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Protections of wood against shipworms

by

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Report for 1935, 1936 + 1937

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Report for 1935-1937

Preliminary investigations of methods for protecting wood against shipworms (Teredo navalis) were commenced in 1935, reliance having been placed up to that time on copper paint. They were continued in 1936 and are summarised in a "Summary Report" for 1936. Preliminary results from the use of a mixture of tar, benzol and copper oleate and some consideration of the general problems are given in Note 54 of Progress Reports, Atlantic Biological Station - "A new protection for wood against shipworms". Further experiments and observations in 1937 were the subject of another summary report for 1937. This report reviews the work of the earlier years and the 1937 experiments and observations on the use of preservatives. The investigation of the setting period will be covered in a subsequent report.

The general problem. It has, of course, long been realized that in the warmer salt waters of our coast, including all the southern Gulf of St. Lawrence and the Bras d'Or Lakes, wood kept in the water must be protected against attack by shipworms. For a number of years the standard preservative for permanent structures such as wharves and bridges has been creosote applied under pressure, and for smaller objects such as boats copper paint applied annually. The two fields present separate problems. For permanent structures which cannot be removed for repainting a preservative is required which is as little subject as possible to removal by chafing and creosote applied under pressure appears to be effective and, because of its penetration, suitable in that respect. For lighter wooden equipment it is not so suitable because it is expensive, increases the weight of the wood a great deal and does not protect the surface from chafing as well as a hard surface coating which can be renewed. The ordinary copper paint is an effective preservative of the latter type as long as the coating is complete when the Teredo larvae are settling. It has been the standard preservative in this field for a number of years but its cost is too high for cheap equipment presenting large surfaces. Our investigations have had as their purpose the development of a cheaper preservative for this field which may include oyster culture equipment (such as rearing trays or floats for spat collection), boats, dories, lobster traps, etc.

The problem was broughtto the fore by the development of the use of floating trays for rearing small oysters and by its adoption by the industry from 1935 on. Using, when first constructed, a single coat of white paint and a coat of copper paint and repainting with copper paint each year, a 4' x 12' floating tray with wire-cloth bottom and wooden cover costs approximately $6.00 per year over a three-year period (including initial cost of $10.00) (Bulletin XLVIII, 1935). Of this almost 50% is the cost of the paint. These figures are, of course, only approximate as costs of lumber and labour vary considerably. They

serve to show the relative importance of paint costs and the saving which can be effected by cheaper substitutes. The mixture of tar, copper oleate and stove oil which has been found satisfactory for this purpose in 1937 costs only about 10% of the cost of white or copper paint.

1935 experiments with creosote. An attempt to find a cheaper substitute for copper paint was made in 1935. Creosote was tried applied both cold with a brush and by dipping in hot creosote. The details of the trials are not significant in view of the fact that it was entirely ineffective except in a single instance. When heating the creosote in a large metal container in the open it caught fire and one piece of spruce board, which was in the creosote at the time and remained there until it had cooled after the fire was extinguished, resisted shipworm attack completely. Other similar pieces, whether painted with a brush or immersed in boiling creosote even as long as twenty minutes, were honey-combed. It was concluded that creosote could not be used under ordinary conditions and that to obtain the necessary penetration special equipment was necessary, or else such lengthy or dangerous exposure as to be impracticable.

The ineffectiveness of creosote when applied cold with a brush has been confirmed in 1937, and this method does not seem to offer any solution of our difficulties. It is possible that long exposure to cold creosote might be effective and it is planned to make further experiments in this direction. But even if protection was provided in that way the equipment and time necessary for handling large quantities of wood seem likely to make the method too expensive.

Experiments in 1936. Further preliminary trials were made in 1936 in a number of directions.

(1) Creosoted lumber. Lumber, consisting of 2" x 4", ½" boards and 1" x 3", which had been treated with creosote under pressure was purchased in 1936 and used to construct rearing trays of the usual type. In this small lumber the creosote had penetrated throughout except where unusual resistance was offered by knots. The lumber was described as: "The above creosoted lumber to have basis treatment with net retention of 16# preservative per cubic foot of wood for use where material must be proof against shipworm attack. Material to be treated under pressure with A.R.E.A. Grade one Creosote to the net retention indicated, treatment to conform to the recognized standards and approved processes of the American Wood Preservers Association". The cost was $98.55 per M ft. board measure f.o.b. Ellerslie, but it is understood that this would be reduced if larger quantities were purchased than in this case (about 1000 bd.ft.).

