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Technical Report

HARBOR SCREENING TESTS OF MARINE BORER INHIBITORS — V

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U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

HARBOR SCREENING TESTS OF MARINE BORER INHIBITORS — V

Y-R005-07-007

Type C

by

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ABSTRACT

The Laboratory is exposing wood panels impregnated with various materials to determine their resistance to attack by marine borers. This report lists the results of harbor tests of treated panels removed from exposure between 15 August 1961 and 15 August 1962. It also lists all treated panels which have been exposed for one year or more and which have shown no attack or very slight attack. Treatments which have been exposed for less than one year are not reported unless they have failed and have been removed from test.

When impregnated into wood test panels, creosote and 70-30 creosote - coal tar solution are effective against Martesia and teredine attack but not Limnoria attack. Copper salts, chelates, some copper complexes and mercury salts are effective against Limnoria attack at Port Hueneme and Pearl Harbor but are ineffective against teredine and Martesia attack. Tributyltin compounds are effective against Limnoria and teredine borers at Port Hueneme but have shown attack by Limnoria at Pearl Harbor. However, at Pearl Harbor they are effective against Martesia and teredine borers. Copper naphthenate and solubilized copper oxinate are superior to creosote or creosote - coal tar in tests to date at both test sites.

Certain organic, metal organic, and inorganic compounds, when combined with creosote or creosote - coal tar solutions, show promise in improving the preservative ability of these materials. Aluminum oxinate, malachite green oxalate, and zinc naphthenate are not effective additives. Treatments with a combination of one material specifically toxic to Limnoria and another material specifically toxic to teredine borers are also showing promise as preservative systems, except that some have experienced Martesia attack.

The tropical woods antidesma pulvinatum, greenheart, and lignum vitae are performing well at Port Hueneme. Afambeau, greenheart, and lignum vitae failed at Pearl Harbor chiefly because of Martesia attack.

Those treatments or woods which have not been attacked by one or more species during their entire period of exposure or as of 15 August 1962 are summarized.

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The Laboratory invites comment on this report, particularly on the results obtained by those who have applied the information.

FOREWORD

This is the twelfth in a series of reports[1-11] on studies conducted by the Laboratory to develop more effective methods and materials for preservation of wooden structures exposed to the attack of marine boring organisms.

It is the fifth of a series of reports on the results of harbor exposure of treated and untreated test panels which are exposed until there is heavy Limnoria attack or until the panel is weakened by Martesia or teredine attack. Some results which have been reported previously[6,7,9,10] are included in this report for the purpose of comparison.

INTRODUCTION

The destructive action of marine boring organisms on structures submerged in sea water presents a major maintenance problem to Navy shore installations. The replacement of wood piling destroyed by these organisms is a costly operation, and, in addition, may remove the pier from operation during the construction period.

Under Project Y-R005-07-007, the Chief, Bureau of Yards and Docks, requested the Laboratory to investigate methods and materials for reducing or preventing borer attack on wooden marine structures of the Naval Shore Establishment.

One phase of this study is the impregnation of wood panels with toxic materials and the exposure of these treated panels to marine borers in harbors. The treating materials are chosen on the basis of their toxicity to marine borers as determined by the Toxicity Testing Procedure developed at this Laboratory.[8,11] The exposure of small treated panels provides a system for rapidly screening large numbers of potentially useful treatments. The panels can be treated in ordinary laboratory equipment, require relatively small quantities of treating materials, and a large number of treatments can be exposed in a relatively small dock area. Also, the surface-to-volume ratio of these panels is so high that the rate of leaching of the preservative by the sea water is much higher than it would be in round piling sections. This small-panel screening procedure is further accelerated by exposing the more promising treatments in Pearl Harbor where, because of high water temperature and greater numbers and kinds of borers, attack begins after exposure in a half to a fourth the time required for initial attack at Port Hueneme. The exposure of full-sized piles would provide a more accurate evaluation of a preservative treatment, but the use of this method in a preliminary screening would be uneconomical.

PROCEDURE

Treatment

Treating solutions are made up on a volume percent basis for liquids and a weight percent basis for solids. With the exception of coal tar, creosote, creosote - coal tar solutions, and copper naphthenate solution, only inert solvents are used to

make up solutions to 100 percent. In general, these inert solvents are xylene for nonpolar compounds, water for polar compounds, and cellosolve for combinations of polar and nonpolar compounds.

Unless otherwise noted, southern yellow pine panels are used in this study. Sets of ten panels are tagged, weighed, impregnated by the vacuum method, weighed again to determine the amount of preservative retention, and then air-dried to remove any inert solvent present. Details of the procedure are described in Reference 6. Several sets of pressure-treated ponderosa pine samples submitted by the U. S. Forest Products Laboratory, Madison, Wisconsin, are also evaluated.

Exposure and Evaluation

The panels are mounted on single or double Monel racks which are suspended horizontally in the harbor about three feet above the mud line by nylon parachute cords. At Port Hueneme, the racks are removed twice monthly for cleaning the panels. Panels are inspected and rated twice monthly during their first year of exposure, and monthly thereafter. Panels are removed whenever structural failure due to borer damage is imminent. At Pearl Harbor, the panels are cleaned and inspected monthly, removed whenever extensive damage is noted, and returned to the Laboratory for evaluation.

The extent of Limnoria and Martesia attack can be readily determined by inspection of the surface of the panel. In its early stages, teredine attack is very difficult to detect by surface inspection. When this type of attack reaches an advanced stage, the panel loses much of its structural strength and can easily be bent or snapped in two. All panels which are removed from exposure test are sawed in two to show the amount of teredine damage. Damage is assessed as follows:

O = none

T = trace

VL = very light

L = light

M = moderate

H = heavy

VH = very heavy

Limnoria, Martesia, and teredine damage are always rated separately. Although individual records are kept for each panel treated and exposed, the tabular data presented in this report represent average data for all panels of a given treatment exposed at the location specified.

EVALUATION OF TREATMENTS

This report deals with all treated and untreated panels which have been removed from exposure between 15 August 1961 and 15 August 1962, and with all panels which have been exposed for at least one year and which were still under test on 15 August 1962.

1. Creosote and Creosote - Coal Tar Solutions (Table I): Panels treated with large quantities of creosote or creosote - coal tar solutions resist Martesia and teredine attack but not Limnoria attack. The data continue to show that 70-30 creosote - coal tar solution and creosote are approximately equal in preservative ability

2. Inorganic Compounds (Table II): In general, copper salts, chelates, and complexes prevent Limnoria attack for considerable periods of time at Port Hueneme. Those failures which have occurred are the result of teredine attack. At Pearl Harbor these compounds are ineffective against both Martesia and teredine attack. At both Port Hueneme and Pearl Harbor, copper naphthenate (6%) and solubilized copper oxinate (containing 4% copper) are continuing to provide better protection against all types of borers than either creosote or 70-30 creosote - coal tar solution.

Mercury salts also are effective against Limnoria but failed in a shorter time than copper salts because of Martesia and teredine attack.

3. Metal Organic Compounds (Table III): The incomplete data indicate that organic mercury compounds are effective against Limnoria but rather ineffective against Martesia and teredine borers. Tributyltin compounds show early initial Limnoria attack but are resistant for long periods of time against Martesia and teredine borers.

4. Organic Compounds (Table IV): Chloro-o-phenylphenol and phenanthrene are essentially ineffective preservatives. The ether-soluble alkaloids of greenheart sawdust resisted Martesia and teredine attack during their short exposure period but were heavily attacked by Limnoria.

5. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar Solutions (Table V): Combination treatments containing creosote, coal tar, or creosote - coal tar solutions plus an additive toxic to Limnoria are being studied. Although data are incomplete, the results to date show the following trends:

At Port Hueneme and Pearl Harbor, nearly all of the chemicals which are toxic to Limnoria, and which were added to coal tar, creosote, or creosote - coal tar solutions, are performing well in decreasing Limnoria attack. In several instances, Limnoria attack has occurred at an early date, but the rate of progress of the attack was slower than in those panels which did not contain the additive. The rate and degree of Martesia attack is essentially unaffected by these additives.

Panels treated with coal tar containing copper naphthenate (1 and 2%) or tributyltin oxide (1%) are much more resistant to Limnoria than those treated with coal tar only.[9] They are not, however, as resistant to Limnoria as those treated with creosote, creosote solutions, or creosote - coal tar solutions containing one of the above additives.

Aluminum oxinate (1%) and zinc naphthenate (5%) do not increase Limnoria resistance when used as additives to creosote and/or coal tar.

