.H., & Hartford R.R.	Bridge 29, 53, Norwalk River	NH-24 Block Spec. and Panel	1934 to 1947	VH	7	Teredo navalis	0	8		0	8
Stamford	Stamford Rubber Co.		CT-17 Spec.	1937	0	8		0	8		Tr.	8
"	Stamford Gas & Electric Co.		CT-18 Spec.	1937 to 1940	VH	5	Teredo navalis	0	12		Tr.	8
"	Atlas Powder Co.		CT-23 Spec.	1938 to 1940	Tr.	9	Teredo navalis	0	9		Tr.	9
Greenwich	Ruddock Yacht Works		CT-19 Spec.	1937 to 1941	VH	6	Teredo navalis	0	12		M	8

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLIDIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN

NEW YORK

New York	Borough of Manhattan	107th St. and East River	MAN-A Block	1942 to 1945	0	8		0	8		0	8
"	"	79th St. & North River	MAN-B Block	1942 to 1945	0	8		0	8		0	8
"	"	49th St. & East River	MAN-C Block	1942 to 1945	0	8		0	8		0	8
"	"	Pier A, North River	MAN-D Block	1942 to 1945	Tr.	8	Teredo	0	8		0	8
"	"	Pier No. 39 East River to Montgomery Street	MAN-E Block	1942 to 1945	0	8		0	8		0	8
"	"	Dyckman and North River	MAN-F Block	1942 to 1945	0	8		0	8		0	8
"	"	132nd St. & Harlem River	MAN-G Block	1944 to 1945	0	8		0	8		0	8
"	"	207th St. in Board of Transportation Subway Yards	MAN-H Block	1944 to 1945	0	8		0	8		0	8
"	New York Central System	Pier No. 34 East River	NYC-1 Block	1941 to 1947	Tr.	9	Teredo	0	9		Tr.	9

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE		MONTHS TO ATTAIN	DEGREE

NEW YORK, continued

New York	New York Central System	Pier No. 1 North River	NYC-2 Block	1941 to 1947	Tr.	9	Teredo	0	9	0	9
"	United Fruit Co.	Pier No. 3 North River	UF-1 Block and Panel	1938 to 1947	Tr.	10	Teredo	0	10	Tr.	10
"	"	Same, out-board end	UF-2 Block	1938 to 1947	Tr.	9	Teredo	0	9	0	9
"	"	Pier, No. 9, North River, Bulkhead	UF-3 Block	1938 to 1947	S	10	Teredo	0	10	Tr.	10
"	"	Pier No. 9, North River, Outboard end	UF-4 Block	1938 to 1947	Tr.	9	Teredo	0	9	Tr.	9
"	Erie R.R. Co.	Pier No. 20, south side, North River	E-4 Spec. and Panel	1938 to 1947	0	8		0	8	0	8
"	"	Pier No. 7 East River	E-5A Spec. and Panel	1938 to 1947	0	8		0	8	Tr.	8
"	Consolidated Edison Co. of New York, Inc.	Hunt's Point, Bronx	CE-2 Block	1938 to 1947	S	9	Teredo	0	9	Tr.	9
"	"	East River	CE-3 Block	1941 to 1947	0	9		0	9	0	9

MOLLUSCAN BORERS										CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE			LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	

NEW YORK, continued

New York	N.Y., N.H., & Hartford R.R.	Pelham Bay	NH-27 Block	1934 to 1936	0	8		0	8		Tr.	8	
"	"	"	NH-27 Spec. and Panel	1936 to 1947	S	5	Teredo navalis	0	8		S	8	
"	Henry B. Nevins	City Island	HN-1 Spec.	1938 to 1947	VH	8	Teredo navalis	0	8		S	8	
New York Fort Tilden	U.S. Engineer Office, War Department	U.S. Coast Guard Wharf Rockaway Inlet, Jamaica Bay	FT-1 Block	1942 to 1947	Tr.	9	Teredo	0	9		S	9	
Brooklyn	U.S. Naval Magazine, Ft. Lafayette		USNFL-1 Panel	1944 to 1946	0	8		0	8		Tr.	8	
"	New York Naval Shipyard	Pier D	USNNY-1 Panel	1944 to 1947	0	8		0	8		Tr.	8	
"	New York Dock Co.	Pier No. 9 Fulton Terminal	NYD-1 Block	1939 to 1947	0	10		0	10		0	10	
"	"	Pier No. 38, Atlantic Terminal, Buttermilk Channel	NYD-2 Block	1939 to 1947	0	12		0	12		Tr.	12	
"	Bethlehem Steel Co.	56th St. Yard	BSNY-1 Block	1939 to 1947	0	8		0	8		Tr.	8	

				MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE		MONTHS TO ATTAIN	FORMS IDENTIFIED
Brooklyn	Bethlehem Steel Co.	27th St. Yard, Pier No. 3	BSNY-4 Block	1939 to 1947	Tr.	9	Teredo navalis	0	9	Tr.	9
Brooklyn (Flatbush)	Gulf Oil Corporation	Flatbush Tank Wagon Station, Mill Basin, E. of Rockaway Point	GNY-1 Block	1939 to 1947	Tr.	14	Teredo	0	14	Tr.	14
Brooklyn	National Sugar Refining Co.	So. 11th St. Warehouse	NSR-1W Spec.	1938 to 1939	0	8		0	8	0	8
Yonkers	Phelps Dodge Copper Products Corp.		PD-1 Block and Panel	1940 to 1947	0	14		0	14	0	14
Casanova	N.Y.N.H. & Hartford R.R.	Oak Point Yard south of Casanova	NH-28 Block	1934 to 1936	0	8		0	8	0	8
Staten Island	Bethlehem	Drydock No. 4 on Newark Bay	BSNY-2 Block	1939 to 1947	Tr.	8	Teredo navalis	0	8	Tr.	8
Staten Island, Rosebank	Merritt-Chapman & Scott Corp.	Outside end of pier	MCS-1 Spec.	1938 to 1945	VH	12	Teredo navalis	0	15	H	9
"	"	Inside end of Pier	MCS-2 Spec.	1938 to 1945	M	9	Teredo navalis	0	12	MH	12

NEW YORK, continued

					MOLLUSCAN BORERS					CRUSTACEAN BORERS		
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE			LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		
New York	City of New York, Dept. of Plant and Structures	St. George Terminal, Staten Id. Ferry, Borough of Richmond, Slip 5	DPS-1 Block	1935	0	6		0	6		0	6
"	"	Whitehall Terminal Staten Id. Ferry Borough of Manhattan	DPS-2 Block	1935	0	8		0	8		0	8
Staten Island, Totentville	M. and J. Tracy Inc.	Totentville Shipyard	TS-1 Spec. 1942	1935	Tr.	8	Teredo	0	8		Tr.	8
Long Island Sayville	National Lead Co.		NL-1 Block and Panel 1947	1942	Tr.	12	Teredo	0	12		Tr.	12
Long Island Astoria	Consolidated Edison Co. of New York, Inc.		CE-1 Block 1947	1938	0	9		0	9		Tr.	9
Long Island Oceanside	Gulf Oil Corporation		GNV-2 Block 1947	1939	M	12	Teredo naavalis	0	12		MH	12
Long Island Long Island City	National Sugar Refinery	N.Y. Refinery	NSR-1 Spec. 1942	1938	0	8		0	8		Tr.	8
Long Island	City of New York, Dept. of Plant and Structures	Astoria Terminal, Astoria Ferry, Long Island City, Borough of Queens	DPS-3 Block	1935	0	6		0	6		0	6

NEW YORK, continued



LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS						CRUSTACEAN BORERS	
					TEREDINIDAE			PHOLADIDAE			LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		
Edgewater	Barrett Co.	Shadyside Plant	BC-1 Block	1938 to 1942	0	15		0	15		0	14
"	"	Ammonia Dock	BC-2 Block and Panel	1938 to 1947	0	16		0	16		0	16
"	Archer-Daniels Midland Co.		ADM-1 Block	1938 to 1941	0	8		0	8		0	8
"	N. Y., Susquehanna & Western R.R. Co.	Coal Dumper Dock	E-7 Spec.	1938 to 1940	0	8		0	8		0	8
"	National Sugar Refining Co. of New Jersey	North Pier, W. Bank of Hudson River	NSR-1E	1938 to 1940	0	8		0	8		Tr.	8
Weehawken	Erie R.R. Co.	Dock D, moved to Pier No. 7 East River in 1941	E-5 Spec.	1938 to 1941	0	8		0	8		Tr.	8
"	"	Dock H	E-6 Spec. and Panel	1938 to 1947	0	13		0	13		Tr.	13
Hoboken	General Foods Corporation	11th St.	GF-1 Block	1940 to 1947	Tr.	9		0	9		Tr.	9
"	Hoboken Land & Improvement Co.	6th St. Pier	HL-1 Block	1938 to 1939	0	8		0	8		0	8

NEW JERSEY

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS		
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE			MONTHS TO ATTAIN	DEGREE