The trays made of this lumber were exposed throughout the summer of 1936 and no shipworms were found in them. They have since been used throughout the summer of 1937 with no further treatment and no entrance by Teredo. In both these years untreated wood was completely honey-combed in less than a month following settlement of larvae. Creosote applied under pressure is, therefore, a very effective preservative. It has the advantage of being unaffected by

surface chafing and can be roughly handled without danger of spoiling the protection. Judging from colour alone there appears to have been some removal of the preservative from the surface layers and it remains to be seen how long the protection will last. The trays will be kept in use and under observation to test this. The oysters in the trays seemed to be unaffected by the creosote although the latter continued to be in evidence through production of an iridescent surface film even in the second year.

The use of creosoted lumber has some disadvantages. It is very heavy, necessitating the provision of other buoyancy for floating trays, and making equipment built with it more cumbersome. It is also very expensive. The expense per year would, of course, depend on the length of life and this remains yet to be determined. It is, however, worth noting that, as compared with the cheap lumber which can be used with the tar-copper oleate mixture described below, creosoted lumber means an additional cost of about $4.00 per 4' x 12' floating tray. On this basis an average life of at least five years would be needed to offset the expense and the lack of buoyancy. Experience may show, however, that for equipment to be used over a long period of years it is cheapest to use creosoted lumber. The experiment will, of course, be continued.

(2) Removal from the water at intervals. Preliminary experiments in 1936 indicated that if trays made of untreated spruce are removed for three days after each seven days in the water shipworms enter the wood but do not grow large enough to do serious damage. In that year the intensity of the Teredo "set" was high - often over 100 per square inch.

This result is, of course, only an approximate indication of the possibilities, and further experiments are planned in 1938 to give a more complete picture. These will include both study of the rate of growth of the young Teredo and closer attention to the lethal period of exposure to air under various conditions. In the latter connection it may be pointed out that it has been found that at temperatures averaging about 5½°C Teredo some inches in length may live over two months in boards in the air (test boards used in 1937). It is also pointed out that the size to which shipworms can grow without doing serious damage depends on their number and this will vary greatly.

While this method is suitable for protection of equipment such as dories which are normally exposed to water intermittently and while further investigations are planned, a number of considerations eliminate it for the present as a useful method of protecting equipment, such as rearing trays and floats, which is in constant use. 1/. It requires extra equipment to make interchange possible and this makes it more expensive than the use of a cheap preservative such as tar-copper oleate mixture. 2/. It involves much labour. 3/. Weather and other circumstances make regular removal from the water difficult and even two weeks in the water may be fatal. 4/. Although removal at short intervals greatly reduces the damage it does not eliminate it and this method means reduced life of the equipment. 5/. To prevent ordinary weathering and wear a surface coating is desirable and this can be made effective against shipworms.

(3) Tar-copper oleate mixture. A mixture of tar, benzol and copper oleate was developed and recommended as a net preservative some years ago by Harden F. Taylor and Arthur W. Wells of the United States Bureau of Fisheries (U.S.B.F.Doc.947 - "Properties and values of certain fish-net preservatives"). This was prepared in 1936 as a preservative for coffee bags which were then being tried as a substitute for wire cloth in the bottoms of rearing trays, and it was given a preliminary trial as a protection for wood against shipworms with very promising results.

The mixture was used as recommended by Taylor and Wells for nets except that a smaller proportion of benzol was used because the tar was apparently thinner than theirs. Our mixture was made by dissolving a pound of copper oleate in half a gallon of benzol and mixing the solution with a gallon of ordinary net tar.

Two newly-built floating trays, in which the lumber was rather green, were given a single coat of this mixture and placed in the water on July 9th - before the principal settling of Teredo larvae. The mixture was applied cold with a brush and covered as much surface as copper paint. The coat was given a relatively short time to dry and there is reason to believe, on the basis of subsequent experience, that the drying was imperfect. As a result by the end of the season the coating had disappeared in some patches. It is seen, therefore, that it was tried under unfavourable conditions.

In spite of the poor conditions under which it was tried the mixture gave about the same protection as copper paint - i.e. shipworms entered only in small spots which had been chafed. Control trays of untreated lumber were completely destroyed in less than a month.

The cost of the mixture in the form used was about 44 cents per gallon (copper oleate about 22 cents per pound, benzol about 45 cents per gallon and tar about 21 cents per gallon). The low cost and the good results under such poor conditions made it appear the most promising of all methods in view.

