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THE SELECTION AND CARE OF NYLON GILL NETS FOR SALMON

by

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Acknowledgments

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THE SELECTION AND CARE OF NYLON GILL NETS FOR SALMON

1. There are different kinds of nylon --- which kind is best for you?

Nylon is a synthetic or man-made fibre produced basically from air, water, and petroleum oil or coal. By varying the production method it is possible to produce a great variety of nylons, each one having its own physical properties which make it suitable for the job it has to perform. Unfortunately, no one kind of nylon is the best for all jobs, so it is necessary to pick the best nylon for the job you want it to do. This first section discusses the different nylons and points out how their different properties adapt nylon to different jobs.

(a) Chemical differences and related physical differences

The first basic difference between nylons is a chemical one, different chemical constructions giving different physical properties. Two of the many different chemical types of nylon appear in quantity in British Columbia. These are Type 6 from Japan and Europe and Type 66 from Canada, Britain, Europe, and the United States. Each of these basic chemical types of nylon can be varied by changing the extent to which the chemical reaction is allowed to proceed when the nylon is first made and by changing the amount of pigment added to the nylon before spinning. In the Type 6 and in the Type 66 nylons used for salmon gill nets, the chemical reaction and the amount of pigment are both controlled to give twines which are as strong as possible at reasonable cost. Generally speaking, Type 66 nylon can be made stronger than can Type 6 nylon and has more spring at low loads, but Type 6 nylon is cheaper. Therefore, for the same strength gill net, Type 66 nylon gives a finer twine and smaller knot, but Type 6 nylon costs less.

(b) The effect of different yarn weights and yarn constructions, and an explanation of the yarn numbering system

The second difference between nylons arises from the way in which the yarn is manufactured. In the production of nylon yarn, solid flakes of nylon are first heated until they melt, then the melted nylon is pumped out through small holes and is immediately cooled to solidify it as a bundle of long, fine filaments. This bundle of filaments is called the yarn. Coarser yarns may be produced by using either larger holes or more holes of the same size. Stiffer yarns of the same size may be produced by using larger holes but fewer of them.

The size of the yarn is usually measured by weight and is indicated by the number of "denier". The "denier" is the weight in grams of 9000 metres of the yarn, where 1 gram equals about 1/28 oz. and 9000 metres is about 5 nautical miles. For example, the 210-denier nylon yarn commonly used to make salmon gill nets for the Pacific coast weighs 210 grams per 9000 metres. The 140-denier nylon yarn often used to make Great Lakes gill nets weighs 140 grams per 9000 metres, just 2/3 as much as our salmon gill-net yarn. The 250-denier yarn which was once used in Japanese nylon gill nets and is now used in Terylene web weighs 250 grams per 9000 metres, or 19% more thar the 210-denier nylon yarn.

Sometimes the manufacturer tells us how many filaments are in each yarn. More filaments in a yarn of the same size gives a more flexible yarn, but also lets the yarn hold more dirt. When the number of filaments is given, it is the figure after the denier, separated by a hyphen. For example, 210-34 means a 210-denier yarn having 34 filaments per yarn. This is the yarn commonly used in Type 66 nylon gill nets for salmon. 140-68 means a 140-denier yarn having 68 filaments per yarn, the Type 66 nylon used to make many Great Lakes gill nets. 210-15 means a 210-denier yarn having 15 filaments per yarn, the nylon yarn commonly used in Type 6 nylon gill nets for salmon. By having fewer and coarser filaments in a yarn of the same size, 210-15 Type 6 nylon yarn produces a slightly stiffer twine than does the 210-34 Type 66 nylon yarn, other factors such as twist hardness, twine construction, and coating agent being the same in both cases.

All the yarns mentioned so far are made by pumping melted nylon through several small holes at once to produce what is called a "multifilament" yarn, that is, a yarn which contains many filaments. If the melted nylon is pumped through only one hole, then the yarn contains only one filament and is called a "monofilament" yarn. Monofilament nylon is usually Type 6 and is used for leader line, etc. in sports fishing. Because of stretching problems, monofilament nylon cannot be made as strong as can multifilament nylon of the same weight, and it has a greater tendency to stretch permanently during use. The knot strength of monofilament nylon is quite low, and, because of its springiness, monofilament nylon cannot be handled by the netting looms except in fine and relatively weak sizes. For example, the strongest machine-made monofilament nylon netting tested at this Station had a wet mesh strength of only 4-1/2 pounds, far too weak for salmon.

Thus, yarn weight (denier) and the number of filaments per yarn, both of which affect the flexibility and strength of the twine, make the second difference between different nylons.

(c) The effect of different stretching procedures, and the meaning of "tenacity"

When first made, nylon yarn has the property that if it is pulled it will stretch and it will remain stretched even after the pull is released. Further, it is relatively weak for its size. Therefore, the nylon manufacturers stretch the yarn to 3 or 4 times its original length so that it becomes finer and stronger and has more spring. Applying more stretch at this time increases production costs but makes the twine stronger and leaves less permanent stretch to come out of the twine under future loads. However, because the nylon breaks on the stretching machine if stretched too much, there is a limit to how much the strength of nylon can be increased by stretching.

The producers of Type 66 nylon make two styles of nylon yarn, each being stretched a different amount during manufacture. For clothing fabrics and many industrial uses where high strength is not necessary and where extra elasticity may be an advantage, the nylon yarn is stretched as little as is practical, giving what is called "regular tenacity" yarn. But where high strength is needed, even if the cost is greater, the nylon yarn is stretched as much as is practical, giving what is called "high tenacity" yarn. The tenacity of the yarn as determined during stretching is thus the third difference between different nylons, high tenacity yarns being about 1-1/2 times as strong as regular tenacity yarns of the same size.

"Tenacity" is tensile strength expressed on an equal weight basis. As a comparison, the strength of steel, wood, and wire is expressed in pounds per square inch, that is, on an equal area basis. The structural or mechanical engineer can then calculate the strength of any particular beam or wire by multiplying this unit strength by the cross-sectional area of that beam or wire. For example, cold rolled steel has a tensile strength of about 60,000 lb./sq. in. so that a piece of bar stock 1 in. wide by 1/8 in. thick (cross section area = 1/8 sq. in.) has a breaking strength of about 60,000 x 1/8 = 7500 lb.). In a similar way, the textile engineer uses "tenacity" to calculate the strength of any particular filament or yarn. For example, "regular tenacity" nylon has a tenacity of about 5 grams per denier so that a 70-denier yarn would have a tensile strength of about 5 x 70 = 350 grams (0.77 lb.). As another example, "high tenacity" nylon has a tenacity of about 7.2 grams per denier so that the 210-denier high tenacity yarn used to make many salmon gill nets has a tensile strength of about 7.2 x 210 = 1512 grams (3.3 lb.).

(d) Continuous filament compared with staple yarn

At this stage of manufacture, each filament in the yarn runs the full length of the yarn and hence is called "continuous filament". However, knots tied in twines made from continuous filament nylon tend to spring open unless specially treated, and cloth made from it tends to feel cold and clammy. When it is desirable to overcome these difficulties, the manufacturers "crimp" the nylon, that is, make it all kinky, then "staple" it, that is, cut it into fibres about 3 in. long, and then "spin" it, that is, twist it into a yarn much as is done with cotton or wool. In this form the nylon is called "staple" or "spun". It has a much rougher feel than continuous filament nylon and the knots hold much better, but it is much bulkier, particularly in the water, it is less than half as strong in the straight twine and about 4/5 as strong at the knot, and it costs more to make. Because the yarn strength of staple nylon is as much dependent on the friction between the fibres as on the strength of the fibres themselves, regular tenacity nylon is usually found to be satisfactory for staple nylon twine.

Thus, the fourth difference between nylons is whether it is continuous filament or staple, continuous filament nylon being best where the twine must be fine and light and where the knots can be given special treatment as in gill-net web, and staple nylon being best where the twine can be coarser but where hand-tied knots must hold without special setting as in hanging twine.

(e) The effect of different twine constructions, and explanation of the twine numbering systems

The fifth difference between nylon twines results from the way in which the yarns are twisted together to form the twine. Most of the nylon web used in British Columbia is 3-ply construction, that is, if the twine is untwisted, the filaments and yarns in it will be found grouped into three plies of equal size. Each of these plies in turn is made of several yarns, smaller twines having fewer yarns per ply and larger twines having more. Some Japanese nylon twines are 4-ply construction. These twines each contain four plies and each ply contains three or four yarns. At least one United States company makes what they call nylon "salmon" twine. This twine may contain any number of plies, four, five, six, seven, etc., just like linen gill-net web, and each of these plies in turn contains three yarns. There is very little experimental information to tell us which twine construction catches the most fish. Three-ply construction is the most popular in British Columbia, although good results have also been obtained with other constructions. Generally speaking, three-ply twines tend to keep their shape better, whereas a greater number of plies tends to permit the twine to change shape when squeezed.

