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PROGRESS REPORT ON TESTS IN COMMERCIAL FISHERIES OF CORDAGES MADE FROM VARIOUS FIBERS 1/

Until October 1942, hand knitted manila trawl nets, principally of English origin, were used exclusively in the North Atlantic trawl fisheries. Some had been imported from Japan, Germany, and other European countries prior to 1941. Inventories of all nets and sections on hand were obtained at that time and, from accurate replacement records furnished by vessel operators, it was possible to estimate how long existing stocks would last. Results of this study indicated that sometime during the following six months fishermen would need replacement otter trawl nets made from fibers possessing the general characteristics of manila.

Since 1928 there have been attempts to sell hard fiber (manila) machine-made webbing of domestic manufacture. Up to 1942 efforts were unsuccessful, particularly with large trawl nets, because machine-made webbing had been reported less satisfactory than that made by hand. With imports of all handmade netting cut off early in 1942, it was now apparent that machine-made netting would have to be utilized. At the same time, sisal cordage, the only hard fiber available, had to be used, since all supplies of manila were cut off for the duration of the war.

Sisal, called "wartime manila," apparently has most of the desirable characteristics of manila except that it is 15 to 20 percent lower in tensile strength. It was expected to be available in sufficient quantity after being placed under the control of the War Production Board. Conferences held during the latter part of 1942 with the manufacturers of machine-made webbing indicated that there would be an assured supply of hard fiber netting suitable for all sections of the otter trawls except the cod-end. Double twine is desirable for this section, which is the most essential part of the net, and there are no machines in this country capable of making double twine meshes of sufficiently heavy twine for use on the larger trawlers.

Since the cod-ends for the larger trawl nets apparently had to be hand knitted, and after formal requests for importation of these had been refused, conferences were held with the War Relocation Authority to obtain the services of interned American born Japanese to hand knit them. Last minute changes in policy

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1/ This progress report was prepared on May 15, 1944, by Frank W. Firth, formerly, technologist, Division of Commercial Fisheries.

by the War Relocation Authority with regard to establishing such an industry within the camps, however, resulted in failure to accomplish this aim. High wages in war emergency work and a lack of already skilled persons prevented domestic manufacture within the United States. Renewed requests to the Lend Lease Administration for cod-ends from England, finally resulted in granting permission to import them in the spring of 1943. These were to be made from sisal twine. The first shipments were rushed over and were received here at about the time that the manila cod-ends in stock had been exhausted.

Meantime, two cod-ends, knitted by hand from sisal twine, under the direction of the Fish and Wildlife Service personnel, were completed for experimental testing. The first one was made of single twine of a size which was thought might be possible to use in a knitting machine, namely, 750', 4 strand. This cod-end was in service for only one trip of six fishing days and was unfortunately lost at the beginning of the next trip. Observations made at the conclusion of the trip indicated considerable wear on the knots but in other respects no definite comparison can be made with similar manila sections.

The other cod-end was made of double twine, namely, 1350', 4 strand. This size of twine was selected to be equivalent to the strength of the manila twine used formerly. After six weeks of service it had to be discarded because of abrasion and general weakness. The fishermen using this cod-end claimed that in the area in which they were fishing, a manila cod-end would have given at least another three weeks of service. It was concluded that sisal would give more than two-thirds the service of manila, if double twine meshes were used.

There were numerous objections raised against the use of single twine mesh cod-ends, and eventually the manufacturer of the machine-made webbing stated that they would prefer not to make any double twine meshes because of a shortage of mechanics needed to keep the machines in operation on this heavy webbing.

In May 1943, a pair of lower wing sections, another part of the trawl net subject to heavy wear, were hand knitted from 1100', 4 strand sisal twine. This size of twine had a tensile strength approximately equal to that of manila twine used in wing construction. At the end of three weeks these wings were performing almost as well as those made from manila twine, but after six weeks they were removed because abrasions had weakened the twine to the breaking point. Manila sections are ordinarily serviceable for approximately ten weeks.

It can be concluded, from these service tests of sisal twine net sections, that it is essential that replacement be made on the basis of tensile strength rather than a comparable twine size. Sisal was found to soak up more water than manila, thus causing greater swelling of the twines and allowing sand and other grit to get in between the yarns resulting in internal abrasion in addition to the usual external abrasions. The data further indicate that sisal twine can be used as a substitute for manila twine if proper precautions are taken to guard against these faults, that is, if the present quality is maintained.

