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Port Hueneme, California

HARBOR SCREENING TESTS OF MARINE BORER INHIBITORS - IV

Y-R005-07-007

Type C

by

H. Hochman, Ph.D., T. Roe, Jr.

OBJECT OF TASK

To develop improved methods of timber treatment aimed at preventing marine borer attack.

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 1960 and 15 August 1961. It also lists all treated panels which have been exposed for one year or more and which have shown no attack or very slight amounts of 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, 70-30 creosote - coal tar solution, and tributyltin compounds are effective against Martesia and teredine attack but not Limnoria attack. Copper salts, chelates, and complexes, mercury salts, and toxaphene are effective against Limnoria attack at Port Hueneme and Pearl Harbor but are ineffective against teredine and Martesia attack. 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, especially toward Limnoria. These additives are p-aminophenylmercuric acetate, biphenyl, chlordan, copper naphthenate, copper oxinate, copper sulfate, copper arsenate, solubilized copper oxinate, dieldrin, endrin, nickel arsenate, phenyl ether, phenylmercuric chloride, phenylmercuric

oleate, and toxaphene. Aluminum oxinate, tributyltin oxide, 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.

The tropical woods antidesma pulvinatum and greenheart 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 of borers during their entire period of exposure or as of 15 August 1961 are summarized.

Stock available at OTS: $1.50.

FOREWORD

This is the tenth in a series of reports[1-9] on studies conducted by the Laboratory to develop more effective methods and materials than those presently available for preservation of wooden structures exposed to the attack of marine boring organisms.

It is the fourth 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] 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 develop improved methods of timber treatment aimed at preventing marine 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] 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 higher 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 which has been 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 1960 and 15 August 1961, and with all panels which have been exposed for at least one year and which were still under test on 15 August 1961.

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. From data obtained to date, 70-30 creosote - coal tar solution and creosote appear to be equal in preservative ability.

2. Inorganic Compounds (Table II): In general, copper salts, chelates, and complexes prevent Limnoria attack for considerable periods at Port Hueneme; at Pearl Harbor they are not effective chiefly because of 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 are also effective against Limnoria, but they are not equal to copper compounds in this effectiveness.

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. Conversely, tributyltin compounds are ineffective against Limnoria but quite effective against Martesia and teredine borers.

4. Organic Compounds (Table IV): Dibenzofuran is fairly effective and toxaphene very effective in preventing Limnoria attack, but neither material is effective against teredine borers. Malachite green oxalate in redwood has prevented attack by teredine borers for long periods at Port Hueneme, but failed after short exposure at Pearl Harbor because of Martesia attack.[9]

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 materials added to coal tar, creosote, or creosote - coal tar solutions are performing well in decreasing Limnoria attack. These additives are p-aminophenylmercuric acetate, biphenyl, chlordan, copper naphthenate, copper oxinate, copper sulfate, copper arsenate, solubilized copper oxinate, dieldrin, endrin, nickel arsenate, phenyl ether, phenylmercuric chloride, phenylmercuric oleate, and toxaphene. Limnoria attack has occurred at an early date in several instances, but the rate of progress of the attack was slower than in those panels which did not contain the additive.

Panels treated with coal tar containing copper naphthenate (1 and 2%) or phenylmercuric oleate (5%) are much more resistant to borers than those treated with coal tar only. They are not, however, as resistant to borer activity as those treated with creosote, creosote solutions, or creosote - coal tar solutions containing one of the additives mentioned above.

Aluminum oxinate (1, 2.5, or 5%) tributyltin oxide (0.5 or 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, 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.

Those combination treatments which show promise 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 (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) endrin (1%) and malachite green oxalate (1%)

(k) malachite green oxalate (2%) and dieldrin (5%)

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

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

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

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

(a) copper naphthenate (3%) and linseed oil (50%) [equal parts of copper naphthenate solution (containing 6% Cu) and linseed oil]

(b) phenylmercuric oleate (14%) and linseed oil (50%) (equal parts of 28% phenylmercuric oleate solution and linseed oil)

(c) tributyltin oxide (1%) and ammonium sulfide (20-24%) (double treatment)

Sodium silicate-hydrochloric acid treated panels do resist borer attack but are very brittle and easily damaged.

7. Untreated Panels and Solvent-Extracted Untreated Panels (Table VII): The tropical woods antidesma pulvinatum and greenheart are performing well after extended periods at Port Hueneme. Greenheart panels which have been extracted with acetic acid, chloroform, ether, 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. 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.[10]

DISCUSSION

According to data obtained so far, the most promising treatments are those which are 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% creosote showed initial Limnoria attack in an average of five months, and panels treated with 50% creosote containing 10% biphenyl were attacked in 5-1/2 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 30 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 a preservative with greater effectiveness in preventing Limnoria attack. 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 form a complex with some of the creosote constituents in some manner 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.

A number of preservative systems 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 combinations show promise as useful preservative systems. 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 prediction 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, cuprammonium compounds, and copper chelates are 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 attack; tributyltin compounds, against Martesia and teredine attack.

4. Dibenzofuran and toxaphene should be investigated further because of their ability to prevent Limnoria attack.

5. The addition of one of the following materials to creosote or creosote - coal tar solutions improves their resistance to Limnoria attack: p-aminophenylmercuric acetate, biphenyl, chlordan, copper naphthenate, copper oxinate, copper sulfate, copper arsenate, solubilized copper oxinate, dieldrin, endrin, nickel arsenate, phenyl ether, phenylmercuric chloride, phenylmercuric oleate, and toxaphene.

6. Combination treatments of a copper compound plus a precipitating agent, a copper compound plus a tributyltin compound, an insecticide plus malachite green oxalate, an insecticide plus a tributyltin compound, or a phenylmercury compound plus a tributyltin compound show promise as preservatives.

7. Afambeau, greenheart, and lignum vitae are subject only to Martesia and teredine attack. Antidesma pulvinatum has not been attacked by 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 mixed with compounds such as malachite green oxalate.

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

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 projected NCEL treatment plant.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Messrs. Francis A. Dunwell and Joseph R. Moses of the District Public Works Office, Fourteenth Naval District, Pearl Harbor, for their invaluable assistance and cooperation in making possible the exposure of test panels at Pearl Harbor.

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9. NCEL. Technical Report 147, Harbor Screening Tests of Marine Borer Inhibitors - III, by H. Hochman and T. Roe, Jr., 16 May 1961.

10. Bernice P. Bishop Museum. Bulletin 217, Resistance of Woods to Marine Borers in Hawaiian Waters, by C. H. Edmondson, Honolulu, Hawaii, 1955, p. 23-4.