The numbering system used for salmon gill-net twine in this manual and, for several years, for Canadian and British netting, is based on an official, but more elaborate, system for silk and for all continuous filament synthetic textiles. The numbers describe the basic yarn and how the yarns are put together to form the twine. The first number is the yarn weight in denier (see Section 1(b) above) and, because there are many different systems for describing yarn weight, the letter "d" is placed after this number to indicate that the "denier" system is being used. The second number, separated from the first by a sloping line, is the number of yarns which have been twisted together to form each ply. And finally, after another sloping line, is the number which tells how many plies have been twisted together to form the final twine. For example, 210d/5/3 means that each yarn weighs 210 denier (that is, 210 grams per 9000 metres), that 5 yarns have been twisted together to form each ply, and that there are 3 plies in the twine. Practically all nylon gill nets for Pacific coast salmon are made from 210-denier yarn so this figure is often omitted, leaving 5/3 as the twine number in this case. However, different yarn sizes may be made, particularly when improved nylons or new synthetic fibres are developed, and the yarn weight figure may be used again in the twine number. For example, Terylene gill-net web is made from heavier 250-denier yarn, and this fact should be stated in the twine number on the bale tag. Often, too, the sloping line between the last two numbers is omitted, leaving #53 as the twine number in our example. However, this omission leads to confusion when there are more than nine yarns per ply or more than nine plies in the twine. For example, #123 twine could mean there are 23 plies of 1 yarn each or 3 plies of 12 yarns each, but by using the sloping line to make the twine number 12/3 there is no doubt that the twine has the latter construction.

Some Japanese nets are numbered one size lighter than they actually are so that when a fisherman buys a net marked, for example, "Canada #43" he is actually getting a net of 5/3 twine construction. This is done so that the fisherman will choose a net which is about as strong as a Canadian or British 4/3, even though it is heavier. Adding further to the confusion, Japanese #28 nets are actually 3/3 twine construction, not 2/8 construction, although it does not follow that all #28 nets in the future will be of 3/3 twine construction.

Another system sometimes used on Japanese netting is to give the total number of yarns in the twine. For example, 210d/3/3 twine may be called Z9, or 210d/5/3 may be called J15, etc. This system is not misleading as is the system described in the last paragraph above, but it does not tell us so much about the twine as does the recommended system.

Several other numbering systems are also used, most of them based on the construction of the twine, but it is not practical to discuss all of them here. The above system, with its modifications, is the one which is used most. If another system has been used to label a net, it is often possible to estimate the twine number from the weight of the net or from the yards per pound of the twine. Tables 1 and 2 in Appendix A and the formula given in Section 3(h) may be of some help in this.

(f) <u>The effect of different twist hardnesses</u>

The amount of twist put into the twine and the direction of the twists make the sixth difference between different styles of nylon. There are three twisting operations in the manufacture of nylon salmon twine. First the filaments in the yarn are twisted together to form a compact yarn, then several yarns are twisted together to form each ply, then several plies are twisted together to form the twine. The amount of twist inserted in each twisting operation must be carefully controlled by the manufacturer, otherwise the twine will tend to kink. Such kinking is a defect. Certain conditions which the twine may experience after it is made may throw the twist off balance and cause kinking, for example, boiling in water, but the manufacturer should not be blamed if the twine kinks under such conditions. It is possible for the manufacturer to put in a lot of twist or only a little twist and still produce a balanced twine. Generally speaking, more twist keeps the dirt out better and increases wear resistance, but it makes the twine stiffer and weaker. Less twist leaves the twine stronger and more flexible and gives more secure knots, but lets the twine fluff out more in the water, permits more dirt to cling to the twine, and leaves the nylon filaments loose on the surface of the twine to catch more readily on slivers, finger nails, etc. and become broken. Just which twist gives the best compromise between flexibility, strength, wear resistance, knot security, dirt holding, and "fluffiness" in the water is different for different areas and different fishing conditions, and can be determined only by fishing experience.

(g) Hot stretch compared with stabilizing

When a nylon twine is first twisted it contains many internal stresses, just like a newly cast engine block. These stresses are sometimes left in the twine to relieve themselves, or one of two commonly used processes may be applied to relieve these stresses artificially. These after-twisting treatments create the seventh difference between different nylons.

If the internal stresses are left to relieve themselves, then it is practically impossible to predict how the mesh length of the finished netting will change with time, use, and abuse. Usually the web shrinks, sometimes 2%, sometimes 10%, sometimes it even stretches, and it has been known to shrink as much as 25% when boiled. One of the after-twisting treatments is known as "hot stretching". The twine is heated to allow the internal stresses to decrease and, at the same time, tension is applied to even up the filaments and to prevent local shrinkage. The twine is stretched slightly in the process so that it becomes a little finer and a little stronger, but it is still subject to shrinkage when boiled, such as when being dyed. The other after-twisting treatment is known as "stabilizing". The twine is subjected to moist heat without tension.

This is, in effect, pre-shrinking so that further shrinkage in boiling water is usually less than 2%. "Stabilized" twine is slightly heavier than "hot stretched" twine, but it has slightly more spring, particularly at low loads, and it is less subject to shrinkage in use. Thus, where mesh length is critical and the netting is to be dyed or cleaned in boiling water, "stabilized" twine is preferred. Where mesh length is not critical, or where the netting will not be exposed to boiling water, or where it is desired to shrink the netting after the first period of use, then "hot stretched" nylon may be better. Untreated nylon should be used only where any changes in mesh length do not matter.

(h) Characteristics of different machine-tied knots

The eighth possible difference between different nylon gill nets is in the type of knot tied by the netting loom when the twine is made into web. Fig. 1 shows sketches of nine different machine-tied knots which are used or have been used to make commercial nylon gill nets for catching salmon in British Columbia.

The single knot, otherwise known as the Weaver's knot, Sheet Bend, or English knot, is the simplest and cheapest to produce. However, it is slightly weaker than the others, and tends to slip more easily. Further, if a strong steady pull is applied to the two twines at the bottom of the knot, it is often possible to pull the standing loop at "a" in Fig. 1 through the other loop to form a true slip knot. The single knot may be tied by hand with a netting needle as shown in Fig. 2.

A simple modification of the single knot is the "knot-and a-half" which has reduced tendency toward twine slip and inversion into a slip knot. In this, the standing loop takes an extra turn around the twine from the upper right at "b" in Fig. 1. This extra turn adds bulk so that if the two twines from the bottom of the knot are pulled, it is more difficult to pull the lump at "b" through the knot to form a slip knot than is the case with the single knot. Further, the extra turn helps to keep the twine from slipping within the knot. The "knot-and-a-half" can be tied quite easily by hand when mending a net. As shown in Fig. 2, proceed the same way as to make a single knot, except pass the needle through the standing loop two times instead of once and pull the twine snug before passing the needle around the standing loop to complete the knot.