(4) Controls. As controls for the 1936 trials, small untreated trays were exposed throughout the season and most of the equipment in use was protected by copper paint. The untreated trays were attacked badly - over 100 Teredo per square inch entering the wood in many cases. They fell apart of their own weight in less than a month after the first large "set", the thin boards of the cover breaking up first. The copper-painted trays showed the usual results obtained in a year of severe shipworm attack. Complete protection was afforded by the copper paint where the coating remained intact but some shipworms entered where the coating was chafed off.

Experiments in 1937. Experiments in 1937 were designed to test further the effectiveness of the tar-copper oleate mixture and variations of it in comparison with other coatings. For this purpose test boards were exposed. In addition there were further large-scale trials with the Department's equipment and by various members of the industry. The mixture was also used on a small boat which was kept in the water throughout the summer.

A. Test boards. Test boards of planed spruce 18" x 6" x 1" were coated with various preservatives, suspended from the landing stage late in June and removed from the water early in November. They were suspended at the same depth and were covered at all tides. The details follow:

(1) Control. Two control boards of untreated planed spruce were placed in the water June 21st. They completely disintegrated in August. The "set" of Teredo larvae was very heavy in 1937, again exceeding 100 per square inch. The intensity and the dates at which it occurred will be shown by examination of test boards exposed for that purpose, results of which will be given in a later report. These boards were placed in the water in two series. One consisted of 15 boards placed in the water on June 17th and removed one at a time at weekly intervals thereafter. The other consisted of boards placed in the water one at a time twice a week and each left for a week. These provide an additional control. It is necessary here only to point out that there was a heavy Teredo attack in 1937 on boards within a few feet of those on which various preservatives were tested.

(2) White paint -two coats. Two boards, each with two coats of white paint, were placed in the water June 25th. When removed November 5th both were in good condition and bore no oyster spat or bryozoa. Chipping of the boards revealed no Teredo. The two coats of white paint (Moore's White Marine) gave complete protection.

(3) Copper paint - one coat. Two boards, each with only one coat of copper paint (Union Jack), were placed in the water June 21st. When removed November 5th they were in good condition and bore no spat or bryozoa. The surface was very clean. Chipping revealed no Teredo in the boards. Complete protection.

(4) White paint (one coat) and copper paint (one coat). Two boards each with one coat of white paint (Moore's Marine) and on it one coat of copper paint (Union Jack) were placed in the water June 21st. When removed on November 5th each had many spat on one side and on that side some of the copper paint had scaled off - possibly with spat. Some bryozoa were present. The boards were sound and chipping revealed no Teredo. Complete protection.

(5) Creosote painted on. Two boards on which creosote was painted with a brush were placed in the water on June 21st. One was lost. The other when taken in on November 5th was completely honeycombed. Examination of the surface revealed over 25 Teredo per sq.cm. had entered in some parts and only one or two per sq.cm. in others. Negligible protection.

(6) Creosoted lumber. Two pieces of the lumber creosoted under pressure, which was used in 1936 and is referred to above, were placed in the water on June 21st. One was lost and the other when removed on November 5th was in good condition. It had no spat or bryozoa. Chipping revealed no Teredo and showed that the creosote had penetrated throughout. Complete protection.

(7) Tar, copper oleate and benzol. Two boards painted with two coats of this mixture (benzol ½ gal., tar 1 gal., copper oleate 1 lb.) were placed in the water June 21st. When removed November 5th both

boards were sound. Both bore numerous spat, bryozoa and hydroids. Chipping revealed in one board a single Teredo about 10" long which had entered at a chafed edge. In the other it revealed several which had entered at a spot which examination with the microscope showed to have been left uncovered by the original coating, and three or four in each of two chafed spots on the edges. There was not enough damage to weaken the board perceptibly. Complete protection was shown where the coating remained and there was no serious damage.

(8) Tar, copper oleate and gasoline. Two boards painted with two coats of this mixture (gasoline ½ gal., tar 1 gal., copper oleate 1 lb.) were placed in the water June 25th. When removed on November 5th both boards were sound and bore some spat, bryozoa and hydroids. Chipping revealed no Teredo in one and in the other four which had entered along an edge at one corner where the coating had been knocked off. Complete protection except where coating obviously knocked off in one minute place.