SYMBOLS USED IN TABLES

*	This panel series, or part thereof, was still under test as of 15 August 1961.
**	One or more panels in this series had been attacked by this species as of 15 August 1961.
***	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 1961.
NC	Not checked.
S	Panel split during cleaning operations.
X	Data not available as of 15 August 1961.
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 1. 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.
50% Creosote						18.4	5		18	VH	0	0
90% Creosote (1/8" panel)	35.2	27	37	M	0	35.5	14	20	20	M	T	0
100% Creosote (1/8" panel)	31.0	32.5	70.5*			34.3	7.5		15	H	0	0
100% Creosote	35.7	22	61*			40.8	9		17	M	0	0
	40.2	26	53.5*			35.7	10	18	51*			
	32.7	29	52.5*			42.4	5		20	H	0	0
	33.3	19.5	51*			35.8	4	N	13*			
	37.2	17.5	48.5*									
	29.9	16	44*									
	33.5	11	42*									
	39.1	2	24*									
	25.7	8	16.5*									
	23.3	**	14*									
100% Creosote (FPL)	45.8	**	24*			45.8	7.5	N	21*			
100% Creosote in Douglas fir	39.8	**	37.5*			41.5	7.5	**	32*			
	41.0	2.5	24*									
70-30 Creosote - Coal Tar	40.4	28	61*			38.4	10		22.5	M	0	0
	27.1	N	42*			32.6	5		22	VH	0	0
	19.7	12	36*			30.9	4	**	13*			
	23.1	7	30*									
	35.7	**	16.5*									
70-30 Creosote - Coal Tar in Douglas fir	38.5	18	37.5*			33.9	9	10.5	32*			
	41.4	4	24*									

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	**	36*									
1% Copper Acetate + ht. tr.	0.38	**	36*									
1% Copper Acetate in Douglas fir	0.21	**	36*									
1% Copper Acetate + ht. tr. in Douglas fir	0.30	**	36*									
2% Copper Acetate	0.75	**	36*									
2% Copper Acetate + ht. tr.	0.74	**	36*									
2% Copper Acetate in Douglas fir	0.71	**	36*									
2% Copper Acetate + ht. tr. in Douglas fir	0.67	**	36*									
5% Copper Acetate	1.86	N	36*									
5% Copper Acetate + ht. tr.	1.98	N	36*									
5% Copper Acetate in Douglas fir	1.14	N	35*									
5% Copper Acetate + ht. tr. in Douglas fir	1.36	N	36*									
2% Copper Epoxy	0.65	10***	14	T	H	0.66	6	5.5	8	T	L	L
1% Copper Formate + ht. tr. in Douglas fir	0.45	21***	35	T	M	0.47	7	10	12	L	L	M

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.
2% Copper Formate + ht. tr. in Douglas fir	0.95	N	37.5*			0.94	12	12	14	L	VL	L
1% Copper Naphthenate	0.29 0.28	43 N	53.5* 24*			0.26	24.5	26.5	27.5	L	L	L
1% Copper Naphthenate in Douglas fir	0.18	**	33.5*			0.16	**	15	32*			
3% Copper Naphthenate in Douglas fir	0.31	**	33.5*			0.45	N	N	32*			
6% Copper Naphthenate	1.18 1.31	N N	53.5* 24*			1.22 1.38	N N	N N	51* 21*			
6% Copper Naphthenate in Douglas fir	0.46	N	33.5*			0.32	**	**	32*			
1% Copper Sulfate in Redwood	0.35 0.37	** **	52.5* 16.5*			0.38		9	11	0	H	0
1% Copper Sulfate in Western Red Cedar	0.34	**	52.5*			0.46		6	9.5	0	H	0
2% Copper Sulfate	0.75	26***	22	T	H							
2% Copper Sulfate + ht. tr.	0.75		24.5	0	H							
2% Copper Sulfate in Douglas fir	0.55	N	30*									
2% Copper Sulfate + ht. tr. in Douglas fir	0.71	**	30*									

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.
5% Copper Sulfate	1.84	20.5	32	T	H							
5% Copper Sulfate in Douglas fir	1.54	N	35*									
5% Copper Sulfate - ht. tr. in Douglas fir	1.75	**	35*									
10% Copper Sulfate	3.89		32.5	0	M							
10% Copper Sulfate - ht. tr.	3.95	**	36*									
10% Copper Sulfate in Douglas fir	3.19	N	35*									
10% Copper Sulfate - ht. tr. in Douglas fir	3.51	**	35*									
10% Copper Sulfate in Redwood	3.55	N	52.5*			3.32		17	17	0	L	0
10% Copper Sulfate in Western Red Cedar	2.52	**	52.5*			3.88		9	11.5	0	M	VL
10% Solubilized Copper Oxinate	3.22	38	52.5*			3.18		14.5	18	0	H	T
25% Solubilized Copper Oxinate	7.3	**	52.5*			8.1	22***	21	30.5	VL	M	VL
50% Solubilized Copper Oxinate	15.5	**	52.5*			14.9	N	**	51*			
5% Cuprammine Sulfate	1.33	N	37.5*			1.38	20	21***	23	H	VL	M
5% Cuprammine Sulfate - ht. tr.	1.85	**	36*			1.89	15	**	32*			
5% Cuprammine Sulfate in Douglas fir	2.45	29	37.5*			2.33	N	**	32*			

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.
5% Cuprammine Sulfate + ht. tr. in Douglas fir	1.59	**	35*			1.47	N	22.5	32*			
5% Cupric Ethylenediamine Sulfate + ht. tr.	2.01	**	36*			1.91	9	11	12	VL	VL	H
5% Cupric Ethylenediamine Sulfate in Douglas fir	1.23	**	35*			1.44	17***	16	24	VL	VL	VL***
5% Cupric Ethylenediamine Sulfate + ht. tr. in Douglas fir	1.69	**	33.5*			1.85	17***	12	20	VL	M	T***
7% Cupric p-Phenylenediamine Sulfate	2.79	7	9.5	VL	H	2.72	5***	5	7	T	L	M
7% Cupric p-Phenylenediamine Sulfate + ht. tr.	2.71	7***	7	T	H	2.62	7.5***	5	7.5	T	L	VH
7% Cupric p-Phenylenediamine Sulfate in Douglas fir	2.48	11***	12	T	VH	2.60	8***	6	9	T	L	H
7% Cupric p-Phenylenediamine Sulfate + ht. tr. in Douglas fir	2.07	14***	12	T	VH	2.12	5***	6	7	T	L	L
5% Mercuric Acetate	2.03	35	42*			2.06	**	**	21*			
5% Mercuric Acetate + ht. tr.	2.10	34	42*			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.
0.5% p-Aminophenylmercuric Acetate	0.19		26	0	H	0.21	14	12.5	14.5	T	M	VH
1% p-Aminophenylmercuric Acetate	0.39 0.41	19*** **	42* 16.5*			0.37	11***	8.5	13	T	L	H
1% p-Dimethylaminophenylmercuric Acetate in Douglas fir	0.35	--	35*			0.35	30***	14	27	T	H	VL***
1% Tributyltin Coconut Fatty Acid Salt	0.27	N	44*			0.27	4	N	21*			
0.5% Tributyltin Oxide	0.13	**	37.5*									
1% Tributyltin Oxide	0.27	N	37.5*			0.25 0.26	10 5	N N	30* 25.5*			