The double knot appears in machine-made netting in four different forms, but these forms are similar in that the needle twine takes two wraps around the standing loop instead of one wrap as in the single knot (compare Double Knot A with the Single Knot in Fig. 1 and Double Knot C with the Single Knot in Fig. 2). The double knot was the first answer to the tendency of the single knot to slip and to turn inside out. In Type 66 nylon the double knot is 5% to 10% stronger than the single knot, but it requires more twine so that the net is heavier, and the knot is bulkier and hence more visible in the water. Also, the double knot costs more to make. Double Knot A in Fig. 1 is the same as would be tied by a left-handed net man, that is, tied the same way as Double Knot C in Fig. 2 but from right to left instead of from left to right. It appears in some Japanese double-knot nets and in alternate rows in

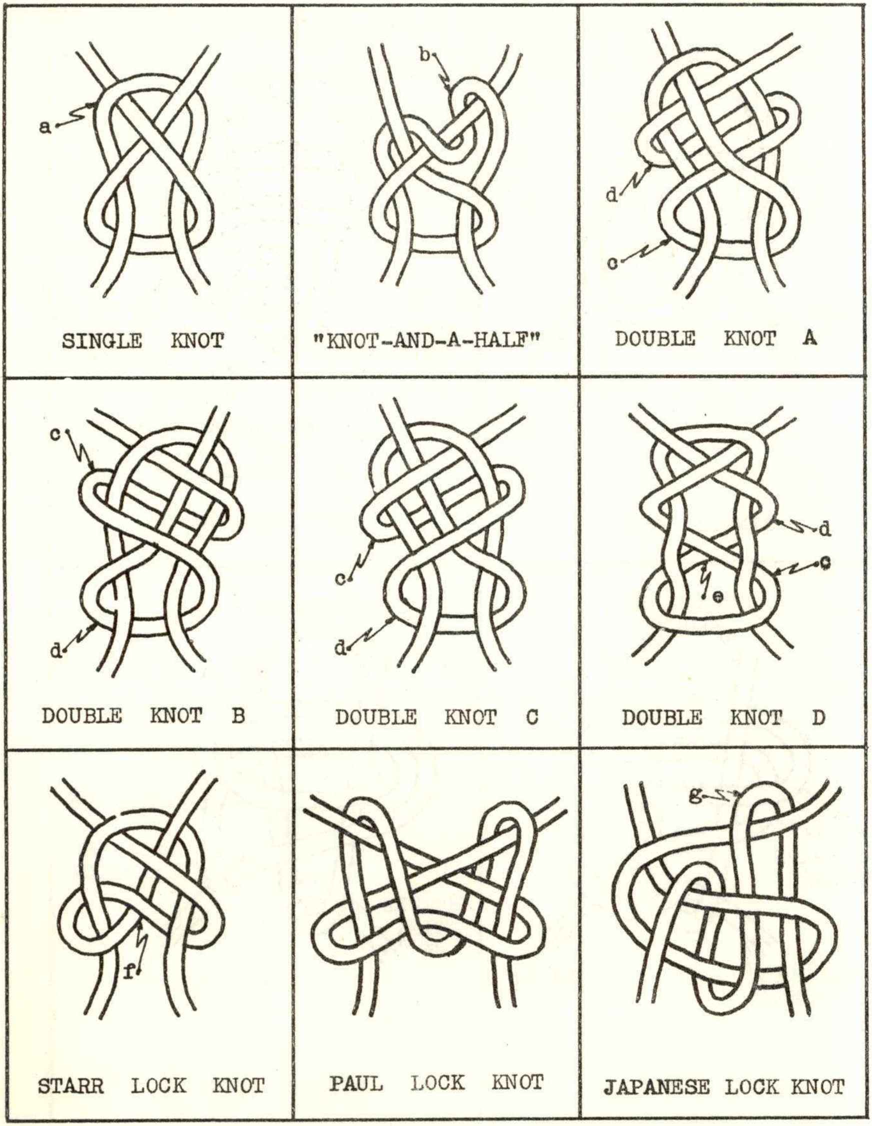
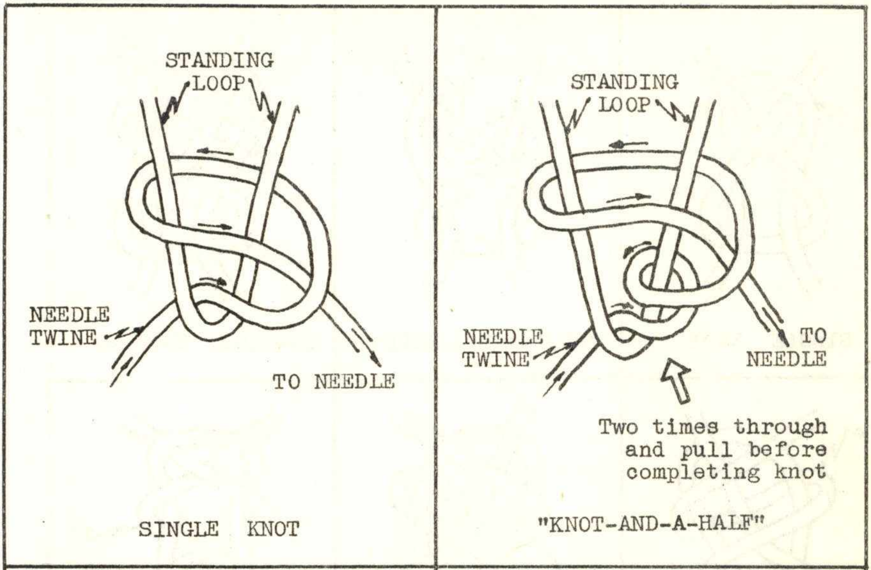
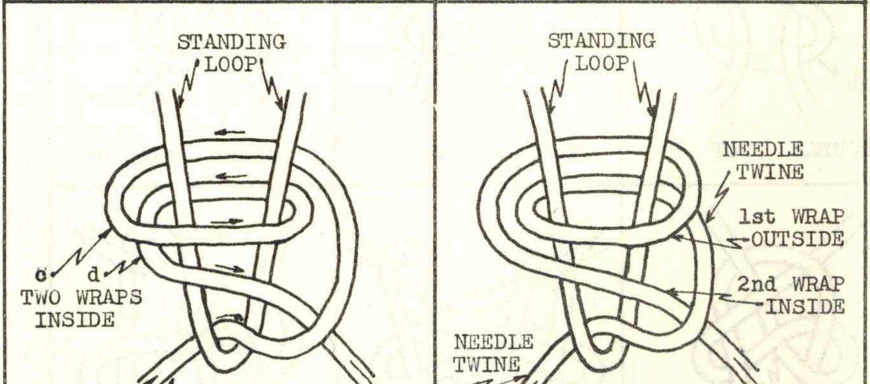


Fig. 1 Machine-Tied Knots Used to Make Nylon Gill Nets for Catching Salmon



SINGLE KNOT

"KNOT-AND-A-HALF"



DOUBLE KNOT C

DOUBLE KNOT D

Fig. 2 Knots Used to Make Nylon Gill Nets, as Tied by Hand netting from the Canadian double-knot loom. Double Knot B in Fig. 1 is tied in exactly the same way as is Double Knot A, but it is pulled tight with the first wrap "c" on the opposite side of the second wrap "d" from where it lies in Double Knot A. In other words, Double Knot A may be converted into Double Knot B without being untied simply by lifting wrap "c" over wrap "d". Double Knot B is made by the French double-knot loom. Double Knot C in Fig. 1 is tied the same way as is Double Knot C in Fig. 2, but is pulled tight with wrap "c" nearer to the point of the standing loop than is wrap "d". It is the mirror image of Double Knot B, and it appears in netting from the Canadian double-knot loom in the rows between the rows of Double Knot A. Double Knot D in Fig. 1 is tied slightly differently from the other double knots. For example, when making Double Knot C as shown in Fig. 2, the needle is passed under the needle twine both times when forming the two wraps "c" and "d", but for making Double Knot D as shown in Fig. 2, the needle is passed outside the needle twine for the first wrap and under the needle twine for the second wrap. As a result, in Double Knot D, the second wrap "d" in Fig. 1 crosses outside the first wrap "c" at the back of the knot at "e". The second wrap is thus held out from the knot and is very exposed to wear. This knot is found in some Japanese double-knot netting. All these forms of the double knot are about equivalent in strength and in resistances to slip and to inversion into a slip knot, but the first three are preferred because the last is the more subject to wear. For this same reason, when a double-knot gill net is being mended, it is better to tie the knot shown as Double Knot C in Fig. 2, rather than that shown as Double Knot D.

Under certain circumstances it is possible for the double knots to be turned inside out when the twines of the standing loop are pulled apart. The lock knots were designed to prevent this. The simplest of these is the Starr Lock Knot, made in the United States. It is a modification of the single knot in which the upper twine passes behind the wrap of itself at "f" in Fig. 1 before passing under itself to complete the knot. The Starr Lock Knot is very awkward to tie by hand, but it is very little more bulky than the single knot, has somewhat less tendency to slip, and cannot be turned inside out. The Paul Lock Knot, also made in the United States, has the least tendency to slip and cannot be turned inside out, but it is relatively bulky and is hence more visible in the water. The Japanese Lock Knot cannot be turned inside out, but it is more subject to slipping than are the other lock knots, particularly if loop "g" in Fig. 1 is pulled through the knot by tension on the lower right twine. Also, because the lower left twine leaves the knot at an unnatural angle when the knot is tight, this knot is weaker and more subject to wear than the others.