NEW JERSEY, continued

Hoboken	Hoboken Land & Improvement Co.	Pier No. 16	HL-2 Block	1938 to 1944	0	8		0	8	0	8		
"	Bethlehem Steel Co.		BSNY-3 Block	1939 to 1947	S	23	Teredo	0	23	Tr.	23		
Jersey City	Erie R.R.Co.	Pier No. 4	E-2 Spec. and Panel	1934 to 1947	Tr.	8	Teredo	0	8	0	8		
Newark	Central R.R. of New Jersey	Bridge No. 7/6L, Newark Bay	CNJ-1 Block	1934 to 1935	0	19		0	19	0	19		
"	Erie R.R.Co.	Newark Bay Bridge, Passaic River Draw	E-1 Block	1934 to 1936	0	6½		0	6½	0	6½		
"	Reilly Tar & Chemical Corporation	Passaic River, 500 Ft. N. of railroad bridge	RT-1 Block	1938 to 1941	0	8		0	8	0	8		
"	"	"	RT-1 Spec.	1938 to 1941	0	8		0	8	0	8		
Bayonne	New York Naval Shipyard	New Ferry Slip N. of Bldg. 102, Bayonne Annex	USNMY-2 Panel	1944 to 1947	0	8		0	8	Tr.	8		
"	Standard Oil Co. of New Jersey	Bayonne Works, Pier No. 6, inner end	SO-1 Block	1938 to 1947	S	9		0	14	Tr.	9		

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	DEGREE	MONTHS TO ATTAIN
					MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN				

NEW JERSEY, continued

Bayonne	Standard Oil Co. of New Jersey	Bayonne Works, Pier No. 6, Outer end.	SO-2 Block	1938 to 1947	S	9		0	13	S	9	
"	The Texas Co.	Bayonne Terminal, Newark Bay	TC-1 Block	1938 to 1944	Tr.	8	<i>Teredo navalis</i>	0	8	Tr.	8	
Bayway	Phelps Dodge Copper Products Corp.		PD-1 Block	1940 to 1947	0	8		0	8	0	8	
Cape May	U.S. Naval Base		USNMJ-1 Panel	1944 to 1946	S	11		0	11	S	11	
PENNSYLVANIA												
Philadelphia	Philadelphia Naval Shipyard	Schuylkill River Quay wall, 250 ft. E. of point G.	USNPP-1 Panel	1944 to 1947	0	8		0	8	0	8	
"	"	Delaware River, S.E. cor. Pier No. 6	USNPP-2 Panel	1944 to 1947	0	8		0	8	0	8	

MOLLUSCAN BORERS				CRUSTACEAN BORERS							
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	

DELAWARE

Wilmington	City of Wilmington, Board of Harbor Commissioners	Wilmington Marine Terminal	MM-1 Block	1935	0	7		0	7	0	7
	Bethlehem-Fairfield Shipyard, Inc.	Pier No. 1	BSF-1 Block	1944 to 1945	0	12		0	12	0	12
"	"	"	BSF-1 Spec.	1944 to 1945	0	12		0	12	0	12
"	"	Pier No. 3	BSF-2 Block	1944 to 1945	0	10		0	10	0	10
"	"	"	BSF-2 Spec.	1944 to 1945	0	12		0	12	0	12
"	Bethlehem Steel Co.	Pier No. 6	BSK-1 Block	1944 to 1946	0	9		0	9	0	9
"	"	Upper Dock	BSK-2 Block	1944 to 1946	0	9		0	9	0	9
"	"	Lower Yard	BSK-3 Block	1944 to 1946	0	9		0	9	0	9
"	"	Key Highway No. 1, Off Shore	BSK-4 Spec. Panel	1944 to 1946	0	8		0	8	0	8

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS						CRUSTACEAN BORERS		
					TEREDINIDAE			PHOLADIDAE			LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		DEGREE	MONTHS TO ATTAIN

MARYLAND, continued

Baltimore	Bethlehem Steel Co.	Key Highway Pier No. 4	BSK-5 Panel	1947	0	6		0	6		0	6
"	Maryland Drydock Co.	810 ft. from bulkhead	MD-1 Block and Panel	1938 to 1947	0	12		0	12		0	12
Baltimore, S. of Patuxent River from Baltimore	"	30 ft. from bulkhead	MD-2 Block and Panel	1938 to 1947	0	8		0	8		0	8
Sparrows Point	Bethlehem Steel Co.		BSB-1 Block and Panel	1938 to 1947	0	8		0	8		0	8
"	"		BSB-2 Block and Panel	1938 to 1947	Tr.	8	Bankia gouldi	0	8		0	8
"	"	Slips 5-6	BSB-3 Spec. and Panel	1944 to 1947	0	9		0	9		0	9