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.
10% Dibenzofuran	2.76	3***	17	VL	H							
1% Malachite Green Oxalate in Redwood	0.42	22	56	H	T	0.41	3***	NC	10	VL	M	0
1% Toxaphene	0.26	N	23	0	VH							

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	70.5*			0.34 33.7	6	9	20	M	T	0
2.5% Aluminum Oxinate in Creosote (1/8" panel)	0.77 29.9	22.5	59	H	0	0.73 27.7	5.5	11	17	VH	VL	0
5% Aluminum Oxinate in Creosote (1/8" panel)	1.47 28.3	27	41.5	H	0	1.67 31.8	6	8.5***	14.5	H	VL	0
0.9% p-Aminophenylmercuric Acetate + 100% Creosote (dbl. treatment)	0.28 28.5	N	14*			0.26 23.7	**	N	13*			
10% Biphenyl 50% Creosote	3.0 15.6	11	30*			3.1 15.7	5.5	12.5	30*			
						3.1 15.5	**	**	25.5*			
5% Chlordan 50% Creosote	1.51 15.1	6	24*			1.53 15.3	5	14	21*			
5% Chlordan 50% 70-30 Creosote - Coal Tar	1.52 15.2	3	24*			1.59 15.9	**	15	21*			
10% Chlordan 50% Creosote	2.45 12.2	10.5	24*			3.02 14.5	**	**	21*			
10% Chlordan 50% 70-30 Creosote - Coal Tar	3.49 17.5	6	24*			3.07 15.5	**	12	21*			
0.5% Copper Naphthenate 50% Coal Tar	0.15 15.2	22.5	42*			0.14 13.6	9	9	20	M	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.
1% Copper Naphthenate 50% Coal Tar	0.28 14.1	--	42*			0.26 12.9	18	NC	39	VH	M	T
2% Copper Naphthenate 50% Coal Tar	0.60 15.0	16	36*			0.59 14.9	10	5.5	17	M	M	0
3% Copper Naphthenate 50% Creosote in Douglas fir	0.41 8.6	**	33.5*			0.64 10.7	N	**	32*			
3% Copper Naphthenate 50% 70-30 Creosote – Coal Tar in Douglas fir	0.56 9.3	N	33.5*			0.43 7.1	**	21	32*			
1% Copper Oxinate in Creosote (1/8" panel)	0.34 33.1	39	70.5*			0.35 35.0	10	8	32*			
2.5% Copper Oxinate in Creosote (1/8" panel)	0.58 22.2	35	70.5*			0.72 27.3	6	7	17	L	L	0
5% Copper Oxinate in Creosote (1/8" panel)	1.58 30.0 1.30 24.4	36 32	70.5* 62*			1.45 27.5	6	6	15	M	L	0
6% Copper Sulfate 100% Creosote (dbl. treatment)						2.0 34.6	N	N	13*			
12% Copper Sulfate 100% Creosote (dbl. treatment)						5.1 34.5	N	N	13*			
14.73% Copper Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (trp. treatment) (FPL)	3.23 3.01 38.7	N	24*			3.23 3.01 38.7	N	N	21*			

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.
5.3% Copper Salt of Naphthenic Acid 50% Creosote	1.64 15.5	7	37.5*			1.53 15.1	9	10.5	32*			
3% Solubilized Copper Oxinate 50% Creosote	0.50 8.2	N	30*			0.59 9.9 0.46 7.7	22 **	N **	panel lost 25.5*			
1% Dieldrin 50% Creosote	0.29 14.8	12.5	33.5*			0.29 14.2	**	8	32*			
1% Dieldrin 50% Creosote in Douglas fir	0.22 10.9	**	33.5*			0.24 11.8	**	9	32*			
1% Dieldrin in Creosote	0.35 33.2	**	33.5*			0.34 33.2	**	**	32*			
1% Dieldrin in Creosote in Douglas fir	0.22 21.6	**	33.5*			0.22 22.0	**	10	32*			
1% Dieldrin 50% 70-30 Creosote - Coal Tar	0.30 15.1	19	33.5*			0.31 15.5	**	8	32*			
1% Dieldrin 50% 70-30 Creosote - Coal Tar in Douglas fir	0.25 12.8	**	33.5*			0.20 9.9	N	8	32*			
1% Dieldrin in 70-30 Creosote - Coal Tar	0.29 28.9	**	33.5*			0.32 31.5	**	**	32*			
1% Dieldrin in 70-30 Creosote - Coal Tar in Douglas fir	0.23 22.7	**	33.5*			0.25 24.7	**	**	32*			

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% Dieldrin 50% Creosote	1.53 15.3	**	30*			1.31 13.1	18	8	30*			
						0.84 8.4	8	6	25.5*			
5% Dieldrin 50% 70-30 Creosote - Coal Tar	1.50 15.0	14	30*			1.48 14.8	**	**	25.5*			
1% Dimethylaminophenylmercuric Acetate 100% Creosote (dbl. treatment)	0.38 29.3	N	14*			0.39 33.5	**	N	13*			
10% Diphenylmethane 50% Creosote	2.81 14.1	9	30*			3.07 15.4	6	**	30*			
1% Endrin 50% Creosote in Douglas fir	0.24 11.8	**	33.5*			0.27 13.4	**	11	32*			
1% Endrin in Creosote in Douglas fir	0.24 24.1	**	33.5*			0.26 26.0	N	9	32*			
1% Endrin 50% 70-30 Creosote - Coal Tar in Douglas fir	0.25 12.2	**	33.5*			0.25 12.4	N	11	32*			
1% Endrin in 70-30 Creosote - Coal Tar in Douglas fir	0.24 23.7	**	33.5*			0.23 23.2	**	11.5	32*			
5% Endrin 50% Creosote	1.41 14.1	**	30*			1.43 14.3	**	4	30*			
						1.38 13.8	N	6	25.5*			
5% Endrin 50% 70-30 Creosote - Coal Tar	1.67 16.7	14	30*			1.49 14.9	N	7	30*			