6. Other Combination Treatments (Table VI): From the data obtained to date, nearly all treatments consisting of a material specifically toxic toward Limnoria and a material specifically toxic toward teredine borers are performing well at Port Hueneme. At Pearl Harbor, however, some of these treatments have failed because of Limnoria or Martesia attack or both.

Combinations of toxic chemicals which show promise at both test sites are:

(a) p-aminophenylmercuric acetate (1%) and malachite green oxalate (2%)

(b) p-aminophenylmercuric acetate (1%) and tributyltin coconut fatty acid salt (1%)

(c) chlordan (5%) and malachite green oxalate (2%)

(d) copper naphthenate (3%) and tributyltin coconut fatty acid salt (1 or 5%)

(e) solubilized copper oxinate (50%) and tributyltin coconut fatty acid salt (1 or 5%)

(f) copper sulfate (14.73%) and sodium monohydrogen arsenate (20.06%)

(g) dieldrin (1 or 5%) and tributyltin coconut fatty acid salt (1 or 5%)

(h) p-dimethylaminophenylmercuric acetate (1%) and tributyltin coconut fatty acid salt (1%)

(i) p-dimethylaminophenylmercuric acetate (1%) and malachite green oxalate (2%)

(j) malachite green oxalate (2%) and endrin (5%)

(k) toxaphene (1 or 5%) and tributyltin coconut fatty acid salt (1 or 5%)

(l) toxaphene (1 or 5%) and tributyltin oxide (1 or 5%)

Other combinations which are performing successfully at both Port Hueneme and Pearl Harbor are:

(a) copper naphthenate (3%) and linseed oil (50%)

(b) tributyltin oxide (1%) and ammonium sulfide (20-24%)

Several other combinations show promise but are not listed here because they have been exposed for too short a time.

7. Untreated Panels and Solvent-Extracted Untreated Panels (Table VII): The tropical woods antidesma pulvinatum, greenheart, and lignum vitae are performing well after extended periods at Port Hueneme. Greenheart panels which have been extracted with acetic acid, chloroform, or methanol are about equal to greenheart according to data obtained to date. All greenheart and extracted greenheart panels have been attacked by teredine borers, and the ether-extracted panels have failed. Sea-water-extracted greenheart panels failed earlier because of Limnoria and teredine borers at Port Hueneme.[9] Afambeau, greenheart, and lignum vitae failed at Pearl Harbor chiefly because of Martesia attack. Antidesma pulvinatum has not been exposed at Pearl Harbor because of previous exposure tests of this wood in Hawaiian waters by Edmondson.[12]

DISCUSSION

According to data obtained so far, the most promising treatments for the preservation of wood in a marine environment are those which contain a combination of materials, each of which is toxic to one or more species of borer. The addition

of certain organic or metal organic compounds to creosote or creosote - coal tar solution produces a preservative which is superior to creosote or creosote - coal tar solution alone.

In the evaluation of the experimental treatment systems the time to initial Limnoria attack has been used as one index for determining the efficacy of any given system. There are two reasons for this: (1) Limnoria attack the surface of the wood and are thus readily detectable; (2) Limnoria, unlike teredine borers, can attack wood treated with creosote or 70-30 creosote - coal tar solution, the present standard preservatives for marine piling.

In reporting Limnoria attack two ratings are emphasized, i.e., time to initial attack and the attack rating at the end of the total exposure period. The time to initial attack should presumably be the time required by the harbor environment to sufficiently alter the surface of the treated panel to render it susceptible to Limnoria attack. As a general rule, those treatments that delay initial attack are better than those that show initial attack after short periods of exposure.

This generalization does not hold for treatments consisting of creosote or creosote - coal tar solution containing additives that are specifically toxic to Limnoria. Frequently the presence of the additive may not alter the time to initial attack but will significantly alter the rate of progress of the attack. For example, at Pearl Harbor, panels treated with 50 percent creosote showed initial Limnoria attack in an average of 5 months,[10] and panels treated with 50 percent creosote containing 10 percent biphenyl were attacked in 5.5 months. The creosoted panels, however, were so heavily attacked by Limnoria in 18 months that they were removed from test, but the panels containing the biphenyl additive were only moderately attacked after 42 months and are still under test.

In some instances the addition to creosote or creosote - coal tar solution of a chemical specifically toxic to Limnoria does not result in an improved preservative. One or more of a number of factors that would be difficult to anticipate may operate. Among these are: (1) the quantity of additive may be too small to exert a toxic effect; (2) the additive may in some manner form a complex with some of the creosote constituents and become less toxic, more soluble, or more peptizable by sea water; and (3) the additive in the presence of creosote may be more readily detoxified by the harbor fauna and flora.

Many preservative systems listed in this report contain no creosote or creosote - coal tar solution but are composed of a combination of materials, each of which is toxic to one or more species of borer. A number of these show promise as useful preservatives. Here, too, the combination may be less effective than one

might have reason to expect from the results of the exposure of the individual toxic agents. Again, interactions similar to those postulated for the interaction between creosote and a chemical additive may be involved. It is apparent, therefore, that no definite predictions can be made about the effectiveness of a multicomponent system containing compounds each of which is known to be effective against one or more species of borers. Each system must be evaluated. Compounds which have proved effective individually and which are potentially valuable in multicomponent systems should be evaluated in such systems.

CONCLUSIONS

1. Creosote and creosote - coal tar solutions are effective against Martesia and teredine borers but not against Limnoria. Creosote and 70-30 creosote - coal tar solution have about the same preservative ability.

2. Inorganic copper and mercury compounds and copper chelates are generally effective against Limnoria only, but higher concentrations of copper naphthenate and solubilized copper oxinate have exhibited a degree of effectiveness toward all types of borers.

3. Phenylmercury compounds are effective against Limnoria; tributyltin compounds, against Martesia and teredine borers.

4. The addition of certain inorganic, organic, and metal organic compounds and insecticides to creosote or creosote - coal tar solutions improves their resistance to Limnoria.

5. Creosote-free combination treatments containing constituents specifically toxic to each borer species show promise of being effective in marine environments.

6. Afambeau, greenheart, and lignum vitae resist Limnoria attack, but are subject to Martesia and teredine attack at Pearl Harbor and teredine attack at Port Hueneme. Antidesma pulvinatum has not been attacked by either Limnoria or teredine borers at Port Hueneme.

FUTURE PLANS

1. Exposure tests of treated wood panels will be continued.

2. The results of harbor exposure tests together with Laboratory toxicity tests will be used in developing additional wood treatments.

3. Panels will be tested with individual materials which exhibit high toxicity to marine borers and resistance to leaching in laboratory screening tests.

4. Emphasis will be placed on the addition to creosote, coal tar, or creosote - coal tar solutions of materials which are toxic to Limnoria.

5. Materials which show a high toxicity toward Limnoria and which are soluble in polar solvents will be used in combination with materials such as malachite green oxalate which show high toxicity toward teredine borers.

6. Materials which show a high toxicity toward Limnoria and which are soluble in nonpolar solvents will be used in combination with materials such as tributyltin coconut fatty acid salt or tributyltin oxide which show high toxicity toward teredine borers.

7. Panels will be double-treated when two specifically toxic agents cannot be dissolved in a single solvent system.

8. Treatments which show promise in panel tests will be used to impregnate full-sized piling in the NCEL treatment plant.

9. Barrier systems for creosoted wood will be investigated.

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11. NCEL Technical Report R-188, An Evaluation of Organotin Compounds as Preservatives for Marine Timbers, by H. P. Vind and H. Hochman. 19 March 1962.

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SYMBOLS USED IN TABLES

* This panel series, or part thereof, was still under test as of 15 August 1962.

** One or more panels in this series had been attacked by this species as of 15 August 1962.

*** One or more panels in this series were not attacked by this species during the entire period of harbor exposure.

N No panels in this series had been attacked by this species as of 15 August 1962.

NC Not checked.

S Panel split during cleaning operations.

FPL Panels furnished by the Forest Products Laboratory, Madison, Wisconsin.

O No attack.

T Trace attack.

VL Very light attack.

L Light attack.

M Moderate attack.

H Heavy attack.

VH Very heavy attack.

† Does not include the weight of ammonium sulfide solution absorbed.

NOTE: In some cases there are discrepancies between the time to initial attack and the total exposure time of the panel. This generally occurs when one or more panels in a series are not attacked by a given species. The data presented in the tables are the average of time to initial attack of those panels which were attacked by a given species and the average of the total exposure time of all panels in the series.