MOLLUSCAN BORERS					CRUSTACEAN BORERS						
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE			
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	
Portsmouth	Norfolk Naval Shipyard		USNW-1 Panel	1944 to 1947	M	8	Bankia gouldi & Teredo navalis	0	9	0	9
Worfolk	U.S. Naval Operating Base	Convoy Escort Base, Pier No. 23	USNW-2 Panel	1944 to 1947	VH	4	Bankia gouldi & Teredo navalis	0	8	Tr.	8
<u>NORTH CAROLINA</u>											
Wrights-ville Beach	Ethyl-Dow Chemical Co.		ED-3 Panel	1946	VH	2	Bankia gouldi	0	2	S	2
Kure Beach	"	Plant	ED-1 Block	1940 to 1945	VH	4	Bankia gouldi, Teredo navalis, T. dilatata, and T. (Lyrodus) bipartita	M	6	S	5
"	"	Plant	ED-1 Spec.	1943 to 1944	VH	6	Bankia gouldi, Teredo navalis, T. sigerfoosi and T. (Lyrodus) bipartita	Tr.	8	Tr.	8
"	"	Intake suction basin	ED-1 Spec.	1946	VH	4	Bankia gouldi	0	5	S	5
"	"	Intake suction basin	ED-1 Panel	1946 to 1947	VH	6	Bankia gouldi	Tr.	6	Tr.	6

VIRGINIA

MOLLUSCAN BORERS				CRUSTACEAN BORERS							
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

NORTH CAROLINA, continued

Kure Beach	Ethyl-Dow Chemical Co.	Canal	ED-2 Block	1944 to 1945	VH	3	Bankia gouldi, Teredo navalis and T. dilatata	S	5-6	Tr.	8	
<u>SOUTH CAROLINA</u>												
Charleston	Charleston Naval Shipyard	Pier No. 317-C, Naval Air Station	USNC-1 Panel	1944 to 1947	VH	5	Bankia gouldi & Teredo navalis	0	8	Tr.	1	
"	"	"	USNC-1U Panel	1944 to 1947	S	8	Bankia gouldi & Teredo navalis	0	8	0	8	
"	"	Deperming Station, Naval Air Station	SNC-2 Panel	1944 to 1947	VH	3	Bankia gouldi & Teredo navalis	0	8	0	8	
"	"	"	USNC-2U Panel	1944 to 1947	VH	5	Bankia gouldi & Teredo navalis	0	8	0	8	
"	U.S. Engineers Office	Custom House Pier, Charleston	USNC-3 Panel	1944 to 1947	VH	3	Bankia gouldi, Teredo navalis & Teredo (Lyrodus) sp.	0	8	M	8	

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS					CRUSTACEAN BORERS		
					TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		DEGREE

SOUTH CAROLINA, continued

Charleston	Standard Oil Development Co.	Charleston Refinery Pier, Cooper River	SOD-1 Block and Panel	1945 to 1947	VH	4	Bankia gouldi	0	8	0	8	
"	Southern Railway System	Charleston Coal Pier, offshore end	SRC-1 Block and Panel	1944 to 1947	VH	5	Bankia gouldi & Teredo (Lyrodus) sp.	0	10	Tr.	8	
<u>GEORGIA</u>												
Savannah River	U.S. Naval Receiving Station	Cockspur Island	USNSG-1 Panel	1944 to 1945	VH	3	Bankia gouldi	0	8	Tr.	1	
<u>FLORIDA</u>												
Mayport	U.S. Coast Guard Training Station	S.W. corner of Rivaault Bay	USNM-1 Panel	1944 to 1947	VH	1	Bankia gouldi and Teredo sp.	ME	8	M	8	
Daytona Beach	Mellon Industrial Institute	North Florida Test Service, Ponce de Leon Inlet	DB-1 Panel	1942	VH	5	Bankia gouldi, Teredo (Lyrodus) bipartita and Teredo sp.	0	8	S	6	
"	Bureau of Ships, U.S. Navy	North Florida Test Service, Ponce de Leon Inlet	DM-1 Block	1944 to 1947	VH	4	Bankia gouldi, Teredo (Lyrodus) bipartita, T. navalis, T. dilatata	VH	7	VH	7	Sphaeroma fairly abundant from 1944 to 1947; Chelura also present in 1946.