Besides these knots, there is also available from Japan netting made with the "square", "reef", or "flat" knot shown in Fig. 3. Compared with the single knot, the square knot is bulkier, slips more easily, and is more readily turned into a slip knot by pulling sideways either the top pair or the bottom pair of twines. Also available is knotless netting made on a lace-type machine

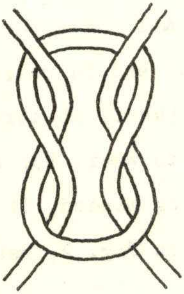


Fig. 3

The

Square

Knot

of two-ply twine in which the plies interlace as they cross through one another at the corners of the mesh, but this has not yet been tried for British Columbia salmon gill nets.

This eighth possible difference between different nylon gill nets, namely that arising from different knots, is often the governing factor in the selection of the net, each knot providing a different compromise between cost and performance for the many different fishing conditions encountered.

(i) The effect of different knot-setting procedures

Nylon is by nature a very springy material. If a piece of nylon netting is manufactured and is then left lying around without further treatment, the knots will spring open and the netting will be useless for catching fish. Knots tied by hand when the net is mended often give this same trouble. Fortunately, nylon can be set into the shape of the knot so that the knots no longer try to spring open. The way in which the knots are set is the source of the ninth difference between different nylon gill nets.

Loads on the net and the action of the water during fishing will set the knots after one and a half to two weeks of use. Some manufacturers depend on this natural process and do not give their netting any special setting treatment. These nets must be used soon after they are made, otherwise the knots will spring open. Also, heavy loads, particularly those acting at an angle in the net, should be avoided until the knots are set by use, otherwise the netting will become distorted. In old-stock nets of this type, the knots are almost always loose and open and should be tightened before the net is used.

Most manufacturers apply a coating of some kind to the netting. No presently-known coating will remain on nylon for the life of the net. Rather, these coatings are designed simply to hold the twine in the shape of the knot and to keep the knot tight until it is set by the action of fishing. Even old-stock netting of this type can be used without being overhauled to tighten the knots, but it is advisable to handle the net carefully for the first couple of weeks. At least one twine manufacturer applies the bonding agent to his twine then sells the treated twine to netting manufacturers who make it into netting. In this case, the bond is broken at the knots when the knot is tied, and surface friction must be relied upon to hold the knots tight. Obviously it is better to apply the bonding agent to the netting after the knots have been tied than to apply it to the twine before the knots are tied, but satisfactory results are claimed for this latter procedure. Also available are commercial mixtures which, when applied to web or twine, are claimed to have the same bonding properties as have the factory-applied agents.

It is possible to set the knots by giving the netting a heat treatment, and the knots are set better if the heat is moist. The netting should be heated more than it will ever be heated again, but not enough to weaken the netting. This heat treatment gives the best and the most permanent set of the knots, but it is the most expensive, and so is not often used.

2. In water, nylon is weaker than linen --- if you want your nylon net to be as strong as your linen net, then it must be heavier

Sometimes claims are made that nylon gill nets are stronger than nets made of other materials. Gill nets for fishing in the lakes of the interior provinces were at one time made of top quality cotton, and nylon gill nets, for the same weight, are over twice as strong as these cotton gill nets. But nylon gill nets for salmon are not quite so strong as top quality linen gill nets of the same weight. Also, some base their claim for nylon on the fact that dry nylon is stronger than dry linen of the same weight, but they do not tell us how to catch fish without getting the net wet.

(a) Comparative test data for nylon and linen twine and netting

Table 1 in Appendix A at the back gives information on the weight, diameter, and strength of new, Type 66, high tenacity, multifilament, nylon gill-net twine and netting made of 210-denier, 34-filament yarn in the usual 3-ply construction. Most of the nylon gill nets made in Canada, Britain and the United States for Pacific Coast salmon are of this type. Table 2 gives corresponding information for new, Type 6, multifilament, nylon gill-net twine and netting made from 210-denier, 15-filament yarn. Most of the Japanese nylon gill nets for Pacific Coast salmon are of this type. The twine numbers given in Table 2 are the actual twine constructions and are not necessarily the numbers marked on the bale. For example, Japanese #28 and Z9 nylons are actually 3/3 construction, #33 is actually 4/3 construction, #43 and J15 are actually 5/3 construction, and so forth, as explained in

Section 1(e) above. For comparison, Table 3 gives the properties of new, good grade, linen gill-net twine and netting of the usual multi-ply salmon twine construction.

The information in all these tables is based on tests performed by me using the procedures commonly employed at this Technological Station. Hence, all figures may be compared with one another. The method of test can affect the test result so that figures obtained elsewhere may not always agree with these. The data presented in this manual are averages of many tests so that, for example, when first put into use about half of all gill nets will be weaker than stated here, and about half will be stronger. Most new gill nets will have properties within 10% of the figures quoted in Tables 1, 2 and 3. As manufacturing methods gradually improve over the years, the properties of the nylon gill nets can be expected to improve. It is planned to continue these tests and to publish revised tables when necessary.

(b) <u>The effect of wetting on mesh strength</u>

Let us compare the properties of Type 66 nylon gill nets given in Table 1 in Appendix A with those of good grade linen gill nets given in Table 3. For example, 50/5 linen was a popular twine for sockeye gill nets --- it gave as light a twine as was practical for the strength required in use. Comparing 5/3 nylon with 50/5 linen, the nylon is seen to be slightly heavier (somewhat fewer yards per pound), the dry mesh of double-knot 5/3 nylon netting is about 24 lb. stronger than that of 50/5 double-knot linen, but when the nets are in the water, the 5/3 nylon is about 1 lb. weaker in the wet mesh than is 50/5 linen, even though it is slightly heavier.

Nylon loses 10% to 20% of its strength when it gets wet, whereas good grade linen increases about 50% in strength. As another example, 40/6 linen gill nets were popular for "fall" fishing. Comparing 7/3 nylon with 40/6 linen, the nylon is slightly heavier (fewer yards per pound), but, although the dry mesh of the double-knot 7/3 nylon netting is 35 lb. stronger than that of the double-knot 40/6 linen, the wet mesh is only about 2 lb. stronger. When testing gill nets for mesh strength it is wise always to test the netting when it is wet to avoid being mislead.

The relative wet mesh strengths of linen web made with #50 yarn and of Type 66 and Type 6 nylons are compared on an equal weight basis in Fig. 4. The lines for the two nylons are both below the line for linen so that, for the same weight, nylon is weaker in the wet mesh than is good grade linen. Looking at it the other way, if you want your nylon net to be as strong in water as was the linen net you used to use, then your nylon net must be slightly heavier than your linen net. If the line for linen netting made with #40 yarn was drawn in Fig. 4, it would lie between the line for linen made with #50 yarn and that for Type 66 nylon, so that, for the same weight, the nylons are weaker even than #40-yarn linen nets.

(c) Specific strength as a measure of quality

For any given material, a heavier net is a stronger net. If a certain manufacturer's product is poor quality, he can bring it up to strength by making it heavier without improving the quality. To determine quality, then, it is necessary to compare strength on a basis of equal weight. In Section 2(b) above, we tried to compare