Table I. Creosote and Creosote - Coal Tar Solutions

Treatment	Port Hueneme					Pearl Harbor						
	Wt. Solute Absorbed lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test		
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
100% Creosote (1/8" panel)	31.0	32.5	82.5*			34.3	7.5		15	H	0	0
100% Creosote	35.7	22	73*			40.8	9		17	M	0	0
	40.2	26	65.5*			35.7	10	18	63*			
	32.7	29	64.5*			42.4	5		20	H	0	0
	33.3	19.5	56	H	0	35.8	4	N	25*			
	37.2	17.5	60.5*									
	29.9	16	56*									
	33.5	11	54*									
	39.1	2	36*									
	25.7	8	28.5*									
	23.3	10	26*									
	34.3	**	15.5*									
	31.1	**	12.5*									
100% Creosote (FPL)	45.8	**	36*			45.8	7.5	**	33*			
100% Creosote in Douglas fir	39.8	**	49.5*			41.5	7.5	16	44*			
	41.0	2.5	36*									
	28.1	**	12.5*									
70-30 Creosote - Coal Tar	40.4	28	73*			38.4	10		22.5	M	0	0
	27.1	N	54*			32.6	5		22	VH	0	0
	19.7	12	48*			30.9	4	**	25*			
	23.1	7	42*			33.2	6.5	11.5	15*			
	35.7	**	28.5*									
	34.4	**	15.5*									
	34.8	**	12.5*									
70-30 Creosote - Coal Tar in Douglas fir	38.5	18	49.5*			33.9	9	10.5	44*			
	41.4	4	36*									
	14.7	**	12.5*									

Table II. Inorganic Compounds

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Copper Acetate	0.38	37***	41	T	M							
1% Copper Acetate + ht. tr.	0.38	24***	37	T	M							
1% Copper Acetate in Douglas fir	0.21	**	48*									
1% Copper Acetate + ht. tr. in Douglas fir	0.30	32	48*									
2% Copper Acetate	0.75	34	48*									
2% Copper Acetate + ht. tr.	0.74	**	48*									
2% Copper Acetate in Douglas fir	0.71	**	48*									
2% Copper Acetate + ht. tr. in Douglas fir	0.67	**	48*									
5% Copper Acetate	1.86	N	48*									
5% Copper Acetate + ht. tr.	1.98	**	48*									
5% Copper Acetate in Douglas fir	1.14	**	48*									
5% Copper Acetate + ht. tr. in Douglas fir	1.36	N	48*									
2% Copper Formate + ht. tr. in Douglas fir	0.95	45.5	49.5*			0.94	12	12	14	L	VL	L
1% Copper Naphthenate	0.29 0.28	43 N	65.5* 36*			0.26	24.5	26.5	27.5	L	L	L
1% Copper Naphthenate in Douglas fir	0.18	**	45.5*			0.16	26***	15	44*			

Table II. Inorganic Compounds (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
3% Copper Naphthenate in Douglas fir	0.31	**	45.5*			0.45	**	**	44*			
6% Copper Naphthenate	1.18 1.31	N N	65.5* 36*			1.22 1.38	N N	N N	63* 33*			
6% Copper Naphthenate in Douglas fir	0.46	N	45.5*			0.32	20***	20	44*			
1% Copper Sulfate in Redwood	0.35 0.37	** **	64.5* 28.5*			0.38		9	11	0	H	0
1% Copper Sulfate in Western Red Cedar	0.34	**	64.5*			0.46		6	9.5	0	H	0
2% Copper Sulfate in Douglas fir	0.55	**	42*									
2% Copper Sulfate + ht. tr. in Douglas fir	0.71	29.5	42*									
5% Copper Sulfate in Douglas fir	1.54	**	47*									
5% Copper Sulfate + ht. tr. in Douglas fir	1.75	**	47*									
10% Copper Sulfate + ht. tr.	3.95	23***	31.5	T	M							
10% Copper Sulfate in Douglas fir	3.19	**	47*									
10% Copper Sulfate + ht. tr. in Douglas fir	3.51	**	47*									

Table II. Inorganic Compounds (Cont'd)

Treatment	Port Hueneme					Pearl Harbor						
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test		
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
10% Copper Sulfate in Redwood	3.55	N	64.5*			3.32		17	17	0	L	0
10% Copper Sulfate in Western Red Cedar	2.52	N	64.5*			3.88		9	11.5	0	M	VL
10% Solubilized Copper Oxinate	3.22	38	64.5*			3.18		14.5	18	0	H	T
25% Solubilized Copper Oxinate	7.3	**	64.5*			8.1	22***	21	30.5	VL	M	VL
50% Solubilized Copper Oxinate	15.5	**	64.5*			14.9	**	37.5	63*			
5% Cuprammine Sulfate	1.33	N	49.5*			1.38	20	21***	23	H	VL	M
5% Cuprammine Sulfate + ht. tr.	1.85	39	48*			1.89	15	21***	25.5	H	VL	M
5% Cuprammine Sulfate in Douglas fir	2.45	29	49.5*			2.33	N	31	44*			
5% Cuprammine Sulfate + ht. tr. in Douglas fir	1.59	**	47*			1.47		22.5	29	0	M	T***
5% Cupric Ethylenediamine Sulfate + ht. tr.	2.01	30***	30	T	M	1.91	9	11	12	VL	VL	H
5% Cupric Ethylenediamine Sulfate in Douglas fir	1.23	**	47*			1.44	17***	16	24	VL	VL	VL***
5% Cupric Ethylenediamine Sulfate + ht. tr. in Douglas fir	1.69	**	45.5*			1.85	17***	12	20	VL	M	T***
5% Mercuric Acetate	2.03	35	54*			2.06	**	19	33*			
5% Mercuric Acetate + ht. tr.	2.10	34	54*			2.26		13.5	13.5	0	L	H

Table III. Metal Organic Compounds

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% p-Aminophenylmercuric Acetate	0.39 0.41	19*** **	30.5 28.5	T	H	0.37	11***	8.5	13	T	L	H
1% p-Dimethylaminophenylmercuric Acetate in Douglas fir	0.35	**	47*			0.35	30***	14	27	T	H	VL***
1% Tributyltin Coconut Fatty Acid Salt	0.27	N	56*			0.27	4	N	33*			
10% Tributyltin Coconut Fatty Acid Salt	2.91	**	12.5*									
0.5% Tributyltin Oxide	0.13	**	49.5*									
1% Tributyltin Oxide	0.27	N	49.5*			0.25 0.26	10 5	N N	42* 37.5*			
10% Tributyltin Oxide	2.66	N	12.5*									
1% Triphenyltin Acetate	0.30	**	12.5*									

Table IV. Organic Compounds

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
5% Chloro o-phenylphenol	1.61	3	15.5*			1.53	3	4.5	5.5	H	L	H
1% Ether Soluble Alkaloids of Greenheart Sawdust						0.36	2		5	VH	0	T***
2% Ether Soluble Alkaloids of Greenheart Sawdust	0.71	2.5	12.5*			0.67	2		6	VH	0	T***
10% Phenanthrene	3.2	4	15.5*			2.9	3	4	5	L	M	T

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Aluminum Oxinate in Creosote (1/8" panel)	0.35 34.5	37	82.5*			0.34 33.7	6	9	20	M	T	0
0.9% p-Aminophenylmercuric Acetate + 100% Creosote (double treatment)	0.28 28.5	**	26*			0.26 23.7	12	**	25*			
10% Biphenyl 50% Creosote	3.0 15.6	11	42*			3.1 15.7	5.5	12.5	42*			
						3.1 15.5	**	**	37.5*			
5% Chlordan 50% Creosote	1.51 15.1	6	36*			1.53 15.3	21***	13	33*			
5% Chlordan 50% 70-30 Creosote - Coal Tar	1.52 15.2	3	36*			1.59 15.9	**	**	33*			
10% Chlordan 50% Creosote	2.45 12.2	10.5*	36*			3.02 14.5	**	21	33*			
10% Chlordan 50% 70-30 Creosote - Coal Tar	3.49 17.5	6	36*			3.07 15.5	N	14	33*			
0.5% Copper Naphthenate 50% Coal Tar	0.15 15.2	22.5	54*			0.14 13.6	9	9	20	M	M	VL
1% Copper Naphthenate 50% Coal Tar	0.28 14.1	**	54*			0.26 12.9	18	NC	39	VH	M	T
2% Copper Naphthenate 50% Coal Tar	0.60 15.0	16	37	H	0	0.59 14.9	10	5.5	17	M	M	0