cola, some being in old Bankia tubes



				MOLLUSCAN BORERS				CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		DEGREE
Key West	U.S. Naval Submarine Base	Pier B. Naval Station	USMK-1 Panel	1944 to 1947	VH	8	Bankia sp. Tereido clappi, T. parksi, T. (Lyrodus) sp., T. (Psilotere-do) sp., and Tereido sp.	0	8		VH	8
"	"	Outboard end of Section Base	USMK-2 Panel	1944 to 1947	VH	8	Tereido clappi, T. parksi, T. (Lyrodus) sp., and Tereido sp.	0	12½		VH	8
Pensacola	Naval Air Training Bases	Ferry Slip Naval Air Station	USNPF-1 Panel	1944 to 1947	VH	1	Bankia Gouldi. Tereido (Psilotere-do) sp. and Tereido sp.	ME	4	Martesia	H	4
"	"	Ferry Slip Palafox St., Pensacola	USNPF-2 Panel	1944 to 1947	VH	2	Bankia Gouldi and Tereido sp.	S	4	Martesia and Hiata	ME	8
"	"	Railroad Trestle, Naval Air Station	USNPF-3 Panel	1944 to 1947	VH	3	Bankia Gouldi and Tereido sp.	S	4	Not determined	Tr.	8

FLORIDA, continued

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS				
					TEREDINIDAE		PHOLADIDAE		DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	FORMS IDENTIFIED					
GULF OF MEXICO - CARIBBEAN													
TEXAS													
Galveston	U.S. Naval Frontier Base		USNGT-1 Panel	1944 to 1946	VH	5	Bankia gouldi, B. mexicana, T. (Lyrodus) sp. and Teredo sp.	Tr.	8	Not determined	S	8	
Port Aransas	Humble Pipe Line Co.	Dock No. 1 Harbor Island	PA-1 Spec. and Block	1942 to 1947	VH	8	Bankia gouldi, B. mexicana, Teredo navalis, T. (Lyrodus) Bipartita and Teredo sp.	M	9	Martesia striata	VH	8	
Corpus Christi	U.S. Naval Air Station		USNCC-1 Panel	1944 to 1947	VH	3	Bankia gouldi, Teredo navalis T. (Lyrodus) sp., T. (Psilocladero) sp., and Teredo sp.	0	8		M	8	Trace of Sphaeroma in 1945
BERMUDA ISLANDS													
Bermuda	U.S. Naval Operating Base		USNHH-1 Panel	1946 to 1947	S	4	Teredo somersi	0	8		VH	8	Trace of Sphaeroma in 1946

LOCATION	MOLLUSCAN BORERS				CRUSTACEAN BORERS					
	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE		

CUBA

GULF OF MEXICO - CARIBBEAN

Guantanamo Bay	U.S. Naval Operating Base		USNGC-1 Panel	1944 to 1947	VH	2	Teredo (Teredothyra) dominicensis, T. (Lyrodus) sp. and T. (Pedloterodo) sp.	VH	1	Hiata and Martesia	M	4	
<u>PUERTO RICO</u>													
San Juan	U.S. Naval Air Station	Temporary wharf at San Antonio Tank Farm	USNSU-1 Panel	1944 to 1947	VH	1	Bankia sp. Teredo navalis, T. Parksi, T. (Lyrodus) sp. and Teredo sp.	VH	4	Hiata and Martesia	MH	8	Sphaeroma present in 1944 and 1945 mostly traces but 45-50 on surface of one panel.
<u>VIRGIN ISLANDS</u>													
St. Thomas	U.S. Naval Submarine Base	Krum Bay	USNVI-1 Panel	1944 to 1947	M	6½	Teredo (Lyrodus) sp. and Teredo sp.	0	10		VH	6	Chelura numerous in 1945 and 1946.
<u>BRITISH WEST INDIES</u>													
Trinidad	U.S. Naval Operating Base	Pier No. 1 Fueling Pier	USNVI-1 Panel	1944 to 1947	VH	4	Bankia Katherinae, B. mexicana, B. zeteki, Teredo (Lyrodus) sp., T. affinis group and T. massa group.	S	8	Martesia and Hiata	M	7	

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS		
					TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE

VENEZUELA

SOUTH AMERICA

Aruba	Standard Oil Development Co. (Aruba Refinery)	New Laker Reef Berth	A-1 Panel	1945 to 1947	Tr.	8	Too dry to determine	0	8		H	8
"	"	Point mid-way between Utility and Gasoline Docks	A-2 Panel	1945 to 1947	0	8	"	0	8		H	7
"	"	Butterworth Dock	A-3 Panel	1945 to 1947	VH	8	"	0	8		VH	8
"	"	Main Wharf	A-4 Panel	1945 to 1947	S	8	Not determined	0	8		VH	8
"	"	Lake Tanker Wharf	A-5 Panel	1945 to 1947	Tr.	8	"	0	8		VH	3
Maracaibo	Creole Petroleum Corporation	Flow Station No. 20 Legunillas Field	CP-1 Panel	1945 to 1947	VH	7	Teredo (Neoteredo) healdi	0	9		0	8
Caripito	"	Pier No. 1 San Juan River	CP-2 Panel	1945 to 1947	S	7	Not identified	0	8		0	8



LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN

ITALY (SICILY)

MEDITERRANEAN AREA

Palermo	U. S. Naval Operating Base		USNSI-1 Panel	1944 to 1945	VH	3	Teredo Paoloterredo sp. and T. (Lyrodus) sp.	0	8		VH	8	Chelura abundant in 1945.
<u>MOROCCO</u>													
Casablanca	U. S. Naval Operating Base	Tug Berth at the Liberty Landing, Casablanca Harbor	USNCB-1 Panel	1944 to 1945	H	2	Teredo (Lyrodus) sp. and Teredo sp.	0	3		Tr.	3	
<u>TUNISIA</u>													
Bizerte	Eighth Amphibious Force, Advanced Amphibious Training Base		USNFB-1 Panel	1944 to 1945	S	5	Teredo	0	5		M	5	

LOCATION	MOLLUSCAN BORERS										CRUSTACEAN BORERS	
	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDAE			LIMNORIA	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		
PACIFIC OCEAN												
ALASKA												
Adak	U. S. Naval Operating Base	Dock No. 9 Sweeper Cove	USNAA-1 Panel	1944 to 1947	S	8	Bankia setacea	0	8		S	8
Dutch Harbor	"		USNDH-1 Panel	1944 to 1947	S	8	Bankia setacea	0	8		Tr.	8
Kodiak	"	Temporary Pier, Women's Bay	USNKA-1 Panel	1944 to 1947	VH	9	Bankia setacea	0	12½		MH	11
"	"	Permanent Pier, Women's Bay	USNKA-2 Panel	1944 to 1947	MH	11½	Bankia setacea	0	13		S	13
"	"	Marome Railway, Women's Bay	USNKA-3 Panel	1944 to 1946	VH	11	Bankia setacea	0	11		MH	8
"	"	Woody Island Pier	USNKA-4 Panel	1944 to 1947	MH	11½	Bankia setacea	0	13		S	11
"	"	Army Pier, St. Paul Harbor	USNKA-5 Panel	1944 to 1945	M	11	Bankia setacea	0	11		Tr.	11
Sitka	U. S. Naval Air Station		USNSA-1 Panel	1944 to 1946	VH	8	Bankia setacea	0	8		VH	8

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS			
					TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN
WASHINGTON												
Hadlock	U.S. Naval Magazine and Net Depot	Indian Island	USNII-1 Panel	1944 to 1947	VH	6	Bankia setacea	0	9	0	S	4
Bremerton	Puget Sound Naval Shipyard	S. end of Receiving Station Pier	USNPS-1 Panel	1944 to 1947	VH	8	Bankia setacea	0	12	0	S	12
"	"	N. side of Pier No. 1 (Fuel Oil Pier)	USNPS-2 Panel	1944 to 1947	VH	6	Bankia setacea	0	12	0	M	10
"	"	S. end of Pier No. 8	USNPS-3 Panel	1944 to 1947	VH	5	Bankia setacea	0	12	0	M	8
Seattle	U.S. Naval Station	S.W. corner of Pier No. 90	USNS-1 Panel	1944 to 1947	VH	3	Bankia setacea	0	7	0	S	7
"	"	S.W. corner of Pier No. 91	USNS-2 Panel	1944 to 1947	VH	3	Bankia setacea	0	8	0	S	8
Tacoma	Todd Pacific Shipyards Inc.	Outfitting Pier No. 4	USMTW-1 Panel	1944 to 1946	VH	4	Bankia setacea and Teredo (Lyrodus) sp.	0	8	0	S	8
OREGON												
Astoria	U.S. Naval Station	North end of Pier No. 2, Port Docks	USNAO-1 Panel	1944 to 1946	0	8		0	8	0	0	8



MOLLUSCAN BORERS										CRUSTACEAN BORERS						
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLIDIDAE			DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED						