An imminent shortage of sisal, because of limited shipping available during the spring of 1943 from Africa where the bulk of this fiber is grown, made it imperative that other more available fibers be given service tests. The principal fibers from a standpoint of availability were cotton and jute. These

fibers possess approximately 55 to 60 percent the tensile strength of manila and are soft fibers which means that abrasion resistance would be considerably less than that of the hard fibers. For cotton, the most discouraging factors were the larger size twines necessary to maintain equivalent tensile strength, and the much higher cost. The physical characteristics of jute twine obtained from the manufacturers, indicated that it was so lacking in durability that it offered little promise as a substitute in trawl nets. A small section of jute twine was knitted into a trawl net made of manila twine and in less than a week this section went to pieces.

Cotton webbing made from 96 thread, medium laid, seine twine, gastar treated, was fashioned into a cod-end. This was placed in service on a large otter trawl net, and after 18 hours it was removed because the amount of fish caught in this period was less than half that of the other vessels, using hard fiber cod-ends on the same grounds during the same period of time. Single twine meshes were used, since it was machine made. In the extreme end of the section, the meshes were found to have stretched 20 percent over the original size. Around the splitting strap, where the greatest strains occur, the mesh bars were of various sizes due to stretching of the twine. The knots on the lower half had worn to the point that it was feared the meshes might break at any time. An attempt was made to use the cod-end again on a subsequent trip, but after one day of fishing the meshes finally broke because of abrasion, resulting in a loss of a considerable quantity of fish. This rather definitely suggests that the use of cotton twine in trawl nets is limited to the small sized nets used on vessels of low horsepower. Such nets have always been used for inshore fishing.

Sisal ropes began to be used rather extensively during the summer of 1943, and appeared to be a fairly satisfactory substitute for manila cordage although they had to be replaced much more frequently. When the quality of sisal cordage was lowered to a tensile strength of only approximately 75 percent that of manila complaints came in from many fishermen that the replacement rate was so frequent it hampered fishing operations.

For cordage uses, where manila or sisal are not permitted, jute was the most promising fiber for substitution from the standpoint of availability. The demand on cotton for twines and a shortage of both fibers and machinery for making cotton ropes limited the use of cotton.

Practical fishing tests were made with jute ropes treated with extra water-proofing materials as well as chemicals to protect against mildew and fungus attacks, in sizes large enough to obtain sufficient strength. Jute ropes were used on otter trawls for foot rope roundings, quarter ropes, buoy lines, and belly lines. On purse seine vessels they were used for purse-weight lines, and hoisting or cargo tackles.

In every case the jute ropes showed a serious lack of resistance to abrasion, which limited their usefulness in the fishing industry. When tested as quarter ropes, where two lines are used on either side of the trawl net, one line was new manila rope and the other a jute rope. In this particular instance the jute rope broke after six weeks, while the manila line was still serviceable for another six weeks. For other purposes the jute lines were serviceable only one-fourth to one-third as long as those of manila. In addition, the jute lines parted without

any previous signs to indicate weakness, whereas manila and sisal ropes usually show strands breaking gradually. This gives the fishermen sufficient warning to repair or replace such lines.

Because of the acute shortage of sisal cordage during the late summer and fall of 1943, it became apparent that at least a portion already allocated for fishing purposes would have to be substituted for by other fibers. Since the buoy lines, called "pot-warps," used in the lobster fisheries, required a large quantity of cordage in relation to returns of seafood, and since only two sizes of ropes, 6 and 9 thread, were used, it was decided to study substitute possibilities for this end use. At this time also the twine situation became so critical that the further use of sisal heading twine for lobster pot funnels was denied, although it was permissible to use whatever stocks were in the hands of the dealers.

Accordingly, a series of tests with buoy lines for lobster pots using jute, flax, coir and "hempsal" (a combination of 30 percent American hemp and 70 percent African sisal fibers), were started in September 1943 and extended through the winter of 1943-44. Jute warps were the first to be tested and out of 24 lines placed in service over a four month period, the average life of the lines approximated one month. They had been given the same treatments as those given to the larger jute ropes. In all cases failure resulted from abrasion at the lower ends of the lines on the ocean bottom and from passing over the pulleys and winch heads when hauling in the gear. Where jute lines were hauled by hand, from dories, they gave excellent service because much abrasion had been eliminated and also because such fishing is carried on in relatively protected inshore grounds. Dory fishing is not very extensive so it should be concluded that jute lines are generally not suitable for the lobster fisheries.