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
3% Copper Naphthenate 50% Creosote in Douglas fir	0.41 8.6	**	45.5*			0.64 10.7	**	**	44*			
3% Copper Naphthenate 50% 70-30 Creosote - Coal Tar in Douglas fir	0.56 9.3	N	45.5*			0.43 7.1	22.5	21	44*			
1% Copper Oxinate in Creosote (1/8" panel)	0.34 33.1	39	82.5*			0.35 35.0	10	8	34	H	T	0
2.5% Copper Oxinate in Creosote (1/8" panel)	0.58 22.2	35	82.5*			0.72 27.3	6	7	17	L	L	0
5% Copper-Oxinate in Creosote (1/8" panel)	1.58 30.0	36	82.5*			1.45 27.5	6	6	15	M	L	0
	1.30 24.4	32	63S	M	0							
3% Solubilized Copper Oxinate 50% Creosote	0.50 8.2	N	42*			0.59 9.9	22		panel lost			
						0.46 7.7	**	18	37.5*			
0.4% Copper Stearate in Creosote	0.13 34.1	**	12.5*									
6% Copper Sulfate 100% Creosote (double treatment)	2.0 36.9	N	15.5*			2.0 34.6	**	**	25*			
12% Copper Sulfate 100% Creosote (double treatment)	5.2 35.8	N	15.5*			5.1 34.5	**	**	25*			

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
14.73% Copper Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (triple treatment) (FPL)	3.23 3.01 38.7	N	36*			3.23 3.01 38.7	N	N	33*			
5.3% Copper Salt of Naphthenic Acid 50% Creosote	1.64 15.5	7	49.5*			1.53 15.1	9	10.5	26	H	VL	0
1% Dieldrin 50% Creosote	0.29 14.8	**	45.5*			0.29 14.2		8	32	0	H	0
1% Dieldrin 50% Creosote in Douglas fir	0.22 10.9	**	45.5*			0.24 11.8	**	9	44*			
1% Dieldrin in Creosote	0.35 33.2	**	45.5*			0.34 33.2	30.5	23	44*			
1% Dieldrin in Creosote in Douglas fir	0.22 21.6	**	45.5*			0.22 22.0	**	10	44*			
1% Dieldrin 50% 70-30 Creosote - Coal Tar	0.30 15.1	19	45.5*			0.31 15.5	**	8	44*			
1% Dieldrin 50% 70-30 Creosote - Coal Tar in Douglas fir	0.25 12.8	**	45.5*			0.20 9.9		8	34	0	M	T***
1% Dieldrin in 70-30 Creosote - Coal Tar	0.29 28.9	**	45.5*			0.32 31.5	**	20	44*			

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Dieldrin in 70-30 Creosote - Coal Tar in Douglas fir	0.23 22.7	**	45.5*			0.25 24.7	**	29	44*			
5% Dieldrin 50% Creosote	1.53 15.3	**	42*			1.31 13.1		8	34	0	H	0
						0.84 8.4		6	28	0	M	0
5% Dieldrin 50% 70-30 Creosote - Coal Tar	1.50 15.0	14	42*			1.48 14.8	33***	**	37.5*			
1% p-Dimethylaminophenylmercuric Acetate 100% Creosote (double treatment)	0.38 29.3	**	26*			0.39 33.5	13	**	25*			
10% Diphenylmethane 50% Creosote	2.81 14.1	9	42*			3.07 15.4	6	N	42*			
1% Endrin 50% Creosote in Douglas fir	0.24 11.8	**	45.5*			0.27 13.4	**	11	44*			
1% Endrin in Creosote in Douglas fir	0.24 24.1	**	45.5*			0.26 26.0	N	9	44*			
1% Endrin 50% 70-30 Creosote - Coal Tar in Douglas fir	0.25 12.2	**	45.5*			0.25 12.4	N	11	44*			
1% Endrin in 70-30 Creosote - Coal Tar in Douglas fir	0.24 23.7	**	45.5*			0.23 23.2	**	11.5	44*			

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor						
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test		
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
5% Endrin 50% Creosote	1.41 14.1	**	42*			1.43 14.3		4	25	0	H	0
						1.38 13.8	N	6	37.5*			
5% Endrin 50% 70-30 Creosote - Coal Tar	1.67 16.7	14	42*			1.49 14.9	N	7	42*			
2% Malachite Green Oxalate 10% Creosote (double treatment)	0.79 2.87	7	28.5*			0.79 2.89	5.5	6	11	VH	L	0
2% Malachite Green Oxalate 25% Creosote (double treatment)	0.77 7.28	6	28.5*			0.76 7.12	5	6	12	VH	M	0
2% Malachite Green Oxalate 50% Creosote (double treatment)	0.78 15.5	5	28.5*			0.81 16.7	5.5	7	15*			
2% Malachite Green Oxalate 100% Creosote (double treatment)	0.76 33.8	**	28.5*			0.77 34.0	7	10	15*			
5% Manganous Oxinate in Creosote (1/8" panel)	1.60 30.3	35	82.5*			1.87 34.8	11	11.5	18S	VL	VL	0
	1.86 37.0	36	76.5*									
14.86% Nickel Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (triple treatment) (FPL)	3.71 3.43 20.7	N	36*			3.71 3.43 20.7		15	33*			
10% Phenyl Ether 50% Creosote	3.02 15.1	7	42*			2.91 14.6	7	10	42*			

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Phenylmercuric Chloride in Creosote	0.26 26.2	28.5	73*			0.42 41.9	12.5	15.5	66*			
1% Phenylmercuric Chloride 50% 70-30 Creosote - Coal Tar in Douglas fir	0.23 11.8	**	45.5*			0.23 11.4	**	7	37.5*			
1% Phenylmercuric Chloride in 70-30 Creosote - Coal Tar in Douglas fir	0.16 15.1	16	45.5*			0.19 20.9	22	17	44*			
1% Phenylmercuric Oleate in Creosote	0.37 36.8	29.5	73*			0.37 37.3	6	NC	11	M	T	0
1% Phenylmercuric Oleate (solid) in Creosote	0.37 36.9	N	15.5*			0.27 26.8	7	**	15*			
1% Phenylmercuric Oleate (solid) in 70-30 Creosote - Coal Tar Solution	0.17 16.1	**	15.5*			0.14 14.2	7.5	**	15*			
1% Phenylmercuric Oleate 10% Creosote 30% Coal Tar	0.36 3.6 10.7	29.5	56.5*	VH	0	0.32 3.2 9.5	6	15	15	M	M	0
1% Phenylmercuric Oleate 50% Creosote 10% Coal Tar	0.27 13.7 2.7	30	70.5*			0.26 12.9 2.6	9	NC	20	M	T	0
1% Phenylmercuric Oleate 50% Creosote 30% Coal Tar	0.31 15.7 9.4	34	70.5*			0.37 18.6 11.1	6	9***	25	VH	VL	0

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Phenylmercuric Oleate 66% Creosote 30% Coal Tar	0.34 22.5 10.3	**	70.5*			0.33 21.5 9.8	17	23	54*			
1% Phenylmercuric Oleate 74% Creosote 10% Coal Tar	0.20 15.1 2.0	34	70.5*			0.29 21.1 2.9	7.5	18	66*			
5% Phenylmercuric Oleate 10% Coal Tar	1.20 2.38	30***	62	T	M	1.15 2.29	15	19.5	20.5	VL	H	VL
5% Phenylmercuric Oleate 30% Coal Tar	1.11 6.63	33	70.5*			1.16 7.26	17***	16.5	29	T	H	L
5% Phenylmercuric Oleate 50% Creosote	1.97 19.7	29	73*			1.74 17.4	17.5	15.5	36	H	M	T
5% Phenylmercuric Oleate (solid) in Creosote	1.76 33.2	N	15.5*			1.56 29.5	**	**	15*			
	1.76 33.3	N	12.5*									
5% Phenylmercuric Oleate (solid) in Creosote in Douglas fir	0.89 16.9	**	12.5*									
5% Phenylmercuric Oleate (solid) in 70-30 Creosote - Coal Tar Solution	1.00 19.0	N	15.5*			0.79 14.9	7	**	15*			
5% Phenylmercuric Oleate 10% Creosote 10% Coal Tar	1.14 2.26 2.26	40	70.5*			1.27 2.52 2.52	18	21	36	T	M	VL