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.
2% Malachite Green Oxalate 10% Creosote (dbl. treatment)	0.79 2.87	7	16.5*									
2% Malachite Green Oxalate 25% Creosote (dbl. treatment)	0.77 7.28	6	16.5*									
2% Malachite Green Oxalate 50% Creosote (dbl. treatment)	0.78 15.5	5	16.5*									
2% Malachite Green Oxalate 100% Creosote (dbl. treatment)	0.76 33.8	**	16.5*									
2.5% Manganous Oxinate in Creosote (1/8" panel)	0.92 35.5	30	59	M	0	0.86 33.1	6	7	14	H	VL	0
5% Manganous Oxinate in Creosote (1/8" panel)	1.60 30.3	35	70.5*			1.87 34.8	11	11.5	18S	VL	VL	0
	1.86 37.0	36	64.5*									
14.86% Nickel Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (trp. treatment) (FPL)	3.71 3.43 20.7	N	24*			3.71 3.43 20.7	N	15	21*			
10% Phenyl Ether 50% Creosote	3.02 15.1	7	30*			2.91 14.6	7	10	30*			
1% Phenylmercuric Chloride in Creosote	0.26 26.2	28.5	61*			0.42 41.9	12.5	15.5	54*			
1% Phenylmercuric Chloride 50% 70-30 Creosote - Coal Tar in Douglas Fir	0.23 11.8	**	33.5*			0.23 11.4	**	7	25.5*			

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 70–30 Creosote – Coal Tar in Douglas fir	0.16 15.1	16	33.5*			0.19 20.9	**	**	32*			
1% Phenylmercuric Oleate 50% Creosote	0.34 17.0	26.5	43	VH	0	0.33 17.1	11.5	15***	23.5	VH	T	0
1% Phenylmercuric Oleate in Creosote	0.37 36.8	29.5	61*			0.37 37.3	6	NC	11	M	T	0
1% Phenylmercuric Oleate 10% Creosote 30% Coal Tar	0.36 3.6 10.7	29.5	58.5*			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	58.5*			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	58.5*			0.37 18.6 11.1	6	9***	25	VH	VL	0
1% Phenylmercuric Oleate 66% Creosote 30% Coal Tar	0.34 22.5 10.3	**	58.5*			0.33 21.5 9.8	17	23	54*			
1% Phenylmercuric Oleate 74% Creosote 10% Coal Tar	0.20 15.1 2.0	34	58.5*			0.29 21.1 2.9	7.5	18	54*			

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

Treatment	Port Huename					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% Coal Tar	1.20 2.38	30	58.5*			1.15 2.29	15	19.5	20.5	VL	H	VL***
5% Phenylmercuric Oleate 30% Coal Tar	1.11 6.63	33	58.5*			1.16 7.26	17***	16.5	29	T	H	L
5% Phenylmercuric Oleate 50% Creosote	1.97 19.7	29	61*			1.74 17.4	17.5	15.5	36	H	M	T***
5% Phenylmercuric Oleate 10% Creosote 10% Coal Tar	1.14 2.26 2.26	40	58.5*			1.27 2.52 2.52	18	21	36	T	M	VL
5% Phenylmercuric Oleate 10% Creosote 30% Coal Tar	1.57 3.13 9.39	34.5	58.5*			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	58.5*			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	58.5*			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	58.5*			1.60 16.4 9.58	19	21.5	54*			

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 71% Creosote 10% Coal Tar	1.75 24.8 3.50	38	58.5*			2.03 28.8 4.05	25.5	15.5	54*			
6% Phenylmercuric Oleate in Creosote	2.19 39.6	31	61*			2.48 41.4	**	24	54*			
1% Solubilized Tributyltin Oxide 50% Coal Tar	0.33 16.3	11	42*			0.31 15.4	6.5	12***	21	VH	L	0
1% Toxaphene 50% Creosote	0.29 14.5	4	14*			0.30 14.8	2.5	N	13*			
1% Toxaphene 50% Creosote in Douglas fir	0.25 12.4	**	14*			0.26 12.6	2	**	13*			
1% Toxaphene in Creosote	0.30 29.3	9.5	14*			0.34 33.6	7	N	13*			
1% Toxaphene in Creosote in Douglas fir	0.24 23.6	**	14*			0.25 23.8	2	N	13*			
5% Toxaphene 50% Creosote	1.62 16.2	**	14*			1.50 15.0	5	N	13*			
5% Toxaphene 50% Creosote in Douglas fir	1.42 14.2	**	14*			1.40 14.0	7	N	13*			
5% Toxaphene in Creosote	1.50 28.4	**	14*			1.64 30.9	4	N	13*			

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% Toxaphene in Creosote in Douglas fir	1.19 22.5	4	14*			1.07 20.1	4.5	**	13*			
0.5% Tributyltin Oxide 50% Coal Tar	0.15 14.6	12	37.5*									
1% Tributyltin Oxide 50% Coal Tar	0.27 13.5	12.5	37.5*			0.31 15.8	6		31	VH	0	0
1% Tributyltin Oxide 50% Creosote	0.33 16.6	**	30*			0.30 14.6	11.5	N	30*			
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 (dbl. tr.)	0.39 0.76	**	14*			0.39 0.77	N	N	13*			
1% p-Aminophenylmercuric Acetate 1% Tributyltin Coconut Fatty Acid Salt (dbl. treatment)	0.39 0.27	N	14*			0.39 0.27	**	N	13*			
5% Biphenyl 2% Malachite Green Oxalate	1.66 0.66	4	30*			1.75 0.70	3	7.5	13	VH	L	0
5% Chlordan 2% Malachite Green Oxalate	1.87 0.72	**	24*			1.73 0.69	**	**	21*			
2% Copper Acetate 1% Malachite Green Oxalate	0.75 0.38	**	36*			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	**	33.5*			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	36*			0.66 11.0	**	**	32*			
3% Copper Naphthenate 50% Linseed Oil in Douglas fir	0.35 5.9	**	36*			0.21 3.5	23	22	32*			
3% Copper Naphthenate 1% Tributyltin Coconut Fatty Acid Salt	0.69 0.23	N	14*			0.75 0.25	N	N	13*			