(9) Tar, copper oleate and stove oil. Two boards each with two coats of this mixture (stove oil, similar to kerosene, ½ gal., tar 1 gal., copper oleate 1 lb.) were placed in the water June 30th. When removed on November 5th both boards were sound and bore some spat, bryozoa and hydroids. Chipping revealed a single Teredo in each which had in each case entered at a spot on an edge where the coat had been knocked off. Complete protection except where the coating was knocked off and negligible damage altogether.

(10) Tar and benzol only, two coats. Two boards each with two coats of a mixture of one part of benzol to two parts of tar, and without copper oleate, were placed in the water June 25th. Chipping revealed two Teredo in one which had entered at a small spot on one edge. In the other there had been some invasion destroying about ¼ of the board. The Teredo had entered along one 1" face (apparently through the coating) and a few at each of two corners (apparently through chafed spots). Partial protection and except for one edge of one board complete protection where the coating had persisted.

(11) Tar and benzol, one coat. Two boards each painted with one coat only of a mixture of one part of benzol with two parts of tar and with no copper oleate were placed in the water on June 22nd. When removed on November 5th both boards were still entire but badly honey-combed throughout. Teredo had entered on all parts of the surface and through the coating. The invasion did not exceed 10 per sq.cm. in any part examined with the microscope. Thus the invasion was much reduced but the protection insufficient to be of practical value. The boards bore some spat and bryozoa.

(12) Tar and gasoline, two coats. Two boards each painted with two coats of a mixture of one part of gasoline and two parts of tar with no copper oleate were placed in the water on June 22nd. When removed on November 5th one board was sound and the other seriously damaged. Chipping revealed two Teredo in the sound board which had apparently entered at one end. In the other chipping revealed that over half of the board was badly damaged, all the Teredo having apparently entered along one of the 1" faces. They had passed through the coating there which was continuous but thinner than elsewhere and it is suggested that in this case (as possibly in the bad board in 10) the second coat was missed along that face.

Boards testing single coats of the tar-copper oleate mixtures and testing double coats of tar and benzol with lower and higher proportions of copper oleate than above were all lost in severe storms. It is pointed out that the boards were hung sufficiently close together to be subject to some collision with one another and with the poles of the stage during these storms. This accounts for the damage to the coats along the corners where the danger of abrasion would be greatest and it is believed that in this respect the conditions were worse than usually occur in floats and trays anchoured separately.

In searching for shipworms in the boards which were not obviously honey-combed and which could not be broken up by hand, each board was chipped away gradually with a sharp hatchet and it is believed that this revealed all the shipworms.

Microscopic examination of the surfaces showed a good many cases in which Teredo larvae had settled and started to bore but had not finally succeeded. In these cases the depths of the depressions varied from barely enough to be perceptible to over half the diameter of the larvae (which are nearly spherical). In untreated boards removed during the summer a great many such empty depressions were found but it is believed that the majority were cases in which entrance into the board had been interrupted and the larvae washed off in the course of removal of the boards. Examination after final removal of the boards in the above series revealed a very small proportion of such unoccupied depressions - only a small fraction of one per cent of the occupied burrows. It seems, therefore, that the protective coverings are effective through prevention of any perceptible start of burrowing and that if the Teredo larvae can start they can succeed in establishing themselves in the vast majority of cases. Whether the deciding factor is purely physical or whether it is the reaction of larvae to chemicals, either before settlement or after slight and imperceptible burrowing, the observations do not indicate. This aspect of the problem requires further investigation.

B. Experience of the oyster industry in 1937. The effectiveness of copper paint when a continuous coating is maintained has been demonstrated by the experience of many years and we are interested here in the use of the mixture of tar and copper oleate.

After seeing the results of the preliminary trials in 1936 and having in mind the very great saving several oyster farmers used the mixture of tar and copper oleate in 1937 on floats for spat collection and on rearing trays. The following are representative examples on which definite information is available and a number of others used the mixture with similar results.