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
5% Phenylmercuric Oleate 10% Creosote 30% Coal Tar	1.57 3.13 9.39	34.5	70.5*			1.84 3.67 10.55		20	28	0	H	0
5% Phenylmercuric Oleate 50% Creosote 10% Coal Tar	1.93 19.3 3.86	41	70.5*			1.65 16.5 3.27	19	22.5	39.5	M	L	0
5% Phenylmercuric Oleate 50% Creosote 30% Coal Tar	1.53 15.3 9.23	38.5	70.5*			1.69 16.9 10.1	27	22.5	51	VH	M	0
5% Phenylmercuric Oleate 51.2% Creosote 30% Coal Tar	1.79 18.4 10.2	36	70.5*			1.60 16.4 9.58	19	21.5	46.5	H	VL	0
5% Phenylmercuric Oleate 71% Creosote 10% Coal Tar	1.75 24.8 3.50	38	70.5*			2.03 28.8 4.05	25.5	15.5	58	VH	L	0
6% Phenylmercuric Oleate in Creosote	2.19 39.6	31	73*			2.48 41.4	**	24	66*			
1% Solubilized Tributyltin Oxide 50% Coal Tar	0.33 16.3	11	54*			0.31 15.4	6.5	12***	21	VH	L	0
1% Toxaphene 50% Creosote	0.29 14.5	4	26*			0.30 14.8	2.5	**	25*			
1% Toxaphene 50% Creosote in Douglas fir	0.25 12.4	**	26*			0.26 12.6	2	13	25*			

Table V. Combination Treatments Containing Creosote, Coal Tar, or Creosote - Coal Tar (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Toxaphene in Creosote	0.30 29.3	9.5	26*			0.34 33.6	7	**	25*			
1% Toxaphene in Creosote in Douglas fir	0.24 23.6	9	26*			0.25 23.8	2	**	25*			
5% Toxaphene 50% Creosote	1.62 16.2	**	26*			1.50 15.0	5	18.5	25*			
5% Toxaphene 50% Creosote in Douglas fir	1.42 14.2	**	26*			1.40 14.0	7	19	25*			
5% Toxaphene in Creosote	1.50 28.4	**	26*			1.64 30.9	4	**	25*			
5% Toxaphene in Creosote in Douglas fir	1.19 22.5	4	26*			1.07 20.1	4.5	15.5	25*			
0.5% Tributyltin Oxide 50% Coal Tar	0.15 14.6	12	49.5*									
1% Tributyltin Oxide 50% Coal Tar	0.27 13.5	12.5	49.5*			0.31 15.8	6		31	VH	0	0
1% Tributyltin Oxide 50% Creosote	0.33 16.6	**	42*			0.30 14.6	11.5	**	42*			
5% Zinc Salt of Naphthenic Acid 50% Creosote	1.63 16.3	6.5	29	H	0	1.49 14.9	6.5	7	19	H	L	0

Table VI. Other Combination Treatments

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% p-Aminophenylmercuric Acetate + 2% Malachite Green Oxalate (double treatment)	0.39 0.76	**	26*			0.39 0.77	**	**	25*			
1% p-Aminophenylmercuric Acetate + 1% Tributyltin Coconut Fatty Acid Salt (double treatment)	0.39 0.27	N	26*			0.39 0.27	12.5	**	25*			
5% Biphenyl 2% Malachite Green Oxalate	1.66 0.66	4	42*			1.75 0.70	3	7.5	13	VH	L	0
5% Chlordan 2% Malachite Green Oxalate	1.87 0.72	**	36*			1.73 0.69	**	16	33*			
2% Copper Acetate 1% Malachite Green Oxalate	0.75 0.38	**	48*			0.75 0.38	10.5	11.5	15	H	L	0
2% Copper Acetate 1% Malachite Green Oxalate in Douglas fir	1.00 0.51	**	45.5*			1.14 0.57	18***	12	18	L	M	0
2% Copper Epoxy 1% Malachite Green Oxalate	0.67 0.34	12	21	M	H	0.66 0.33		5	9	0	M	T
3% Copper Naphthenate 50% Linseed Oil	0.61 10.1	N	48*			0.66 11.0	34	28	44*			
3% Copper Naphthenate 50% Linseed Oil in Douglas fir	0.35 5.9	**	48*			0.21 3.5	23	22	33	M	M	0

Table VI. Other Combination Treatments (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
3% Copper Naphthenate 1% Tributyltin Coconut Fatty Acid Salt	0.69 0.23	N	26*			0.75 0.25	N	N	25*			
3% Copper Naphthenate 5% Tributyltin Coconut Fatty Acid Salt	0.82 1.35	**	26*			0.84 1.40	N	N	25*			
5% Copper Sulfate 3.2% PVM/MA	1.43 0.92	**	49.5*									
10% Copper Sulfate 3.2% PVM/MA	3.72 1.22	42	49.5*									
50% Solubilized Copper Oxinate 1% Tributyltin Coconut Fatty Acid Salt	12.5 0.25	N	28.5*			10.6 0.22	N	N	25*			
50% Solubilized Copper Oxinate 5% Tributyltin Coconut Fatty Acid Salt	13.0 1.30	**	28.5*			13.2 1.32	N	N	25*			
14.73% Copper Sulfate 20.06% Sodium mono H Arsenate (double treatment) (FPL)	3.23 3.01	N	36*			3.23 3.01	**	**	33*			
5% Cuprammine Sulfate 3.2% PVM/MA	1.83 1.17	**	49.5*									
1% Dieldrin 1% Malachite Green Oxalate	0.30 0.30	**	42*			0.32 0.32		4.5	9	0	H	0
						0.33 0.33		4	12.5	0	H	T***

Table VI. Other Combination Treatments (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Dieldrin	0.30					0.25						
1% Tributyltin Coconut Fatty Acid Salt	0.30	**	28.5*			0.25	6.5	N	25*			
5% Dieldrin	1.44					1.32						
5% Tributyltin Coconut Fatty Acid Salt	1.44	**	28.5*			1.32	**	N	25*			
1% p-Dimethylaminophenylmercuric Acetate	0.39					0.40						
1% Tributyltin Coconut Fatty Acid Salt (double treatment)	0.27	**	26*			0.28	15	N	25*			
1% p-Dimethylaminophenylmercuric Acetate	0.38					0.40						
2% Malachite Green Oxalate (double treatment)	0.75	**	26*			0.79	19	15	25*			
5% Diphenylmethane	1.60					1.66						
2% Malachite Green Oxalate	0.64	3	42*			0.67	4	7	12	VH	L	0
1% Endrin	0.36					0.32						
1% Malachite Green Oxalate	0.36	**	42*			0.32		4.5	10.5	0	M	0
2% Malachite Green Oxalate	0.74					0.78						
5% Dieldrin (double treatment)	1.43	N	42*			1.52		7	19	0	H	0
2% Malachite Green Oxalate	0.73					0.75						
5% Endrin (double treatment)	1.44	N	42*			1.44	N	10	42*			
2% Malachite Green Oxalate	0.84					0.86						
1% Toxaphene (double treatment)	0.31	**	15.5*			0.29	**	6	15*			

Table VI. Other Combination Treatments (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
2% Malachite Green Oxalate 5% Toxaphene (double treatment)	0.79 1.45	**	15.5*			0.57 1.24	**	9	15*			
14.86% Nickel Sulfate 20.06% Sodium mono H Arsenate (double treatment) (FPL)	3.71 3.43	28***	31	T	M	3.71 3.43	11.5***	11	15	T	H	VL
14% Phenylmercuric Oleate 50% Linseed Oil	3.99 14.3	**	48*			3.87 13.7	20	18	34.5	H	M	0
14% Phenylmercuric Oleate 50% Linseed Oil in Douglas fir	1.80 6.5	**	48*			2.38 8.5	17	12	29	L	L	L
1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt	0.26 0.26	**	26*			0.28 0.28	7	N	25*			
1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt in Douglas fir	0.18 0.18	6	26*			0.26 0.26	5	N	25*			
1% Toxaphene 1% Tributyltin Oxide	0.27 0.27	N	26*			0.25 0.25	9.5	N	25*			
1% Toxaphene 1% Tributyltin Oxide in Douglas fir	0.27 0.27	**	26*			0.22 0.22	**	N	25*			
1% Toxaphene 5% Tributyltin Oxide	0.31 1.54	N	12.5*									

Table VI. Other Combination Treatments (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
1% Toxaphene 10% Tributyltin Oxide	0.29 2.81	**	12.5*									
5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt	1.40 1.40	N	26*			1.41 1.41	**	N	25*			
5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt in Douglas fir	1.29 1.29	**	26*			1.29 1.29	7	N	25*			
5% Toxaphene 1% Tributyltin Oxide	1.51 0.30	**	12.5*									
5% Toxaphene 5% Tributyltin Oxide	1.34 1.34	N	26*			1.39 1.39	**	N	25*			
	1.59 1.59	N	12.5*									
5% Toxaphene 5% Tributyltin Oxide in Douglas fir	1.35 1.35	**	26*			1.36 1.36	**	N	25*			
5% Toxaphene 10% Tributyltin Oxide	1.67 3.29	N	12.5*									
1% Tributyltin Coconut Fatty Acid Salt 1% Phenylmercuric Oleate	0.29 0.29	**	12.5*									
1% Tributyltin Coconut Fatty Acid Salt 5% Phenylmercuric Oleate	0.26 1.32	**	12.5*									