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 5% Tributyltin Coconut Fatty Acid Salt	0.82 1.35	**	14*			0.84 1.40	N	N	13*			
1% Copper Sulfate 2% Agar	0.14 0.27	13	13	H	H	0.13 0.26	6	8	9	L	M	H
5% Copper Sulfate 3.2% PVM/MA	1.43 0.92	**	37.5*									
10% Copper Sulfate 3.2% PVM/MA	3.70 1.22	**	37.5*									
50% Solubilized Copper Oxinate 1% Tributyltin Coconut Fatty Acid Salt	12.5 0.25	N	16.5*			10.6 0.22	N	N	13*			
50% Solubilized Copper Oxinate 5% Tributyltin Coconut Fatty Acid Salt	13.0 1.30	**	16.5*			13.2 1.32	N	N	13*			
14.73% Copper Sulfate 20.06% Sodium mono H Arsenate (dbl. treatment) (FPL)	3.23 3.01	N	24*			3.23 3.01	N	N	21*			
5% Cuprammine Sulfate 3.2% PVM/MA	1.83 1.17	N	37.5*									
1% Dieldrin 1% Malachite Green Oxalate	0.30 0.30	**	30*			0.32 0.32 0.33 0.33		4.5 4	9 12.5	0 0	H H	0 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 1% Tributyltin Coconut Fatty Acid Salt	0.30 0.30	**	16.5*			0.25 0.25	**	N	13*			
5% Dieldrin 5% Tributyltin Coconut Fatty Acid Salt	1.44 1.44	**	16.5*			1.32 1.32	**	N	13*			
1% p-Dimethylaminophenylmercuric Acetate 1% Tributyltin Coconut Fatty Acid Salt (dbl. treatment)	0.39 0.27	**	14*			0.40 0.28	**	N	13*			
1% p-Dimethylaminophenylmercuric Acetate 2% Malachite Green Oxalate (dbl. treatment)	0.38 0.75	**	14*			0.40 0.79	**	N	13*			
5% Diphenylmethane 2% Malachite Green Oxalate	1.60 0.64	3	30*			1.66 0.67	4	7	12	VH	L	0
1% Endrin 1% Malachite Green Oxalate	0.36 0.36	**	30*			0.32 0.32		4.5	10.5	0	M	0
2% Malachite Green Oxalate 5% Dieldrin (dbl. treatment)	0.74 1.43	N	30*			0.78 1.52	N	7	30*			
2% Malachite Green Oxalate 5% Endrin (dbl. treatment)	0.73 1.44	N	30*			0.75 1.44	N	10	30*			

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.
14.86% Nickel Sulfate 20.06% Sodium mono H Arsenate (dbl. treatment) (FPL)	3.71 3.43	**	24*			3.71 3.43	11.5***	11	15	T	H	VL
14% Phenylmercuric Oleate 50% Linseed Oil	3.99 14.3	**	36*			3.87 13.7	20	18	32*			
14% Phenylmercuric Oleate 50% Linseed Oil in Douglas fir	1.80 6.5	N	36*			2.38 8.5	17	12	29	L	L	L
10% Sodium Silicate 1.5 M Hydrochloric Acid (dbl. treatment - ht. tr.)						1.80 1.94		4	7	0	L	0
1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt	0.26 0.26	**	14*			0.28 0.28	7	N	13*			
1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt in Douglas Fir	0.18 0.18	6	14*			0.26 0.26	4	**	13*			
1% Toxaphene 1% Tributyltin Oxide	0.27 0.27	N	14*			0.25 0.25	**	N	13*			
1% Toxaphene 1% Tributyltin Oxide in Douglas fir	0.27 0.27	**	14*			0.22 0.22	N	N	13*			

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% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt	1.40 1.40	N	14*			1.41 1.41	**	N	13*			
5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt in Douglas fir	1.29 1.29	**	14*			1.29 1.29	7	N	13*			
5% Toxaphene 5% Tributyltin Oxide	1.34 1.34	N	14*			1.39 1.39	**	N	13*			
5% Toxaphene 5% Tributyltin Oxide in Douglas fir	1.35 1.35	**	14*			1.36 1.36	**	N	13*			
1% Tributyltin Oxide 20–24% Ammonium Sulfide (dbl. tr.)	0.28†	**	24*			0.27†	5	N	21*			

Table VII. Untreated Panels and Solvent-Extracted Untreated Panels

Wood	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	33.5					8	22	0	H	0
Antidesma Pulvinatum		N	24*									
Greenheart		N	51*					5	13	0	H	0
		N	33.5*									
		**	30*									
Greenheart, acetic acid extracted		**	51*									
Greenheart, chloroform extracted		**	51*									
Greenheart, ether extracted		23.5	51*									
Greenheart, methanol extracted		**	51*									
Lignum Vitae		N	51*					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 1961 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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
1	50% Creosote						18		18
2	90% Creosote			37					20
3	100% Creosote (1/8" panel)						15		15
4	100% Creosote						20		20
5	100% Creosote (FPL)							21	
6	70-30 Creosote - Coal Tar		42				22.5		22.5
7	5% Copper Acetate		36						
8	5% Copper Acetate + heat treatment		36						
9	5% Copper Acetate in Douglas fir		36						
10	5% Copper Acetate + heat treatment in Douglas fir		36						
11	2% Copper Formate + heat treatment in Douglas fir		37.5						
12	1% Copper Naphthenate		24						
13	3% Copper Naphthenate							32	32
14	6% Copper Naphthenate		53.5			51		51	

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
15	6% Copper Naphthenate in Douglas fir		33.5						
16	1% Copper Sulfate in redwood				11				11
17	1% Copper Sulfate in western red cedar				9.5				9.5
18	2% Copper Sulfate + ht. tr.	24.5							
19	2% Copper Sulfate in Douglas fir		30						
20	5% Copper Sulfate in Douglas fir		35						
21	10% Copper Sulfate	32.5							
22	10% Copper Sulfate in Douglas fir		35						
23	10% Copper Sulfate in redwood		52.5		17				17
24	10% Copper Sulfate in western red cedar				11.5				
25	10% Solubilized Copper Oxinate				18				
26	50% Solubilized Copper Oxinate					51			

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
27	5% Cuprammine Sulfate		37.5						
28	5% Cuprammine Sulfate in Douglas fir					32			
29	5% Cuprammine Sulfate + heat treatment in Douglas fir					32			
30	5% Mercuric Acetate + heat treatment				13.5				
31	0.5% p-Aminophenylmercuric Acetate	26							
32	1% Tributyltin Coconut Fatty Acid Salt		44					21	
33	1% Tributyltin Oxide		37.5					30	
34	1% Toxaphene	23							
35	1% Aluminum Oxinate in Creosote (1/8" panel)								20
36	2.5% Aluminum Oxinate in Creosote (1/8" panel)			59					17
37	5% Aluminum Oxinate in Creosote (1/8" panel)			41.5					14.5