(1) Malpeque Oysters Limited. After discussions with the writer in which it was pointed out that the benzol apparently acted only as a solvent for the tar and copper oleate Mr. Jas. G. MacLean, manager for this company, decided to try in its place the much cheaper stove oil - a variety of kerosene. As it appeared to act satisfactorily as a solvent and produced a coating which dried and hardened well he used the mixture for all the company's equipment in 1937. He used one-half gallon of stove oil to each gallon of tar and somewhat more than a pound of copper oleate. Two coats were applied and care was

taken to have them dry thoroughly. This was used on 125 floating trays and on about 50 floats for spat collection of the type described in Bulletin XLVIII. All of this equipment was in the water throughout the settling period of Teredo larvae and for long enough thereafter to permit growth of the Teredo to a considerable size. In only one of the trays was damage by shipworms found and the damage to floats was negligible and limited to places (such as about the hoops of the puncheons) where the coating was not quite continuous. This is regarded as very good protection - better than the average obtained with copper paint.

(2) R. E. Ellis. Working for a group of oyster farmers who employed him on full time for spat collection and rearing, Mr. Ellis used the mixture for all their equipment in 1937. He used one-half gallon of benzol to each gallon of tar and pound of copper oleate. A number of puncheons used in floats for spat collection were painted with this mixture and unplaned lumber of which rearing trays were built was dipped once and then dried thoroughly. The single coat obtained by dipping was found quite satisfactory on over fifty trays, damage being immaterial and limited to minor places where the coating was chafed off. The coating gave good protection to the puncheons except where it was not continuous about the hoops. The mixture was considered fully as effective as copper paint.

(3) Harman and Beaton Bros. On three two-puncheon floats and on floating trays, a single coat of the mixture (benzol one-half gallon, tar one gallon and copper oleate one pound) was used. When the puncheon floats were put out near the Prince Edward Island Biological Station it was evident that the coating had been poorly applied and was thin and not entirely continuous. The puncheons were badly damaged.

(4) Department of Fisheries. The mixture in the form which had been tried on a small scale in 1936 with such promising results (benzol one-half gallon, tar one gallon and copper oleate one pound) was used on all the Department's equipment in 1937 except on a few trays which were copper-painted for comparison. On part of the equipment on which there remained a reasonably good coat of copper paint from earlier years only one coat was applied. On new equipment or equipment on which a good coat of copper paint had not persisted two coats were applied. The resulting protection was considered as good as that provided by copper paint. Damage was limited to such small items as slats on the bottoms of trays subject to abrasion when trays were pulled ashore for culling. Over 75 floating trays and over 50 puncheons with accompanying frames were used.

The use of the mixture of tar and copper oleate outlined above and other instances of its use by the industry show conclusively that when properly applied it gives as satisfactory protection as copper paint. It is also shown that, as indicated by the test boards, stove oil is as satisfactory a solvent as benzol. As it costs about 15 cents per gallon as compared with 45 cents it is obviously the solvent to be used in future.

The experience also shows that care must be taken to let the coating dry and harden thoroughly and that when applied with a brush two coats should be used for safety. The single coat produced by dipping rough lumber in the mixture is sufficient and a further saving results. The mixture is so cheap that it is not worth while to use planed lumber as is the case with copper or white paint.

C. Boat. A small flat-bottomed row-boat constructed of edge-nailed strips was used for a test of the mixture in 1937. All paint was removed with a blow-torch and a single coat of the mixture was applied early in the spring. The boat was kept in the water until removed at the beginning of July for a second coat of the mixture and it was then kept in the water for the rest of the season. The conditions simulated those on the ordinary motor boat.

The mixture used in this way gave complete protection to the small boat, and gives promise as a substitute for copper paint for boats. The boat was in actual use and aground as often as would be usual with motor boats, and was of such a shape that more surface would be subject to abrasion. As the mixture must be allowed to dry a boat must be kept out of water for several hours whereas copper paint can be returned to the water as soon as applied, but in dry summer weather the mixture will dry and harden in less than a day. It is not believed that more thorough drying before application is required for the mixture than for copper paint.

Conclusions and discussion.

(1) The experiments with test boards and the experience of the industry with hundreds of floating trays show conclusively that the mixture of tar and copper oleate with appropriate solvent gives satisfactory protection against shipworm attack when properly applied and allowed to dry and harden thoroughly. Two coats applied with a brush on planed surfaces or one coat obtained by dipping unplaned spruce are satisfactory but one coat applied with a brush on planed lumber is not quite safe . The latter might be satisfactory if sufficiently thick and carefully applied but the application of two coats both increases the thickness and gives additional assurance of the coating being continuous. A single coat applied with a brush on unplaned lumber was found satisfactory in 1936. It should be thick, continuous and well dried.