Table VI. Other Combination Treatments (Cont'd)

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
5% Tributyltin Coconut Fatty Acid Salt 1% Phenylmercuric Oleate	1.43 0.28	**	12.5*									
5% Tributyltin Coconut Fatty Acid Salt 5% Phenylmercuric Oleate	1.52 1.52	N	12.5*									
10% Tributyltin Coconut Fatty Acid Salt 1% Phenylmercuric Oleate	3.20 0.32	**	12.5*									
10% Tributyltin Coconut Fatty Acid Salt 5% Phenylmercuric Oleate	2.95 1.48	**	12.5*									
1% Tributyltin Oxide 20-24% Ammonium Sulfide (double treatment)	0.28†	**	36*			0.27†	5	**	33*			
1% Tributyltin Oxide 3% Copper Naphthenate	0.27 0.82	N	12.5*									
5% Tributyltin Oxide 3% Copper Naphthenate	1.59 0.96	N	12.5*									
10% Tributyltin Oxide 3% Copper Naphthenate	2.89 0.84	N	12.5*									

Table VII. Untreated Panels and Solvent-Extracted Untreated Panels

Treatment	Port Hueneme					Pearl Harbor					
	Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Lim. Attack	Total Exposure Time, Mos.	Damage When Removed From Test		Wt. Solute Absorbed, lb/cu ft	Mos. to Init. Attack		Total Exposure Time, Mos.	Damage When Removed From Test	
				Lim.	Ter.		Lim.	Mart.		Lim.	Mart.	Ter.
Afambeau		N	45.5*					8	22	0	H	0
Antidesma Pulvinatum		N	36*									
Greenheart		N	63*									
		N	45.5*					5	13	0	H	0
		**	42*									
Greenheart, acetic acid extracted		**	63*									
Greenheart, chloroform extracted		**	63*									
Greenheart, ether extracted			56	0	H							
Greenheart, methanol extracted		N	63*									
Lignum Vitae		N	63*					11	12	0	M	M

Appendix

SUMMARY OF PANELS NOT ATTACKED BY ONE OR MORE SPECIES OF MARINE BORERS

Treated panels and naturally resistant wood panels which have not been attacked by one or more species of marine borers either during their entire period of exposure or as of 15 August 1962 are shown in Figures 1 to 5 and listed in Table VIII. The numbers plotted on the figures refer to the treatments listed in Table VIII.

For those panels which sustained no attack by one or two species of marine borers during their entire harbor exposure, reference to the proper table (I through VII) will show that removal was necessary because of attack by other species of marine borers.

Table VIII. Panels Not Attacked by One or More Species of Marine Borers

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
1	100% Creosote (1/8" panel)						15		15
2	100% Creosote						17		17
3	100% Creosote						20		20
4	100% Creosote			56					
5	70-30 Creosote - Coal Tar						22.5		22.5
6	70-30 Creosote - Coal Tar		54				22		22
7	5% Copper Acetate		48						
8	5% Copper Acetate + ht. tr. in Douglas fir		48						
9	1% Copper Naphthenate		36						
10	6% Copper Naphthenate		65.5			63		63	
11	6% Copper Naphthenate		36			33		33	
12	6% Copper Naphthenate in Douglas fir		45.5						
13	1% Copper Sulfate in Redwood				11				11
14	1% Copper Sulfate in Western Red Cedar				9.5				9.5

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
15	2% Copper Sulfate + ht. tr. in Douglas fir		42						
16	10% Copper Sulfate in Redwood		64.5		17				17
17	10% Copper Sulfate in Western Red Cedar		64.5		11.5				
18	10% Solubilized Copper Oxinate				18				
19	5% Cuprammine Sulfate		49.5						
20	5% Cuprammine Sulfate in Douglas fir					44			
21	5% Cuprammine Sulfate + ht. tr. in Douglas fir				29				
22	5% Mercuric Acetate + ht. tr.				13.5				
23	1% Tributyltin Coconut Fatty Acid Salt		56					33	
24	1% Tributyltin Oxide		49.5					42	
25	1% Tributyltin Oxide							37.5	
26	1% Ether Soluble Alkaloids of Greenheart Sawdust						5		
27	2% Ether Soluble Alkaloids of Greenheart Sawdust						6		

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No *Limnoria* Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No *Limnoria* Attack Total Exposure Time		No *Martesia* Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
28	1% Aluminum Oxinate in Creosote (1/8" panel)								20
29	2% Copper Naphthenate 50% Coal Tar			37					17
30	3% Copper Naphthenate 50% 70–30 Creosote – Coal Tar in Douglas fir		45.5						
31	1% Copper Oxinate in Creosote (1/8" panel)								34
32	2.5% Copper Oxinate in Creosote (1/8" panel)								17
33	5% Copper Oxinate in Creosote (1/8" panel)			635					15
34	3% Solubilized Copper Oxinate 50% Creosote		42						
35	6% Copper Sulfate 100% Creosote (double treatment)		15.5						
36	12% Copper Sulfate 100% Creosote (double treatment)		15.5						
37	14.73% Copper Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (triple treatment) (FPL)		36			33		33	

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No *Limnoria* Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No *Limnoria* Attack Total Exposure Time		No *Martesia* Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
38	5.3% Copper Salt of Naphthenic Acid 50% Creosote								26
39	1% Dieldrin 50% Creosote				32				32
40	1% Dieldrin 50% 70-30 Creosote - Coal Tar in Douglas fir				34				
41	5% Dieldrin 50% Creosote				34				34
42	5% Dieldrin 50% Creosote				28				28
43	10% Diphenylmethane 50% Creosote							42	
44	1% Endrin in Creosote in Douglas fir					44			
45	1% Endrin 50% 70-30 Creosote - Coal Tar in Douglas fir					44			
46	5% Endrin 50% Creosote				25				25
47	5% Endrin 50% Creosote					37.5			
48	5% Endrin 50% 70-30 Creosote - Coal Tar					42			

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
49	2% Malachite Green Oxalate 10% Creosote (double treatment)								11
50	2% Malachite Green Oxalate 25% Creosote (double treatment)								12
51	5% Manganous Oxinate in Creosote (1/8" panel)								18S
52	14.86% Nickel Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (triple treatment) (FPL)				31				31
53	1% Phenylmercuric Oleate in Creosote								11
54	1% Phenylmercuric Oleate (solid) in Creosote		15.5						
55	1% Phenylmercuric Oleate 10% Creosote 30% Coal Tar			56.5					15
56	1% Phenylmercuric Oleate 50% Creosote 10% Coal Tar								20
57	1% Phenylmercuric Oleate 50% Creosote 30% Coal Tar								25

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
58	5% Phenylmercuric Oleate (solid) in Creosote		15.5						
59	5% Phenylmercuric Oleate (solid) in Creosote		12.5						
60	5% Phenylmercuric Oleate (solid) in 70-30 Creosote - Coal Tar Solution		15.5						
61	5% Phenylmercuric Oleate 10% Creosote 30% Coal Tar				28				28
62	5% Phenylmercuric Oleate 50% Creosote 10% Coal Tar								39.5
63	5% Phenylmercuric Oleate 50% Creosote 30% Coal Tar								51
64	5% Phenylmercuric Oleate 51.2% Creosote 30% Coal Tar								46.5
65	5% Phenylmercuric Oleate 71% Creosote 10% Coal Tar								58
66	1% Solubilized Tributyltin Oxide 50% Coal Tar								21

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
67	1% Tributyltin Oxide 50% Coal Tar						31		31
68	5% Zinc Salt of Naphthenic Acid 50% Creosote								19
69	1% p-Aminophenylmercuric Acetate + 1% Tributyltin Coconut Fatty Acid Salt (double treatment)		26						
70	5% Biphenyl 2% Malachite Green Oxalate								13
71	2% Copper Acetate 1% Malachite Green Oxalate								15
72	2% Copper Acetate 1% Malachite Green Oxalate in Douglas fir								18
73	2% Copper Epoxy 1% Malachite Green Oxalate				9				
74	3% Copper Naphthenate 50% Linseed Oil		48						
75	3% Copper Naphthenate 50% Linseed Oil in Douglas fir								33
76	3% Copper Naphthenate 1% Tributyltin Coconut Fatty Acid Salt		26			25		25	