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
38	0.9% p-Aminophenylmercuric Acetate 100% Creosote (double treatment)		14					13	
39	2% Copper Naphthenate 50% Coal Tar								17
40	3% Copper Naphthenate 50% Creosote in Douglas fir					32			
41	3% Copper Naphthenate 50% 70-30 Creosote – Coal Tar in Douglas fir		33.5						
42	2.5% Copper Oxinate in Creosote (1/8" panel)								17
43	5% Copper Oxinate in Creosote (1/8" panel)								15
44	6% Copper Sulfate 100% Creosote (double treatment)					13		13	
45	12% Copper Sulfate 100% Creosote (double treatment)					13		13	
46	14.73% Copper Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (triple treatment) (FPL)		24			21		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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
47	3% Solubilized Copper Oxinate 50% Creosote		30						
48	1% Dieldrin 50% 70–30 Creosote – Coal Tar in Douglas fir					32			
49	1% p-Dimethylaminophenylmercuric Acetate 100% Creosote (double treatment)		14					13	
50	1% Endrin in Creosote in Douglas fir					32			
51	1% Endrin 50% 70–30 Creosote – Coal Tar in Douglas fir					32			
52	5% Endrin 50% Creosote					25.5			
53	5% Endrin 50% 70–30 Creosote – Coal Tar					30			
54	2.5% Manganous Oxinate in Creosote (1/8" panel)			59					14
55	5% Manganous Oxinate in Creosote (1/8" panel)								18

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
56	14.86% Nickel Sulfate 20.06% Sodium mono H Arsenate 100% Creosote (triple treatment) (FPL)		24			21			
57	1% Phenylmercuric Oleate 50% Creosote			43					23.5
58	1% Phenylmercuric Oleate in Creosote								11
59	1% Phenylmercuric Oleate 10% Creosote 30% Coal Tar								15
60	1% Phenylmercuric Oleate 50% Creosote 10% Coal Tar								20
61	1% Phenylmercuric Oleate 50% Creosote 30% Coal Tar								25
62	5% Phenylmercuric Oleate 10% Creosote 30% Coal Tar				28				28
63	5% Phenylmercuric Oleate 50% Creosote 10% Coal Tar								39.5

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
64	5% Phenylmercuric Oleate 50% Creosote 30% Coal Tar								51
65	1% Solubilized Tributyltin Oxide 50% Coal Tar								21
66	1% Toxaphene 50% Creosote							13	
67	1% Toxaphene in Creosote							13	
68	1% Toxaphene in Creosote in Douglas fir							13	
69	5% Toxaphene 50% Creosote							13	
70	5% Toxaphene 50% Creosote in Douglas fir							13	
71	5% Toxaphene in Creosote							13	
72	1% Tributyltin Oxide 50% Coal Tar						31		31
73	1% Tributyltin Oxide 50% Creosote							30	

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
74	5% Zinc Salt of Naphthenic Acid 50% Creosote			29					19
75	1% p-Aminophenylmercuric Acetate 2% Malachite Green Oxalate (double treatment)					13		13	
76	1% p-Aminophenylmercuric Acetate 1% Tributyltin Coconut Fatty Acid Salt (double treatment)		14					13	
77	5% Biphenyl 2% Malachite Green Oxalate								13
78	2% Copper Acetate 1% Malachite Green Oxalate								15
79	2% Copper Acetate 1% Malachite Green Oxalate in Douglas fir								18
80	2% Copper Epoxy 1% Malachite Green Oxalate				9				
81	3% Copper Naphthenate 50% Linseed Oil		36						
82	3% Copper Naphthenate 1% Tributyltin Coconut Fatty Acid Salt		14			13		13	

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
83	3% Copper Naphthenate 5% Tributyltin Coconut Fatty Acid Salt					13		13	
84	50% Solubilized Copper Oxinate 1% Tributyltin Coconut Fatty Acid Salt		16.5			13		13	
85	50% Solubilized Copper Oxinate 5% Tributyltin Coconut Fatty Acid Salt					13		13	
86	14.73% Copper Sulfate 20.06% Sodium mono H Arsenate (double treatment) (FPL)		24			21		21	
87	5% Cuprammine Sulfate 3.2% PVM/MA		37.5						
88	1% Dieldrin 1% Malachite Green Oxalate				12.5				9
89	1% Dieldrin 1% Tributyltin Coconut Fatty Acid Salt							13	
90	5% Dieldrin 5% Tributyltin Coconut Fatty Acid Salt							13	

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
91	1% p-Dimethylaminophenylmercuric Acetate 1% Tributyltin Coconut Fatty Acid Salt							13	
92	1% p-Dimethylaminophenylmercuric Acetate 2% Malachite Green Oxalate (double treatment)							13	
93	5% Diphenylmethane 2% Malachite Green Oxalate								12
94	1% Endrin 1% Malachite Green Oxalate						10.5		10.5
95	2% Malachite Green Oxalate 5% Dieldrin (double treatment)		30			30			
96	2% Malachite Green Oxalate 5% Endrin (double treatment)		30			30			
97	14% Phenylmercuric Oleate 50% Linseed Oil in Douglas fir		36						
98	10% Sodium Silicate 1.5 M Hydrochloric Acid (double treatment + heat treatment)				7				7

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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
99	1% Toxaphene 1% Tributyltin Coconut Fatty Acid Salt							13	
100	1% Toxaphene 1% Tributyltin Oxide		14					13	
101	1% Toxaphene 1% Tributyltin Oxide in Douglas fir					13		13	
102	5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt		14					13	
103	5% Toxaphene 5% Tributyltin Coconut Fatty Acid Salt in Douglas fir							13	
104	5% Toxaphene 5% Tributyltin Oxide		14					13	
105	5% Toxaphene 5% Tributyltin Oxide in Douglas fir							13	
106	1% Tributyltin Oxide 20 - 24% Ammonium Sulfide (double treatment)							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 1961		When Removed	15 August 1961	When Removed	15 August 1961	
107	Afambeau		33.5		22				22
108	Antidesma Pulvinatum		24						
109	Greenheart		51		13				13
110	Lignum Vitae		51		12				