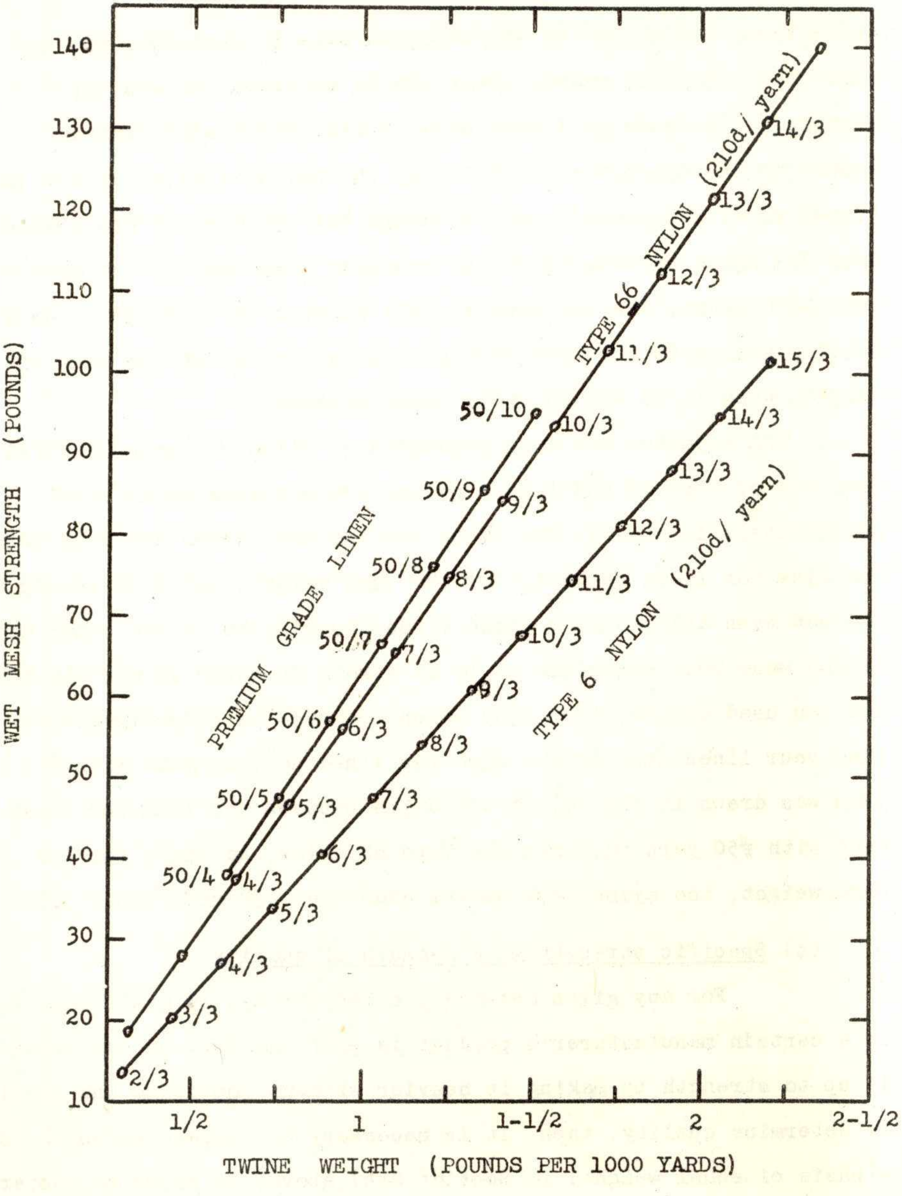


Fig. 4 Wet Mesh Strengths of Nylon and Linen Double-Knot Nets Compared on an Equal Weight Basis

nylon with linen, but the picture was somewhat clouded because these two materials are not made in exactly the same twine sizes. One way to compare strengths of different twines on an equal weight basis is to calculate what is called "specific strength". Specific strength is the greatest length of dry twine which can be supported by a single piece of that same twine without breaking it. The supporting piece of twine may be dry or wet or knotted, or two of them may be tied together to form a mesh. Suppose we have two twines of the same quality, one twice as heavy as the other for pieces of the same length. If both twines are made in the same way and of the same material, the heavier twine will have twice the cross-sectional area and about one and a half times the diameter of the lighter twine. When the quality is the same, the heavier twine is twice as strong as the lighter twine so it will support twice as much weight. But the heavier twine is also twice as heavy as the lighter twine so that the same length of twine weighs twice as much. Therefore, when a piece of the lighter twine is supporting the largest possible ball of lighter twine without breaking, and a piece of the heavier twine is supporting the largest possible ball of the heavier twine without breaking, then, if the quality is the same, both balls will contain the same length of twine and their specific strengths are the same. If a piece of another kind of twine will support a greater length of this other kind of twine, then its specific strength is greater and its quality better.

To calculate the specific strength of twine, simply multiply the strength by the yards per pound.

$$\frac{\text{Specific strength of}}{\text{twine in yards}} = \frac{\text{Twine strength}}{\text{in pounds}} \times \frac{\text{Twine weight in}}{\text{yards per pound}}$$

When the mesh strength of gill-net web is tested, the breaking load is distributed between the two sides of the mesh. That is, two twines carry the load. The mesh strength is thus about twice as great as the knot strength. But, in order to be a measure of quality, the specific strength should be about the same for the mesh and the knot. When calculating the specific strength of the mesh, then, it is necessary to find the greatest length of the same kind of twine which can be supported by half a mesh.

$$\frac{\text{Specific strength of}}{\text{mesh in yards}} = \frac{\text{1/2 mesh strergth}}{\text{in pounds}} \times \frac{\text{Twine weight in}}{\text{yards per pound}}$$

The specific strengths of the twine and mesh of the nylons, of linen, and of Terylene are given in Table 7 in Appendix A at the back. Note that the specific strength is the same for all sizes of twine of the same quality and in the same state. Comparing these figures confirms the previous observation that dry nylon is stronger than dry linen, but that wet nylon is weaker than wet linen on an equal weight basis. They also show that, although Type 66 nylon is nearly 2/3 stronger than Type 6 nylon in the straight twine, it is less than 1/3 stronger in wet netting. Further, both types of nylon netting are stronger with the double knot than with the single knot. Specific strength figures for linen show that gill-net web made from #50 yarn is better quality than that made from #40 yarn.

(d) The importance of toughness

If a gill net, no matter what it is made of, is to keep a salmon that has been caught, then it not only must be strong enough to hold the salmon but it also must be tough enough to absorb the energy which the salmon exerts on the net in its fight for freedom. Toughness is made up of two things, strength and elasticity, so that strength is only half the story and elastic stretch should also be considered in order to understand better why different gill-net materials behave differently.

A simple experiment shows more clearly how toughness contributes to the fish-holding power of a gill net. Soak a piece of 5/3, Type 66 nylon mending twine in water for about an hour, then tie a short loop by means of a bowline knot in each end of the twine. (The bowline has the same shape as the single knot shown in Fig. 1 with the upper right and lower left legs joined to form the loop, the upper left leg being the long, standing end, and the lower right leg being the short end). Hang one loop over a rigid support which has clear space underneath and hang a 3-lb. weight from the other loop. Table 1 in Appendix A tells us that 5/3 nylon twine has a wet, single-knot, mesh strength of 44 pounds. Thus, our single twine should hold about 22 pounds before breaking and can easily support the 3-lb. weight we have hung from the bottom loop. Now hold the 3-lb. weight, still attached to the bottom loop, up beside the top loop, and let it fall freely. The falling weight breaks the twine. The twine was strong enough to hold the weight when still, but was not tough enough to absorb the energy gained by the weight during its fall. The weight did not become heavier as it fell, but it increased in what is called kinetic energy --- and fighting fish have plenty of this.

Fig. 5 shows how different gill-net materials stretch under load. Distances from bottom to top represent load, and distances from left to right represent stretch. Type 66 nylon is stronger than Type 6 nylon, and stretches slightly more before breaking. Wet linen is slightly stronger than wet nylon but it stretches only one quarter as much before it breaks. The much greater stretch of nylon under load partly explains why nylon gill nets of the same twine size and mesh length catch a much wider range of fish sizes (big ones and little ones as well as average) than do linen gill nets. Terylene (Dacron) is between linen and nylon in stretchability. The load on the twine that causes the stretch has been converted from measured load to specific load for Fig. 5. This was done by multiplying the measured load by the yards per pound of the dry twine in the same way that specific strengths were calculated in Section 2(c) above for Table 7. Thus, the behaviour of each material is represented by one curve in Fig. 5, whether the twine is large or small. The actual load required to cause a certain amount of stretch in a particular size of twine may be calculated by dividing the specific load for that stretch by the yards per pound of that twine. For example, according to Fig. 5, Type 66 nylon when wet stretches 10% under a specific load of about 10,000 yd. Therefore 5/3 nylon twine, which according to Table 1 has 1280 yds./lb., stretches 10% when a load of 10,000/1280 = 7-3/4 lb. is first applied to the wet twine. The mesh length will increase 10% under a load of about 2 x 7-3/4 = 15-1/2 lb., 7-3/4 lb. on each side of the mesh. In Fig. 5, the maximum specific load, that is, the specific strength of the twine, is marked with a "+",