Flax lines in service during this same period gave a little better service, lasting about seven weeks, but they were too stiff and difficult to handle. The strands kept breaking, necessitating frequent splicing, and often complete breaks resulted in loss of the pots. Furthermore, the comparatively high cost of this cordage made it uneconomical to use.

Coir rope, 15 thread size, was spliced into 9 thread jute lines and used at the lower or pot end where extreme chafing first wore out jute lines. Within one month all five lines tested were nearly severed by chafing. This rope was also too elastic, the strands unlaid and tangled considerably, and the fishermen were worried each time the pots were hauled up because of the uncertainty of the rope.

"Hempsal" buoy lines in service for three months showed outstanding characteristics in comparison with any fibers tested as a substitute at this time. It was much better than straight sisal because the hemp overcame the brittleness and added to the flexibility lacking in sisal. After three months, at the end of the season, the hempsal was still serviceable enough for starting the next season, whereas straight sisal ropes in most cases were about ready to be discarded, if they were not already worn out in the same period of time. The strength and durability exhibited compared favorably with manila cordage for this particular use.

Jute and hempsal heading twine, 2 and 3 strand, 600', 750' and 900' sizes, in service for a period of three months in lobster pot heads, gave decidedly better service than the sisal twines used for this purpose. The heads made from the latter twines had to be replaced after three months because of the brittleness of the fibers. The pliability of both jute and hempsal twines was an asset

in knitting the heads. Lobster pot heads undergo but little abrasion, so it is evident from the tests conducted that either of these fibers is suitable for replacement.

Coir rope having a diameter of one inch was given a service test as a foot-rope rounding on an otter trawl net. This line is wound around the wire foot-rope in order to prevent the wire from digging into the ocean bottom and wearing out, and principally to prevent the hanging line of the webbing from slipping along the wire causing the net to hang improperly. A good grade hard laid sisal or second grade manila rope, has always been used for this purpose and if the coir rope had proven suitable it would have released the sisal for other uses. After two days of fishing, the coir rope had chafed off almost entirely and only a short length was recovered from one end of the foot-rope which was worn so badly as to be unrecognizable as a rope.

Raffia rope, 5/8 inch in diameter, was used to replace sisal lines holding the metal floats in place along the head-rope of an otter trawl net. This end use was selected because it was known that raffia has little resistance to abrasion. Before the end of one trip, about four days fishing, one float was lost and it was necessary to remove all of the remaining raffia lines and replace with sisal cordage. Later tests as hanging lines on trawl nets, where little abrasion occurs, gave such poor performance that it is not feasible to recommend this fiber for use in fisheries.

It might be of some interest to cite briefly some of the changes which "wartime manila" rope has undergone in the past year and a half since it has been on the market. The very first to appear was made of a combination of African and Java sisal fibers. This was a fine quality rope and in some cases was used by fishermen who were under the impression it was made from manila. The tensile strength ranged up to 90 percent that of rope made of manila fiber, depending upon the amount of Java sisal it contained. By the spring of 1943 Java sisal stocks were exhausted and none was available for replacement. Straight African sisal cordage constituted all that was available. This was a cordage having about 80 and in some cases 85 percent of the tensile strength of manila cordage, if first quality fibers were used. Because of the uncertain shipping facilities, however, it became necessary to extend these African sisal fibers by the introduction of Henequen fibers, more popularly known as Mexican sisal, as well as Pita and Istle fibers in quantities up to 5 percent. This resulted in bringing the tensile strength down to 75 percent that of manila cordage of equal size. This cordage although still called "wartime manila" by some manufacturers, is too brittle for use in fishing and has too little abrasion resistance, but since there are no other cordages as good, it is being utilized to the best possible advantage. Greater care is taken of all ropes aboard fishing vessels than ever before. Treatments are being applied by many fishermen, especially for buoy lines, in order to lengthen the life of these ropes, since they are immersed practically all of the time.

Cooperative research work is now in progress with the U. S. Department of Agriculture, to develop new treatments for cordage. Special attention is being given to treatments for cotton fish nets in order to obtain longer life from these nets. This is essential in view of the shortage of cotton yarns, the great demand for fish netting and the manpower shortage in the knitting mills.