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No *Limnoria* Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No *Limnoria* Attack Total Exposure Time		No *Martesia* Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
77	3% Copper Naphthenate 5% Tributyltin Coconut Fatty Acid Salt					25		25	
78	50% Solubilized Copper Oxinate 1% Tributyltin Coconut Fatty Acid Salt		28.5			25		25	
79	50% Solubilized Copper Oxinate 5% Tributyltin Coconut Fatty Acid Salt					25		25	
80	14.73% Copper Sulfate 20.06% Sodium mono 'H Arsenate (double treatment)(FPL)		36						
81	1% Dieldrin 1% Malachite Green Oxalate				9				9
82	1% Dieldrin 1% Malachite Green Oxalate				12.5				
83	1% Dieldrin 1% Tributyltin Coconut Fatty Acid Salt							25	
84	5% Dieldrin 5% Tributyltin Coconut Fatty Acid Salt							25	

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
85	1% p-Dimethylaminophenylmercuric Acetate 1% Tributyltin Coconut Fatty Acid Salt (double treatment)							25	
86	5% Diphenylmethane 2% Malachite Green Oxalate								12
87	1% Endrin 1% Malachite Green Oxalate				10.5				10.5
88	2% Malachite Green Oxalate 5% Dieldrin (double treatment)		42		19				19
89	2% Malachite Green Oxalate 5% Endrin (double treatment)		42			42			
90	14% Phenylmercuric Oleate 50% Linseed Oil								34.5
91	1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt							25	
92	1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt in Douglas fir							25	
93	1% Toxaphene 1% Tributyltin Oxide		26					25	

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
94	1% Toxaphene 1% Tributyltin Oxide in Douglas fir							25	
95	1% Toxaphene 5% Tributyltin Oxide		12.5						
96	5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt		26				25		
97	5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt in Douglas fir							25	
98	5% Toxaphene 5% Tributyltin Oxide		26					25	
99	5% Toxaphene 5% Tributyltin Oxide		12.5						
100	5% Toxaphene 5% Tributyltin Oxide in Douglas fir							25	
101	5% Toxaphene 10% Tributyltin Oxide		12.5						
102	5% Tributyltin Coconut Fatty Acid Salt 5% Phenylmercuric Oleate		12.5						

Table VIII. Panels Not Attacked by One or More Species of Marine Borers (Cont'd)

No.	Treatment	Port Hueneme			Pearl Harbor				
		No Limnoria Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed	No Limnoria Attack Total Exposure Time		No Martesia Attack Total Exposure Time		No Teredine Attack Total Exposure Time When Removed
		When Removed	15 August 1962		When Removed	15 August 1962	When Removed	15 August 1962	
103	1% Tributyltin Oxide 3% Copper Naphthenate		12.5						
104	5% Tributyltin Oxide 3% Copper Naphthenate		12.5						
105	10% Tributyltin Oxide		12.5						
106	10% Tributyltin Oxide 3% Copper Naphthenate		12.5						
107	Afambeau		45.5		22				22
108	Antidesma Pulvinatum		36						
109	Greenheart		63		13				13
110	Greenheart		45.5						
111	Greenheart, ether extracted				56				
112	Greenheart, methanol extracted		63						
113	Lignum Vitae		63		12				

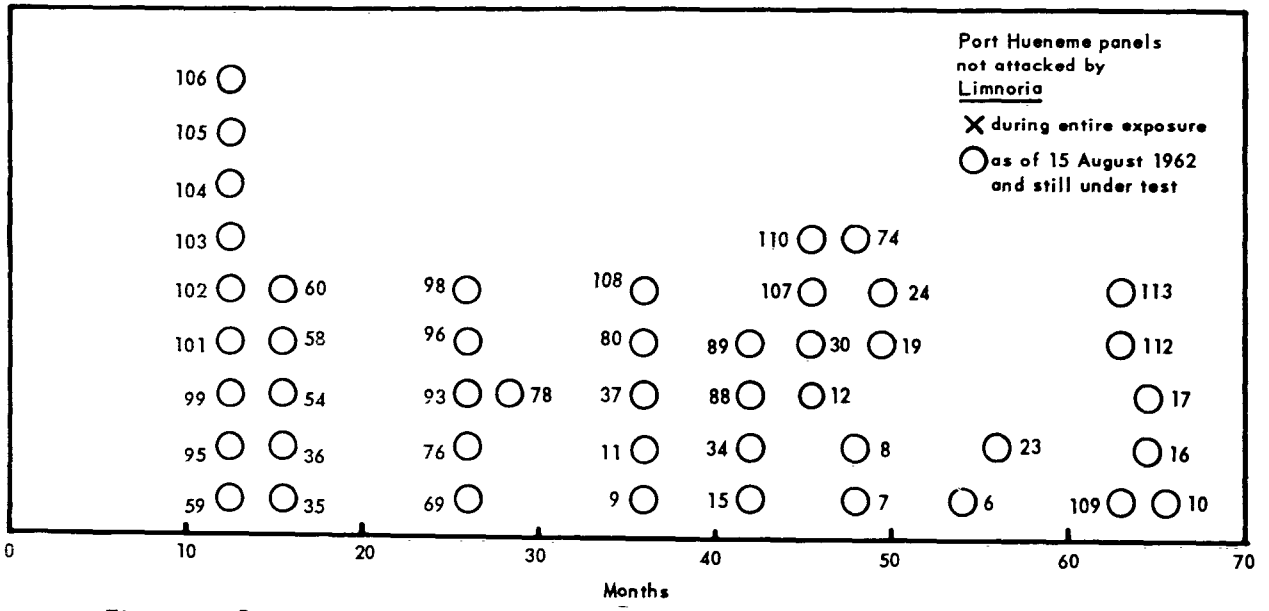

Figure 1. Port Hueneme panels not attacked by Limnoria during entire exposure or as of 15 August 1962.

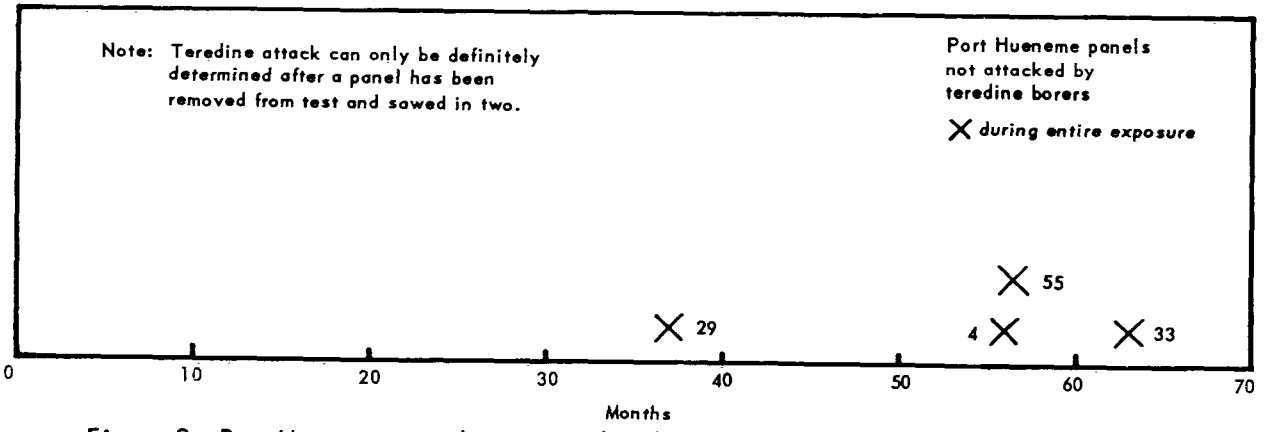

Figure 2. Port Hueneme panels not attacked by teredine borers during entire exposure