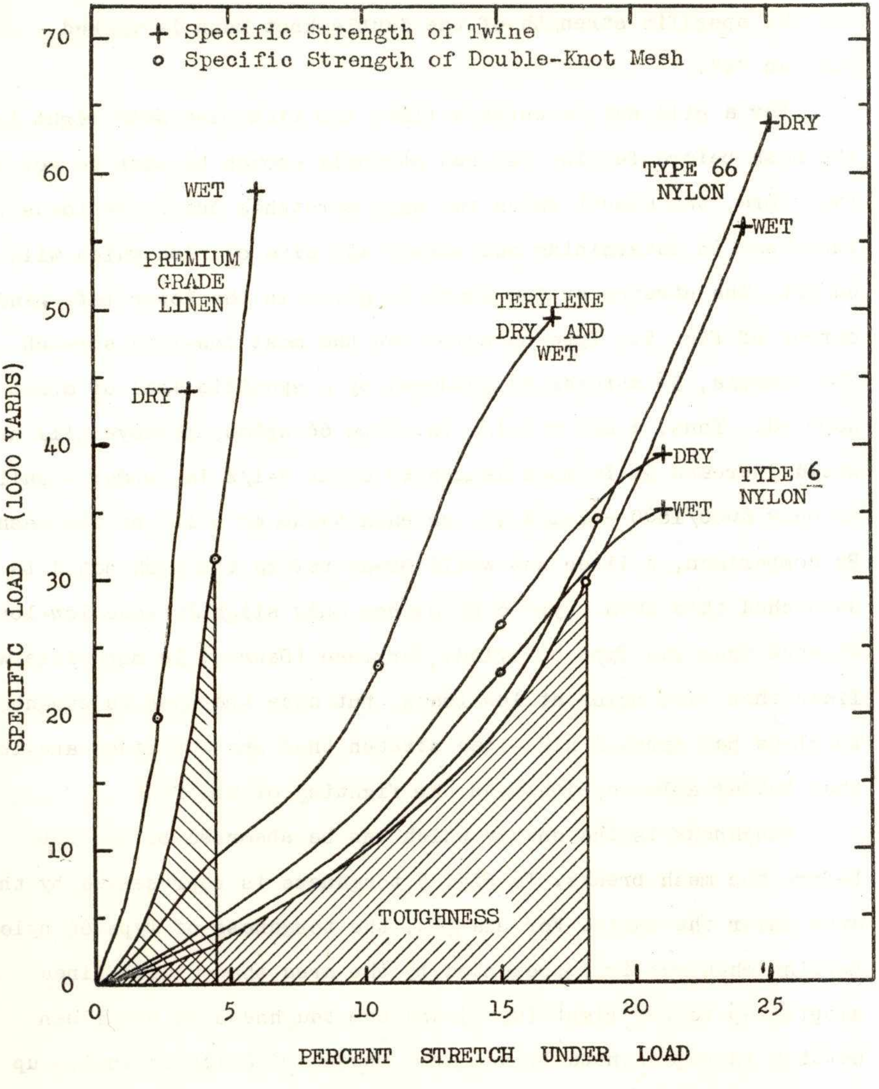


Fig. 5 Load-Elongation and Toughness of Different Twines and Web for Salmon Gill Nets

and the specific strength of the double-knot mesh is marked with an "o".

For a gill net to catch a fish, the fish must swim right into the mesh before feeling the net strongly enough to want to get out. Therefore, the amount which the mesh stretches under low loads is important in determining the number and size of fish which will be caught. The stretch at low loads is given in the lower left-hand corner of Fig. 5. Type 66 nylon has the most low-load stretch. For example, 5% stretch is produced by a specific load of about 4000 yd. Thus, a 4/3 x 5-1/4 in. Type 66 nylon, sockeye gill net would increase 5% in mesh length to about 5-1/2 in. under a pull of only 4000/1600 = 2-1/2 lb. on each twine or 5 lb. on the mesh. By comparison, a linen net would break before the mesh could be stretched this much. Type 6 nylon has only slightly less low-load stretch than has Type 66 nylon. Terylene (Dacron) is more like wet linen than like nylon at low loads, but once the fish is caught, Terylene has greater high-load stretch than has wet linen and is thus better able to withstand the fighting of the fish.

Toughness is the energy which can be absorbed by the web before the mesh breaks. In Fig. 5 toughness is represented by the area under the curve. For example, the toughness of Type 66 nylon netting when wet is represented by the area shaded with lines sloping up to the right (N.E.) and the toughness of wet linen netting is represented by the area shaded with lines sloping up to the left (N.W.). From this it may be seen that Type 66 nylon gill-net web is over four times as tough as linen gill-net web of the same weight. Thus, for the same job, it is often possible to use a Type 66 nylon net which is lighter than a linen net because it is tougher, even though it is weaker.

Another simple experiment shows more clearly how Type 66 nylon is tougher than good grade linen. Soak in water, preferably overnight, a piece of 5/3, Type 66, nylon twine and a piece of 50/5 linen twine of good quality, each about a yard long. The yards per pound, the wet knot strength, and the toughness of these two twines are:

Twine	5/3 nylon	50/5 linen
Yards per pound	1280	1330
Wet knot strength (lb.)	22	24
Toughness (in.-lb./in.)	1.5	0.33

As in the experiment described above, tie a short loop in each end of each piece of twine by means of a bowline knot and hang each piece of twine by one of its loops from a rigid support. The twines should hang freely. Hang a one-pound weight from the bottom loop of the linen twine, then lift the weight, with the bottom loop attached, up beside the top loop of the linen twine, and let the weight fall freely. The falling weight gathers more energy during its fall than the linen twine can absorb and the twine is broken. Now do the same thing with the nylon twine. The nylon is tough enough that it can absorb all the energy in the moving weight, and the weight simply bounces on the end of the twine. (Don't get hit by the weight). Thus, where resistance to energy is concerned, toughness is more important than strength and a fighting salmon can break the mesh of a 50/5 linen net more easily than it can break the mesh of a 5/3 nylon net because 50/5 linen is not so tough as 5/3 nylon, even though it is stronger.

(e) Strength loss during use, related to desirable new strength

Another factor to consider when choosing the twine size for a nylon gill net is the way in which the strength decreases during use. It has been found that, on the average, a well-cared-for nylon net loses about 1/4 of its new strength during the first season, and most of this loss occurs during the first two weeks or so of use. During the second season, the wet mesh strength falls about another 10%. Linen, on the other hand, if well cared for, loses about 17% of its new strength during the first season and another 12% during the second. These are average losses, and individual experiences vary quite widely. Fig. 6 shows how this strength loss occurs on the average for several popular sizes of Type 66 high tenacity nylon and for premium grade linen double-knot gill-net web.

It is common practice to discard a linen sockeye net when its wet mesh strength drops to about 30 lb. (this varies with the fishing area). Referring to Fig. 6 and using this 30-lb. discard standard, an average 50/5 linen sockeye net, if properly cared for, is seen to last about three seasons. If a fisherman gets more than one season out of a 4/3 nylon sockeye net he is lucky, but he should expect two seasons out of a 5/3 nylon sockeye net. Thus, because a 5/3 net costs only about one-sixth more than a 4/3 nylon sockeye net, the 5/3 net is the cheaper in the long run. On the other hand, a 4/3 nylon net has slightly finer twine than has a 5/3 nylon net and so should catch more fish per set under the same conditions, while it is still strong enough to hold the fish. Some fishermen prefer the lighter net, taking the chance that it will catch enough extra fish to