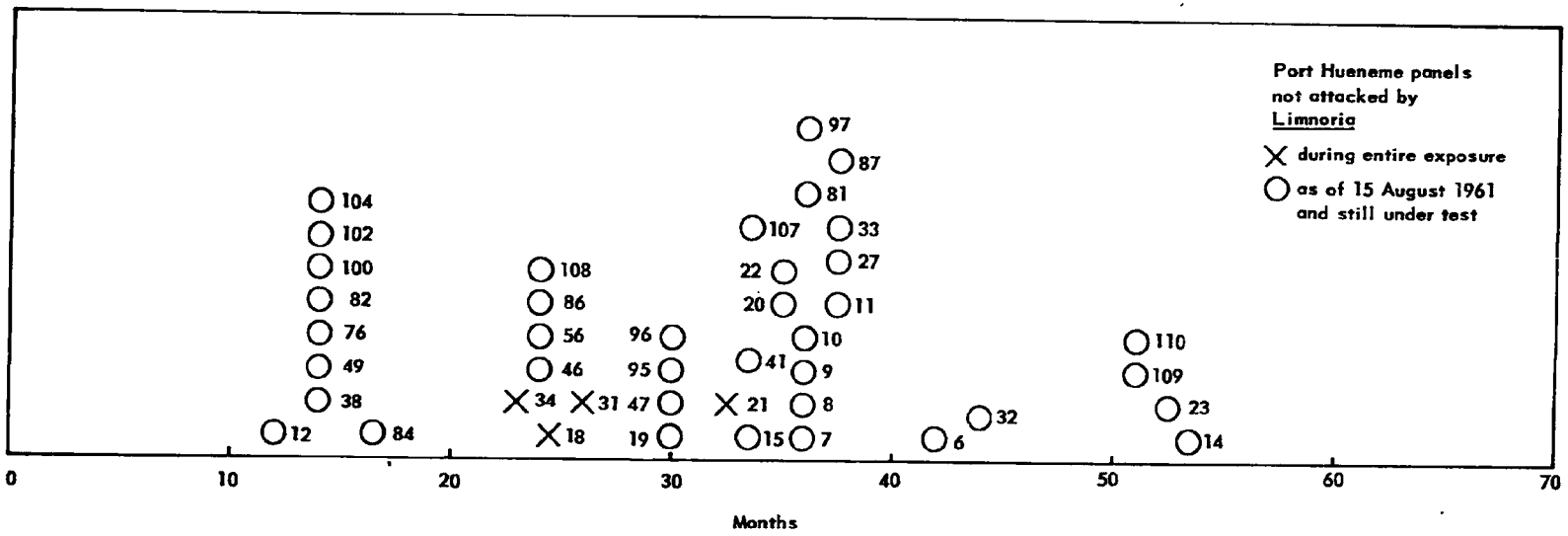

Figure 1. Port Hueneme panels not attacked by Limnoria during entire exposure or as of 15 August 1961.

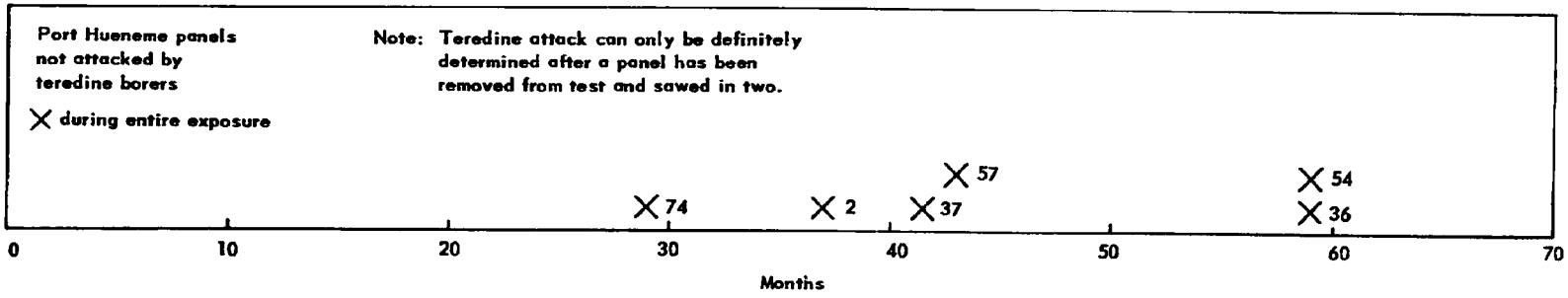

Figure 2. Port Hueneme panels not attacked by teredine borers during entire exposure.

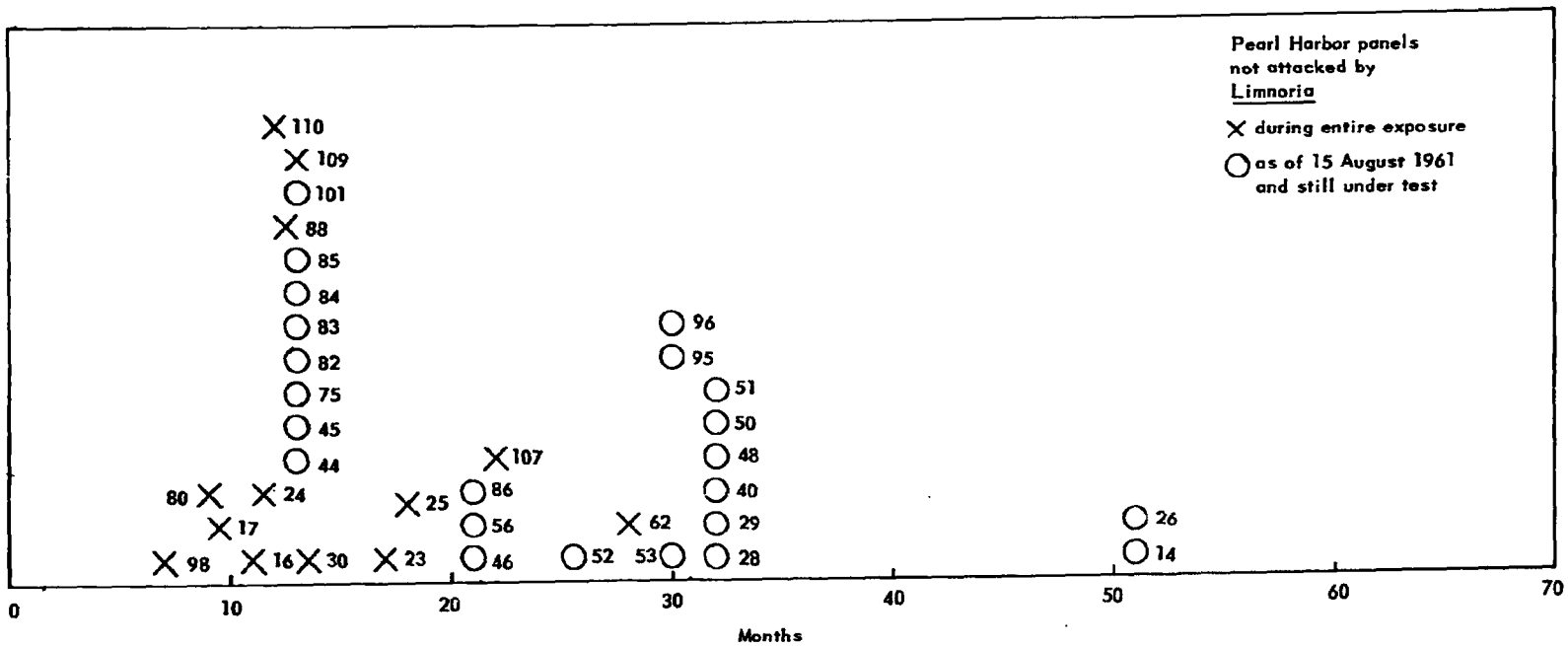

Figure 3. Pearl Harbor panels not attacked by Limnoria during entire exposure or as of 15 August 1961.