The manila fiber situation is more critical than at any time since the outbreak of the war in spite of the zealous care of the War Production Board in allocating manila from the stockpile for only strictly essential needs. In view of the limited quantities of sisal available, the War Production Board, Cordage Branch, has approved the production of hempsal cordage beginning in July 1944. Hence, after July the present hennequen, pita and istle extender fibers will be replaced by American hemp fiber. The percentage of American hemp will be increased according to availability until a maximum of 25 percent is reached.

Although the shipments of sisal fiber from Africa are now on a somewhat better schedule, limited shipping space, as well as an ever increasing demand for cordage due to our expanding shipbuilding program, and second front preparations do not permit any increases in the use of sisal.

Under a cooperative program with the U. S. Navy Department, it is planned to make up various percentage blends of American hemp as well as any other fibers which might become available, with African sisal, in amounts large enough to place in practical fisheries tests. It is furthermore planned to develop special preservative treatments for these new blends in order to further increase the life of such cordages.

Most of the cordages used in these experiments were supplied by various manufacturers interested in knowing to what extent these fibers could be used in commercial fisheries. Appreciation is expressed for their valuable cooperation. The testing was done under my supervision by selected fishermen who were well experienced and from whom reliable reports could be expected. They were most cooperative in allowing me to inspect these lines during the intervals when they were ashore. It was anticipated that in some cases the fishermen might be prejudiced even before a trial test had been concluded, especially against the soft fiber cordage. Cordage was only used after all available information indicated that it would be suitable for specific purpose. In every instance therefore, all available laboratory data concerning each type of cordage were furnished these men.

I am indebted to Conservation Officer Edwin C. Towne, of New Hampshire, for his valuable assistance on the tests with pot-warp and heading twine conducted in the lobster fisheries of that area. Acknowledgment is also made of the assistance rendered by Area Coordinator L. W. Scattergood, U. S. Fish and Wildlife Service, Boothbay Harbor, Maine; Conservation Officer O. A. Richardson, Maine Sea and Shore Fisheries Commission, as well as the many fishermen and cordage manufacturers whose cooperation made these tests possible.

The attached table lists the characteristics of cordage made from the various fibers according to the tests thus far conducted by the Service in commercial fisheries.

COMPARISON OF CORDAGE FIBERS WITH MANILA EQUAL TO 100 PERCENT

Type of Fiber	Approximate Tensile Strength (card) percent	Proposed Use	Abrasion Resistance	Flexibility	Approximate Durability percent	Recommendation	Availability
Manila	100	General Fisheries	VeryGood	VeryGood	100	VeryGood	None
Java Sisal	90	" "	Good	" "	95	" "	"
Blend of Java & African Sisal	85	" "	"	" "	85-90	" "	"
African Sisal	80	" "	"	Good	80	Good	Limited
Blend of African Sisal with 5% extendors of Agave-tow, Henequen, Pita or Istle fiber	75	" "	Fair to Poor	Fair	60-70	Fair	Limited
Hempsal*	90	Lobster potwarps, Lobster pot heading twine	Good	VeryGood	90	VeryGood	Limited
Jute Cordage	60	Quarter ropes, haul-up lines, Tackles, Lobster potwarps	Poor	Good	50	Poor	Fairly Abundant
Jute Twine	60	Otter trawl webbing	Poor	VeryGood	30	Poor	Fairly Abundant
Jute Twine	60	Lobster pot heads	Fair	VeryGood	85-90	Good	Fairly Abundant
Flax Cordage	60	Lobster potwarps	Fair	Poor	75	Fair to Good	Limited
Coir Cordage	25	Lobster potwarps, Otter trawl footrope rounding	Poor	Poor	20	Poor	Fairly Abundant
Cotton twine	55	Otter trawl cod-ends	Poor	Good	50	Fair	Limited
Cotton twine	55	Lobster pot heads	Good	Good	85	VeryGood	Limited
Raffia Cordage	60	Otter trawl hanging lines	Poor	Fair dry Poor wet	25	Poor	Limited

* Hempsal made up of 30 percent American hemp and 70 percent African Sisal.

Rating Table: 1. Very Good; 2. Good; 3. Fair; 4. Poor.