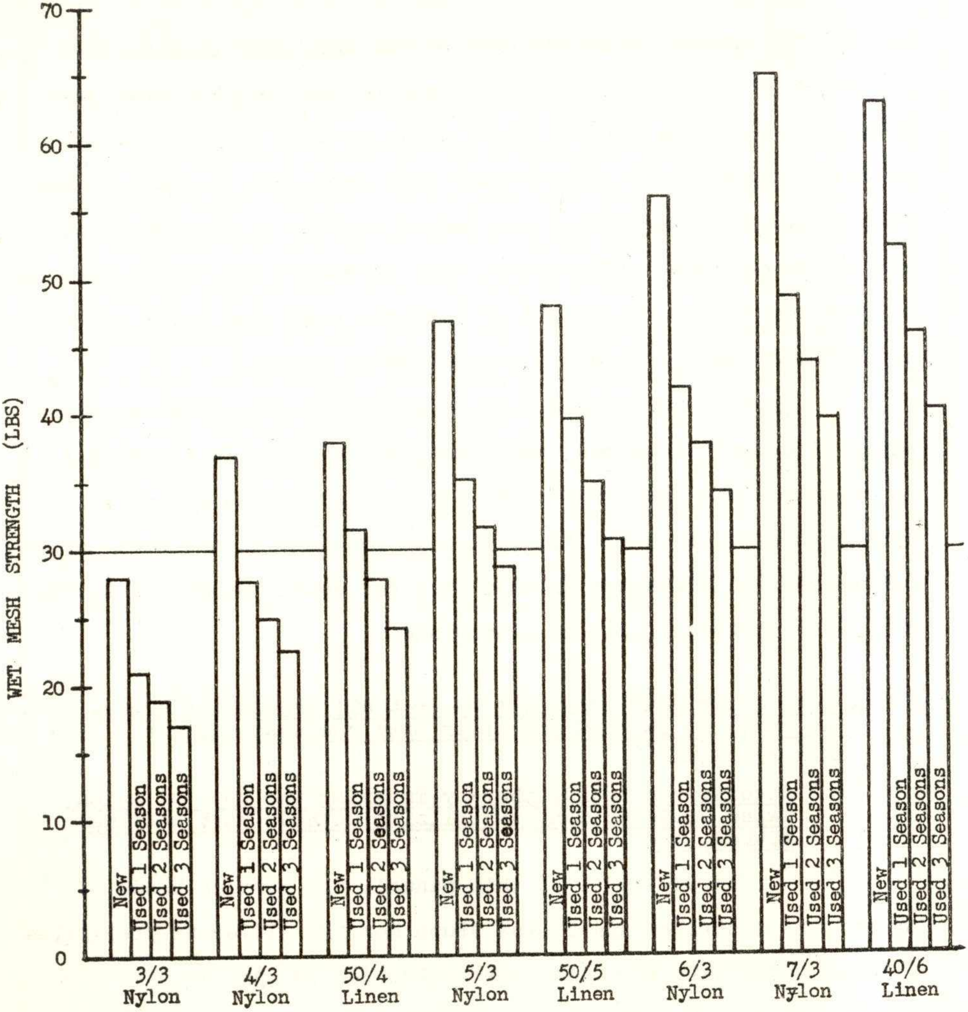


Fig. 6 Drop in Wet Mesh Strength During Use of Linen and Type 66 (210d) Nylon Double Knot Netting.

pay for the higher, long-run cost of the web. More conservative fishermen prefer the heavier net, keeping the long-run gear cost down, and depending more on their skill to keep their catch up. Often the mesh length requirements vary from year to year and the mesh length of a particular net cannot usually be changed to meet the new requirements. Therefore, some fishermen buy the lighter net to last one season regardless of long-run cost, and buy a new net of different mesh length for the following season.

Because conditions vary so greatly among different areas, among different fishermen, and from year to year, it is impossible to recommend the one "best" net. Instead, it is the aim of this manual to place as much information as possible in the hands of the net bosses and fishermen so that they can decide which net is "best" for their particular set of conditions.

3. How to order your nylon net --- not all brands are marked the same, so be sure you order what you want and get what you order

(a) Specify the brand, thereby implying the type of nylon, twine construction, stabilizing method, knot setting method, etc.

In Section 1 of this manual, the various kinds of nylon were described and it was shown how the different properties of each nylon suit it to the particular job it must do. For the netting itself, the only form in which the nylon is fine enough and strong enough to work efficiently, is the continuous multifilament form, where each of many fine nylon "hairs" runs from one end of the twine to the other. Staple or spun nylon web is about 80% as strong as continuous multi-filament nylon web of the same weight.

Further, staple nylon twine tends to puff out in the water and to collect dirt and small growth much more than does continuous multifilament nylon twine. Thus, for the same weight, staple nylon twine is much thicker, particularly in the water. Continuous monofilament nylon web is also about 80% as strong as continuous multifilament nylon web of the same weight. However, monofilament nylon is so springy that the coarsest monofilament which can, so far, be handled by the netting looms is only one one-hundredth of an inch in diameter. This is so fine that the wet mesh strength is only 4-1/2 lb., far too weak for salmon. Therefore, when you order a nylon gill net for salmon, most suppliers will give you web made from continuous multifilament nylon, whether you specify it or not.

Both Type 6 and Type 66 nylons are available in continuous multifilament gill nets for salmon. Generally speaking, Type 6 is cheaper and weaker for the same weight net, whereas Type 66 is more expensive but is finer and stronger. So far, at least, the same brand name is not used for both types of nylon gill net. Therefore, by specifying the brand, you automatically specify the type of nylon. At present, nylon salmon gill nets made in Canada, Britain, and the United States are Type 66 nylon, and most of the nets made in Japan are Type 6. Nylon salmon gill nets from Europe are mostly Type 66, although other nylons may also appear. Other differences, such as arise from yarn tenacity, yarn and twine constructions, twist hardness, stabilizing method, knot setting method, and after-treatment, also vary among different brands and often from year to year in the same brand. Any comment here on how the various brands compare in these differences could not be impartial and probably would be obsolete before this manual could be available. It is better that the net buyer find out from the net salesman what each brand offers and then buy the brand whose particular combination of properties best suits his particular needs.

(b) Specify the type of knot

The second thing to specify is the type of knot. The single knot and the double knot are more widely used than any other for British Columbia salmon gill nets, although the various lock knots are appearing in increasing quantity (see Section 1(h)). In single-knot web the knot is smaller and the web is cheaper but the mesh is weaker than in double-knot web. In many brands of single knot web the problem of knot slippage has been solved by treating the netting after it has been knitted, but double-knot web generally tends to be the more stable. Often the way in which the individual fisherman handles his net will determine which knot is better, therefore it is not possible to recommend the "best" knot here.

(c) Specify the twine size, making sure which numbering system is being used

As explained in Section 1(e), there are several different numbering systems used to identify the twine size. Most of the systems are based on the construction of the twine and hence are quite similar, but certain Japanese nets are marked according to a system which looks like these others but is, in fact, different. It is necessary, therefore, that the buyer and the seller of nylon gill net web understand clearly which twine numbering system is being used in each order. The system which gives the yarn denier, the number of yarns per ply, and the number of plies in the twine (for example 210d/5/3) is recommended because it describes the twine very specifically and because it is used generally in the Canadian, British, and American textile industries, sometimes with minor modifications. The system used on certain Japanese nets where, for example, a 210d/5/3 twine is called #43, is not recommended because it is confusing and misleading. It can result in a net being ordered in one twine size and delivered in another unless both the buyer and the seller are sure they are using the same numbering system. The system which gives the total number of yarns in the twine (for example, 210d/5/3 is called #15) is less confusing than this last system, but it does not tell so much about the twine as does the recommended system. If there is question as to whether the net has been delivered as ordered, the weight of the net (see Section 3(h)) or the yards per pound of the twine (see Appendix A) may be used as a rough check, or the twine may be untwisted and the number of yarns counted. Counting the number of yarns is almost impossible unless both ends of the twine are controlled during untwisting.

(d) Specify the mesh length --- four factors affecting mesh length measurement

The way in which the mesh is measured can make quite a large difference to the result of the measurement. If the same piece of netting is given to ten different net bosses and fishermen without saying first how the mesh is to be measured, chances are that ten different mesh lengths will be reported. As shown in Fig. 7, there are four factors which affect the result of mesh length measurement more than any others.

The first factor is whether the net is dry or wet. Most manufacturers report the mesh length of dry netting, but nylon web increases in mesh length between 1/2% and 1-1/2% when it is wetted (Fig. 7A), whereas linen shrinks about 1-1/2%. This means that if, for example, you want your sockeye net to have a mesh length of 5-1/4 in. in the water, then your nylon net should have a dry mesh length of about 5-3/16 in. and your linen net should be slightly over 5-5/16 in. dry. These different effects of wetting on mesh length can also alter the required "hang-in" of the net. For example, if your linen nets were hung in two meshes to one when dry, then, to get the same mesh shape in the water and on the same lines, your nylon net should be hung in two meshes to about 1.03 meshes when dry. Therefore, to get the same wet "hang-in" with nylon as with linen, when hanging nylon sockeye nets the hanging-bench gauge should be set against the dry mesh a little more than 1/8 in. wider per mesh and for nylon fall nets a little less than 3/16 in. wider per mesh, than you would set it for corresponding linen nets.

The second major factor affecting the results of mesh length measurement is whether or not the length includes either or both of the knots. Many fishermen measure the inside of the mesh (Fig. 7B) because that is where the fish are caught. However, many manufacturers report the mesh length of salmon gill nets to include one knot. When ordering nets from such manufacturers, these fishermen should allow for the width of one knot when specifying mesh length, the allowance being greater for coarser twines than for finer, and greater for double knot than for single knot netting. In any case, it is wise that both the buyer and the seller of the net make sure they are measuring the mesh the same way.