(2) Both the experiments with test boards and the experience of the industry show that stove oil (similar to kerosene) is as satisfactory as benzol as a solvent. It is believed that the function of either is to dissolve the copper oleate and thin the tar and that in the finished and dried coat it is not significant as a preservative. It may, however, affect the rapidity of drying and the consistency of the coat. This requires further experiment, as it may be of significance where rapid drying is desirable as is often the case with boats. The stove oil is much cheaper and less dangerous to handle than either benzol or gasoline, and for ordinary use is the obvious solvent for the future.

(3) The cost of the mixture made with benzol is about 44 cents per gallon and made with stove oil about 29 cents. The latter is less than one tenth of the usual cost of good marine paint or copper paint. As the mixture of tar and copper oleate appears to be as good a general preservative it is a satisfactory cheap substitute for copper paint which has hitherto been the standard protection against shipworm attack for small wooden equipment.

(4) Creosote is entirely ineffective applied with a brush and is ineffective when applied by dipping under the conditions tried.

(5) Creosote applied under pressure so as to penetrate throughout the wood is the most complete protection and if it remains so for a sufficiently long time may in the end be as cheap as the mixture of tar and copper oleate. The original cost is, however, very high and the wood so treated is heavy so that it just barely floats (spruce). There is apparently no adverse effect on oysters reared in trays built of creosoted lumber.

(6) The experiments with test boards confirm the general experience that copper paint gives complete protection when a continuous coat is maintained. It is, however, ten times as expensive as the mixture of tar and copper oleate and the use of the latter on rearing trays, for example, reduces the total expense over three years by about one half.

(7) The mixture of tar, copper oleate and benzol, gave satisfactory results in preliminary trials in 1937 on a small boat. While the protection equals that by copper paint the latter appears to be somewhat more effective against fouling and somewhat easier and less time-consuming to apply.

(8) The experiments with test boards show that ordinary white marine paint gives complete protection against shipworms and indicate that it is as effective as copper paint against fouling. It is, however, equally expensive and does not provide a cheap protection. It may be that the use of copper paint almost exclusively as a protection against shipworms has been encouraged by a misconception produced by the method of use. When copper paint is used a fresh coat is usually applied just before the season when Teredo settle, whereas when white paint is relied on the coat may often be some months old and, therefore, somewhat worn.

(9) Experiments with test boards were started to show the relative effectiveness of various concentrations of copper oleate, but the boards used for this were lost in storms. The results obtained with tar and benzol only, however, give some suggestion that if the coat is sufficiently thick and thoroughly applied the copper oleate is not essential. The actual results of the 1937 tests were, however, that no serious damage was found when the copper oleate was present but that it did occur in certain boards with either two coats of tar and benzol or two coats of tar and gasoline. This requires further investigation. It has long been known that a thick coat of tar, or of tar and pitch, applied hot gives effective protection while, on the other hand, experience with dipping lobster traps in hot tar and producing a thin coat is indicative of imperfect protection. It may be that coats thoroughly applied and hardened using a solvent with the tar would be satisfactory.

(10) Examination of test boards with the microscope indicated that over 99% of the Teredo larvae which succeeded in making a perceptible burrow succeeded in establishing themselves in the wood, even though a perceptible burrow would not generally have to penetrate through the coat. This subject requires further investigation but the observations suggest that the protective coverings are effective through prevention of any perceptible start. The nature of the deciding factor is not known.

Plans for further work. A number of aspects of the general problem of the protection of wood against Teredo require further investigation if the best protective methods are to be developed. Some items in view are given below and as many as possible will be attacked in 1938;

(1) Further experiments with test boards to test preservatives. The 1937 experiments would be repeated and further tests included to show the effects of various concentrations of copper oleate and of single coats of the mixture on planed and unplaned lumber. A series would also be put out in May so that some wear would occur before the setting season.

(2) A series of boards to show the variation in intensity of set in relation to hydrography will be repeated.

(3) A study of the depths at which Teredo settle and the influence of the position (angle) of the surface. It is well to know what are the most dangerous positions as well as seasons.

(4) Experiments with lobster traps to include a comparison of untreated traps and traps treated with tar in the usual manner and with the tar-copper oleate mixture under actual fishing conditions.

(5) Study of the growth rate of Teredo.

(6) Further experiments to determine the maximum safe exposure for untreated wood and the minimum safe period in air for killing the Teredo.

(7) Study of various proportions of the solvents for the tar and copper oleate, and their effects on drying and hardening.

Ellerslie, P. E. I.,
February, 1938.