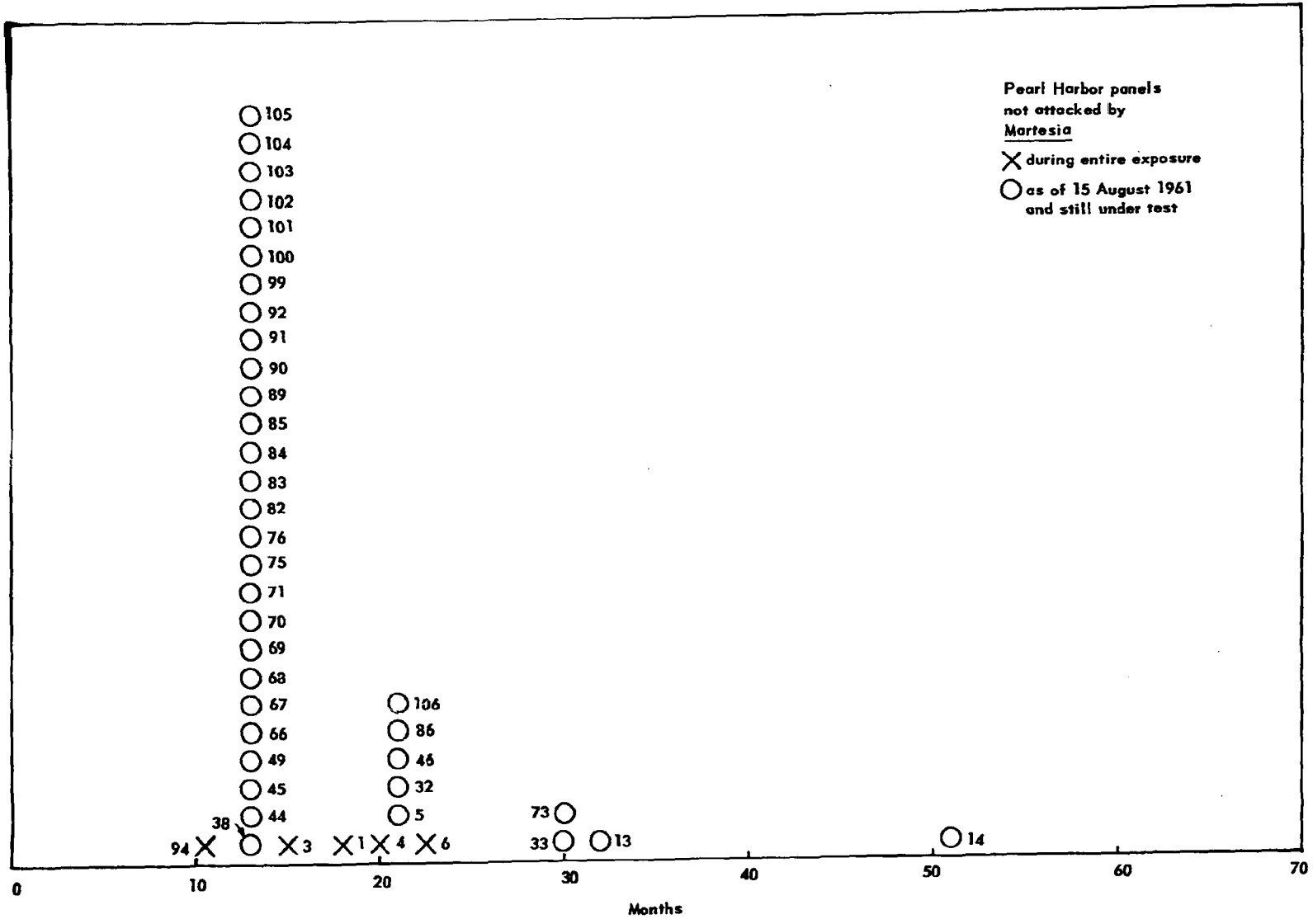

Figure 4. Pearl Harbor panels not attacked by Martesia during entire exposure or as of 15 August 1961.

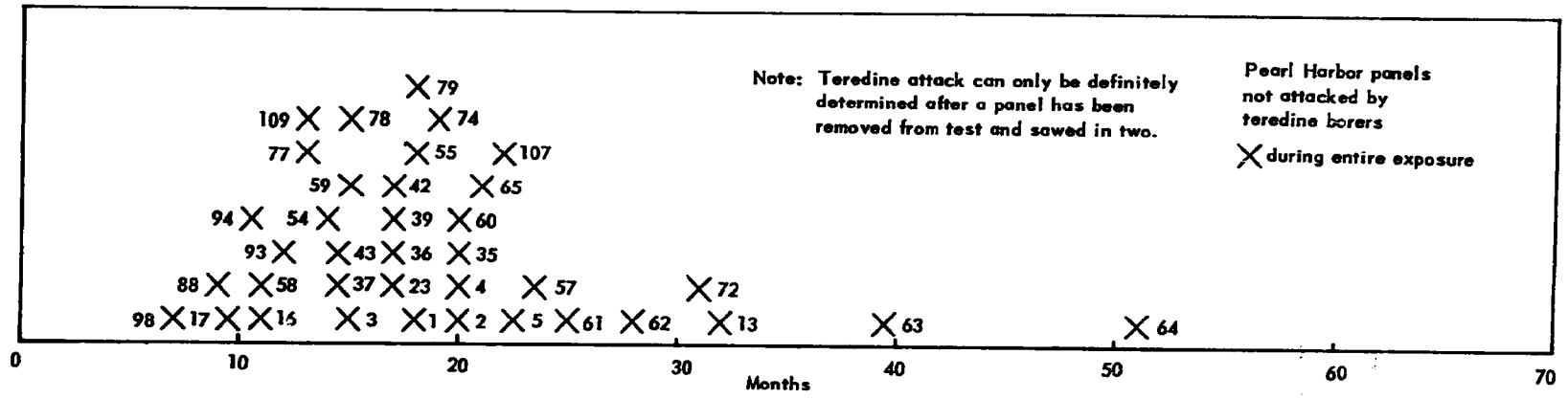

Figure 5. Pearl Harbor panels not attacked by teredine borers during entire exposure.

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