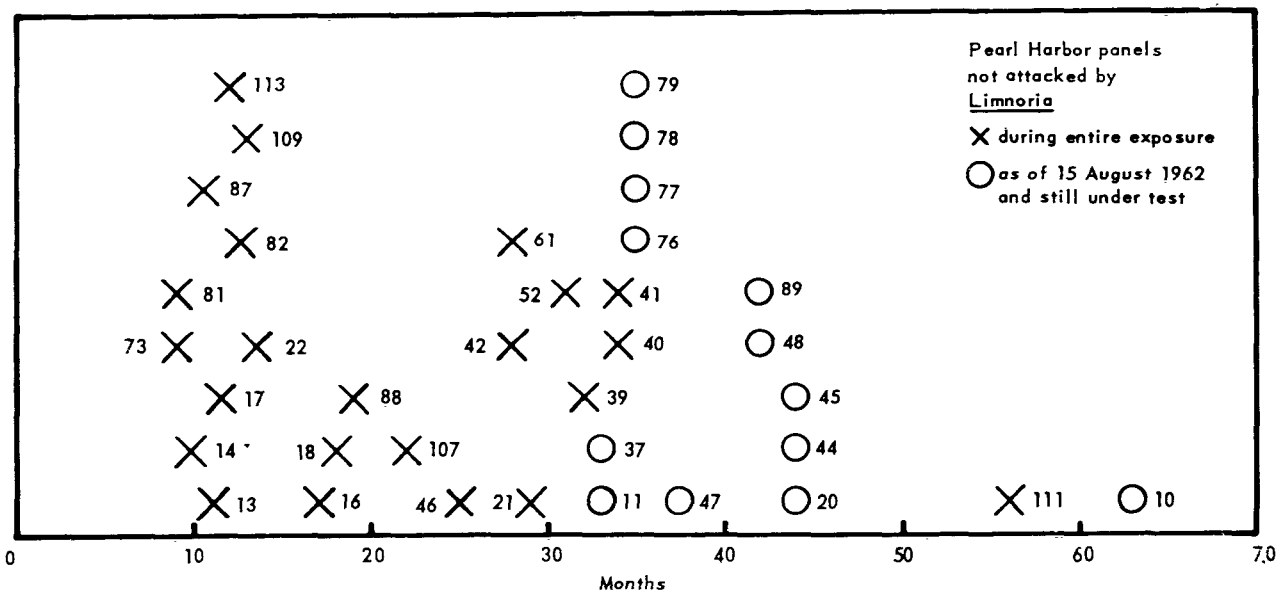

Figure 3. Pearl Harbor panels not attacked by Limnoria during entire exposure or as of 15 August 1962.

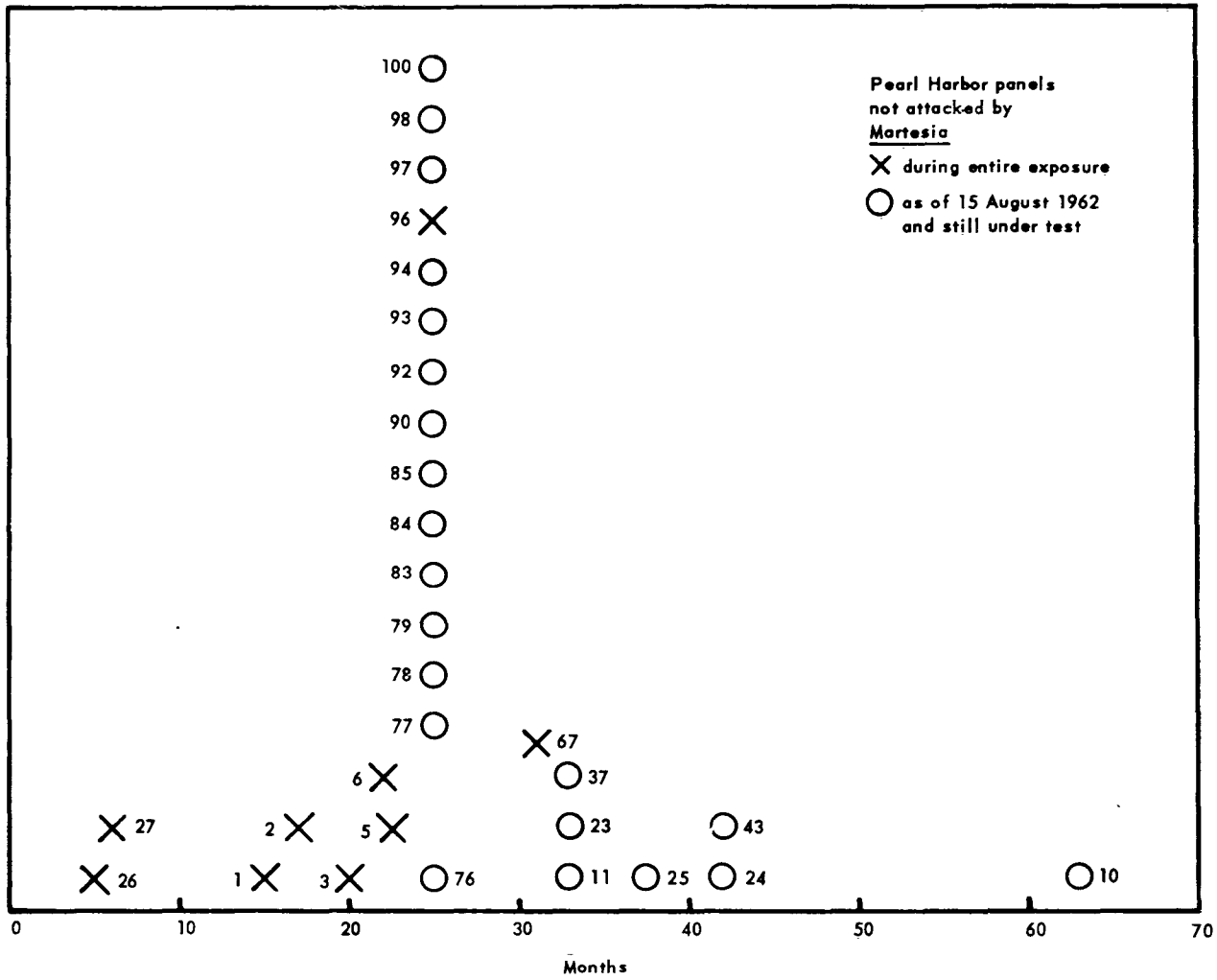

Figure 4. Pearl Harbor panels not attacked by Martesia during entire exposure or as of 15 August 1962.

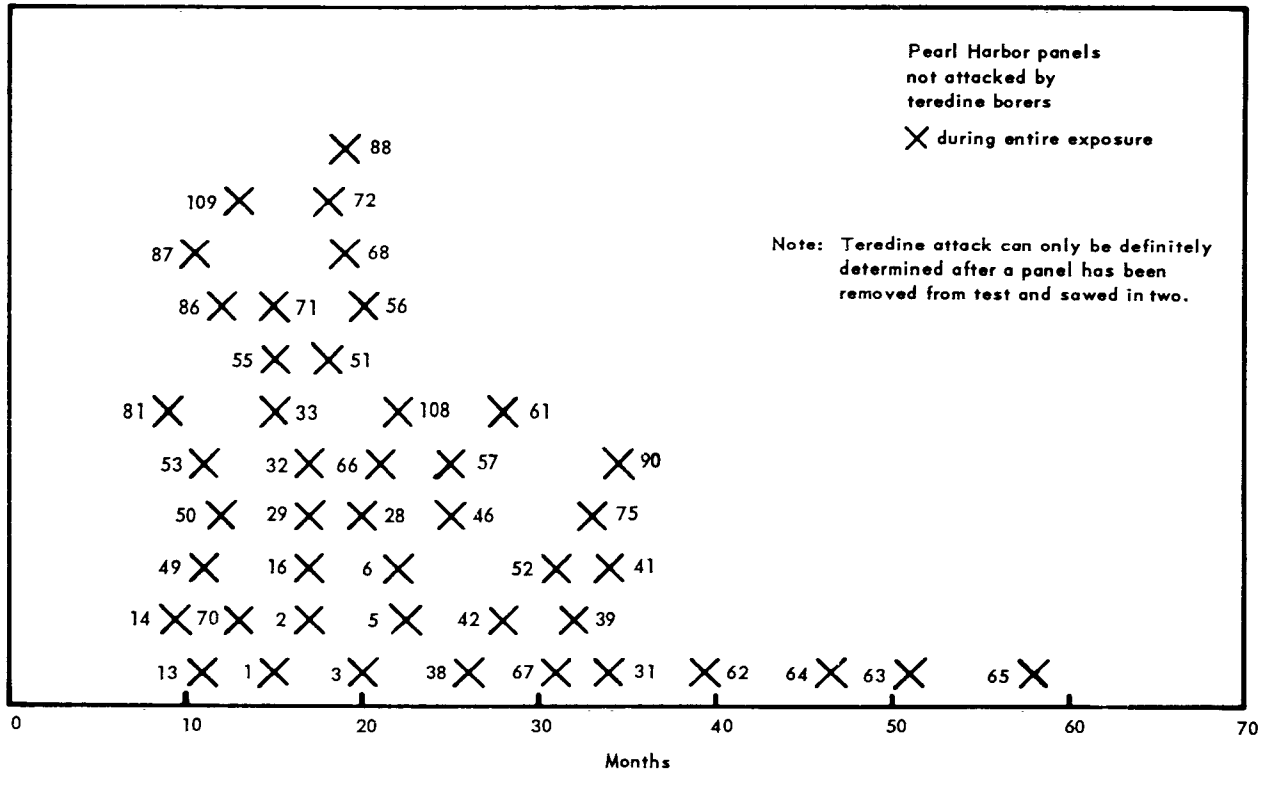

Figure 5. Pearl Harbor panels not attacked by teredine borers during entire exposure.

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