CALIFORNIA

Mare Island	Mare Island Naval Shipyard	S. side of E. end of shipbuilding ways No. 8	USNMI-1 Panel	1944 to 1947	VH	7	Teredo navalis and T. (Lyrodus) sp.	0	10	0	10		0	10	
"	"	N. side of Finger Pier No. 21	USNMI-2 Panel	1944 to 1947	VH	9	Teredo navalis	0	9	0	9		0	9	
"	"	15 ft. from S.E. corner NAD Pier at Berth No. 34-E	USNMI-3 Panel	1944 to 1947	VH	5	Teredo navalis	0	9	0	8		0	8	
San Francisco	U.S. Naval Drydocks at Hunters Point	Pier between Berths Nos. 57 and 58	USNMI-4	1944 to 1947	VH	8	Bankia setacea, Teredo navalis and T. (Lyrodus) diegensis	0	8	MH	8		MH	8	
"	Bethlehem Steel Co., Shipbuilding	San Francisco Yard, Head of Pier No. 5	BSC-1 Block	1944 to 1947	VH	5	Bankia setacea, Teredo navalis T. (Lyrodus) diegensis and T. (Lyrodus) townsendi	0	10	H	10		H	10	
"	"	"	BSC-1 & 1A Spec. and Panel	1944 to 1947	VH	4	Bankia setacea, Teredo navalis	0	12	MH	12		MH	12	

LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	MOLLUSCAN BORERS				CRUSTACEAN BORERS				
					TEREDINIDAE		PHOLADIDAE		LIMNORIA	MISCELLANEOUS	MONTHS TO ATTAIN	DEGREE	MONTHS TO ATTAIN
					MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN					

CALIFORNIA, continued

Alameda	Bethlehem Steel Co., Shipbuilding Division	Alameda Yard	BSC-2 Block	1944 to 1947	Tr.	8	Bankia setacea	0	10	Tr.	8
"	"	"	BSC-2 & 2A Spec. and Panel	1944 to 1946	S	8	Bankia setacea	0	8	Tr.	8
Port Chicago	U.S. Naval Magazine	Naval Magazine near N.E. corner of Barge Pier	USNMI-5 Panel	1945 to 1947	M	8	Teredo navalis	0	9	0	9
"	"	Naval Magazine, 65 ft. from N.E. corner Wharf No. 2	USNMI-6 Panel	1945 to 1947	M	9	Teredo sp.	0	9	Tr.	9
"	"	Naval Magazine, 25 ft. from N.E. corner Wharf No. 3	USNMI-7 Panel	1945 to 1947	S	7½		0	9	Tr.	9
Port Heineme	U.S. Naval Station	Pier No. 1 Bents 12 and 13 from shore end	USNPH-1 Panel	1944 to 1947	VH	3	Bankia setacea, Teredo navalis, T. (Lyrodus) diegensis and T. (Lyrodus) sp.	0	8	Tr.	8

					MOLLUSCAN BORERS				CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS	
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN

CALIFORNIA, continued

Port Heuneme	U.S. Naval Station	West end of Transit Shed No. 1	USNPH-2 Panel	1944 to 1947	VH	4	Bankia setacea, Teredo navalis, T. (Lyrodus) diegensis, T. (Lyrodus) sp. and Teredo sp.	0	8	M	8	
San Pedro	Terminal Island Naval Shipyard	S. end of Approach Pier No. 1 U.S. Naval Drydocks	USNF-1 Panel	1944 to 1947	VH	3	Bankia setacea, Teredo navalis, T. (Lyrodus) diegensis, T. (Lyrodus) sp. and Teredo sp.	0	8	Tr.	8	
"	Bethlehem Steel Co., Shipbuilding Division	Terminal Island Shipyard, Paint Shop No. 1	BST-1 Block	1944 to 1947	VH	7	Bankia setacea and Teredo (Lyrodus) townsendi	0	9	M	7	
"	"	Terminal Island Shipyard	BST-2 Block	1944	MH	2	Teredo (Lyrodus) townsendi	0	2	Tr.	2	
"	"	Terminal Island Shipyard Outfitting Wharf	BST-3 Block	1944	VH	3?	Bankia setacea	0	3?	M	3?	

MOLLUSCAN BORERS				CRUSTACEAN BORERS							
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE		PHOLADIDAE		LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	DEGREE	

CALIFORNIA, continued

San Diego	U. S. Naval Supply Depot Fuel Facility	North end of T-shaped Fueling Pier	USNSD-1 Panel	1944 to 1947	VH	8	Teredo navalis, T. (Lyrodus) diegensis and Teredo sp.	0	13	VH	8	
"	U. S. Naval Station	South side of south Mole Pier	USNSD-1 Panel	1944 to 1947	M	8	Teredo (Lyrodus) sp. and Teredo sp.	0	8	VH	8	
<u>CANAL ZONE</u>												
Balboa	U. S. Naval Operating Base		USNCZ-1 Panel	1944 to 1947	VH	2	Bankia canalis, B. gouldi, B. mexicana, B. zeteki, B. (Nausitorea) sp. and Teredo sp.	S	4	S	4	Martesia and Hiata
"	U. S. Naval Station		USNCZ-2 Panel	1944 to 1945	VH	2	Bankia canalis, B. gouldi, B. zeteki, B. (Nausitorea) sp. and Teredo sp.	Tr.	8	Tr.	8	Martesia and Hiata

MOLLUSCAN BORERS										CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	DEGREE	TEREDINIDAE			PHOLIDIDAE			LIMNORIA	MISCELLANEOUS
						MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE		

HAWAIIAN ISLANDS

Midway Islands	U. S. Naval Operating Base (Navy No. 1504)		USNX-2 Panel	1944 to 1947	H	4	Teredo (Lyrodus) sp. and Teredo sp.	0	8		VH	4	
Pearl Harbor (Oahu)	Pearl Harbor Naval Shipyard	Marginal Timber Wharf near entrance to harbor	USNH-1 Panel	1944 to 1947	VH	2	Bankia hawaiiensis, Teredo milleri, T. parksi, T. trulliformis, T. (Lyrodus) sp. and Teredo sp.	VH	5	Hiata and Martesia	MH	4	
"	"	Under "1010" Wharf	USNH-2 Panel	1944 to 1947	VH	3	Bankia hawaiiensis, Teredo affinis, T. milleri, T. (Lyrodus) diegensis and T. sp.	VH	5	Hiata and Martesia	VH	1	
"	"	Under marginal wharf 1/2 mile up channel from No. 1 Test Board	USNH-3 Panel	1944 to 1947	VH	3	Bankia hawaiiensis, Teredo milleri, T. parksi, T. trulliformis and T. (Lyrodus) diegensis	VH	3	Hiata and Martesia	VH	4	

MOLLUSCAN BORERS										CRUSTACEAN BORERS			
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE			LIMNORIA		MISCELLANEOUS
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	
HAWAIIAN ISLANDS, continued													
Pearl Harbor (Oahu)	Pearl Harbor Naval Shipyard	Fuel Oil Pier, Berth H-2 Kauhua	USNH-4 Panel	1944 to 1947	VH	2	Bankia hawaiiensis, Teredo milneri, T. parksi, and T. (Lyrodus) diegensis	VH	2	Hiata and Martesia	S	8	
Palmyra Island	U.S. Naval Air Station		USMPI-1 Panel	1946	H	4		0	6		VH	6	
Wake Island	U.S. Naval Air Station	Wake-Wilkes Channel	USNWI-1 Panel	1946 to 1947	VH	4	Teredo sp.	0	9		H	8	
"	"	Wake-Peale Channel	USNWI-2 Panel	1946 to 1947	VH	7	Teredo sp.	0	9		H	9	
SOUTHWESTERN ISLANDS OF JAPAN													
Okinawa	U.S. Pacific Fleet Section Base	Katchin Hanto Peninsula in Buckner Bay	USNO-1 Panel	1946	VH	7	Teredo sp.	0	7		Tr.	7	



				MOLLUSCAN BORERS				CRUSTACEAN BORERS				
LOCATION	COOPERATING AGENCY	SPECIFIC LOCATION	TEST NO.	YEAR	TEREDINIDAE			PHOLADIDAE				
					DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED	DEGREE	MONTHS TO ATTAIN	FORMS IDENTIFIED		
										DEGREE	MONTHS TO ATTAIN	MISCELLANEOUS

NEW HEBRIDES ISLANDS, continued

Espiritu Santo Island	U.S. Naval Advanced Base		USNXX-3 Panel	1944 to 1945	VH	2	Bankia hawaiiensis, Teredo gregoryi, T. milleri, T. (Lyrodus) diegensis, T. (Lyrodus) sp., T. (Psiloteredo) sp. and Teredo sp.	0	9		H	5	
"	"		USNXX-4 Panel	1944 to 1945	VH	3	Bankia hawaiiensis, Teredo diconus, T. fulleri, T. gregoryi, T. trulliformis, T. (Lyrodus) sp., T. (Psiloteredo) sp., T. (Teredora) sp. and Teredo sp.	0	8		H	5	