The third major factor affecting the results of mesh length measurement is the direction in which the mesh is pulled while it is being measured. Normal procedure is to stretch the mesh in the up-and-down direction as the net hangs in the water. This is the way the mesh is stretched on the racks and, usually, when hanging in the storage. But the mesh is stretched the other way on the drum and sometimes when new and in the bale. The mesh measures longer when pulled in the up-and-down direction than in the sideways direction. The knots should lie in the manner shown as "up-and-down" in Fig. 7B while the mesh is being measured, single knot as at the top and double knot as at the bottom. This third factor is more important when measuring the mesh length of seine and trawl web than when measuring the mesh length of gill-net web.

The fourth, and probably the most important, factor affecting the results of mesh length measurement is the amount of tension or pull exerted on the mesh while it is being measured. As shown in Fig. 7C, a 4/3 x 5-1/4 in. mesh nylon net for sockeye can be made to look like a 5-1/2 in. mesh net simply by exerting a 5-lb. tension on the mesh and a 13-lb. tension makes it look like a 5-3/4 in. mesh net. Heavier twines do not stretch quite so easily as this, but lighter twines stretch more easily. In any case, the best plan is to hold the mesh with just enough pull to keep the bars of the mesh straight and beside one another, but not with enough pull to stretch the mesh. This extreme stretchiness of nylon also makes it advisable to purchase a nylon gill net with a smaller mesh than in a linen gill net when fishing for the same average-size salmon.

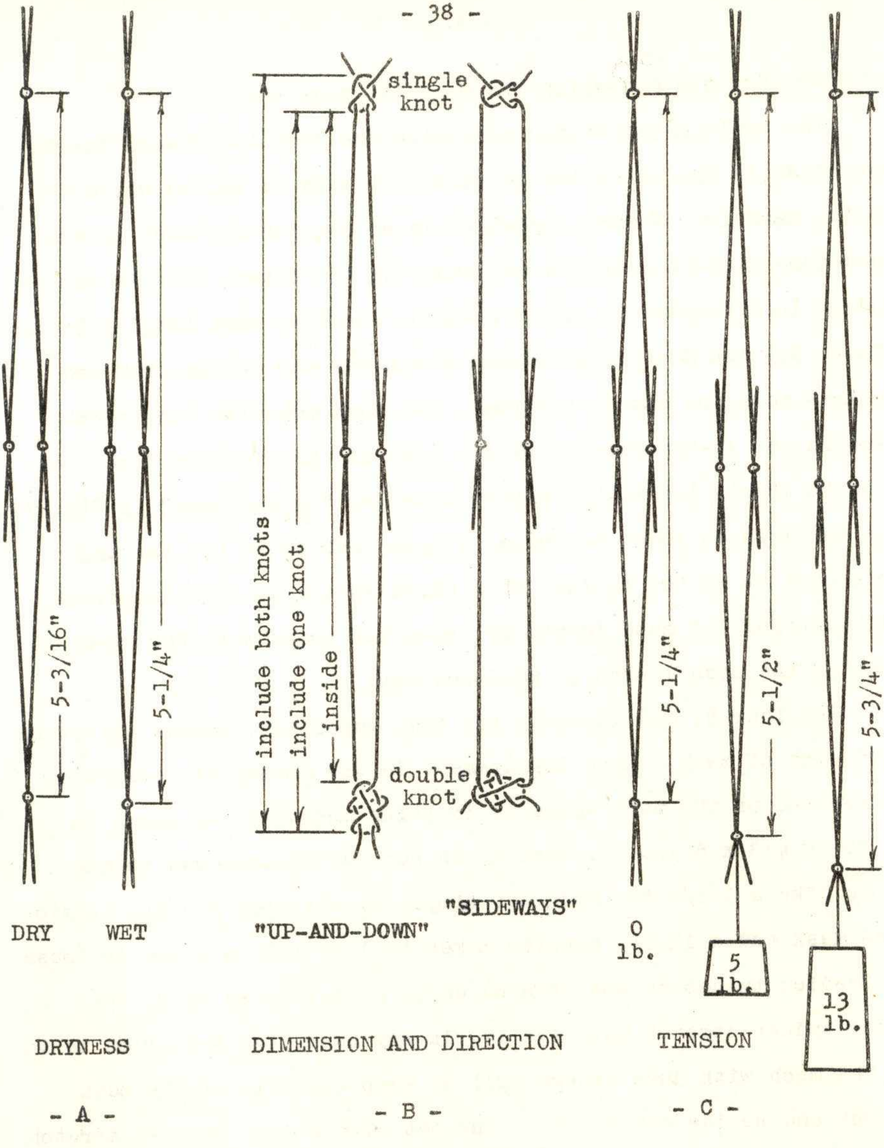


Fig. 7 Factors Affecting Mesh Length Measurement
(based on Type 66 nylon, 210d/4/3 twine, and 5-1/4 in. wet mesh)

(e) Specify the depth of the net

The depth of the strip of netting is usually expressed as the number of meshes between the two selvedges. Most suppliers continually check the Fishery Regulations and provide nets which have the maximum legal depth. However, some fishermen who fish shallower waters prefer nets of less than the maximum legal depth to avoid excessive wear and snagging. In any case, it is best to specify the depth of the strip when placing the order.

(f) Specify the length of the strip of netting

The length of a strip of gill-net web is usually expressed in fathoms and is measured when the strip is stretched out lengthwise unhung. There are no standard lengths but a 200-fm. cork line usually carries about 400 fm. of netting. Many fishermen order just enough web to assemble a net of maximum legal length, others like to order a little spare web in case they tear their net.

(g) Specify the colour, even when ordering white web

Most brands of nylon gill net are available in several shades of green and blue, and one brand even supplies web in which both green and white strands are twisted into the same twine. Net salesmen usually carry dyed samples so that their customers can see exactly what shades are available. Many fishermen prefer to purchase white netting and to dye it themselves (see Section 4). If colour is not specified, many suppliers will provide white netting, but it saves a lot of confusion if colour, even white, is specified with each order.

(h) Formula for estimating the weight of gill-net web

Most nylon gill-net web for salmon is sold by the pound, so that often the purchaser wishes to estimate the weight of different sizes and styles of netting. Also, by comparing the actual weight of a net with what it should weigh, it is often possible to check if the right twine size has been supplied. The following formula permits the estimation of what a particular strip of unselvedged nylon web for a salmon gill net should weigh:

$$\text{weight} = \frac{\text{yarn denier x number of yarns x depth x length}}{840{,}000}$$

where the weight is in pounds, depth in meshes, and length in fathoms. The result of using this formula is only an estimation and the weight of individual nets may vary as much as 5 or 10% from the calculated value. Also, if the web has been coated, the weight may be noticeably increased. For web made with 210-denier yarn (this includes most nylon gill nets for British Columbia salmon), the above formula simplifies to:

$$\text{weight (lb.)} = \frac{\text{yarns per twine x meshes deep x fathoms long}}{4{,}000}$$

For example, to find the weight of a strip of nylon web for a sockeye gill net made of 210d/5/3 twine and 50 meshes deep by 400 fm. long, first determine the total number of yarns in the twine. A 5/3 twine contains 5 yarns in the ply and 3 plies in the twine (see Section 1(e)), making 5 x 3 = 15 yarns in the twine. Then, according to the formula, the weight of the strip of netting is estimated to be:

$$\begin{aligned}\text{weight (lb.)} &= \frac{15 \times 50 \times 400}{4000} \\ &= 75 \text{ lb.}\end{aligned}$$

Similarly, a "fall" net made of 210d/6/3 twine, 60 meshes deep by 500 fm. long has 6 x 3 = 18 yarns in the twine and weighs about

$$\text{weight (lb.)} = \frac{18 \times 60 \times 500}{4000}$$
$$= 135 \text{ lb.}$$

Some manufacturers mark their nylon gill nets according to "standard" weights, often to adjust their overweight nets to competitive prices. The above formula estimates actual weights, not "standard" weights.

(i) Defects which may be found in gill-net web

Generally speaking, the quality of nylon gill nets for salmon is quite good. However, defects sometimes do appear. Assuming adequate wet mesh strength, the following mechanical defects are the result of poor workmanship by the manufacturer.

1. Kinking of the twine --- if the various twists in the yarn, ply, and twine are out of balance, the twine tends to curl into loops when lying slack. This defect cannot be corrected, but must be avoided when the twine is first made. Sometimes harsh treatment, such as prolonged boiling or dry heat, will throw the twine out of balance and cause kinking, but the manufacturer cannot be held responsible for this.
2. Uneven twine --- if the twine has a regular "lumpiness", this may be caused by one of the plies being shorter than the other two (try pulling one of the plies of a piece of nylon mending twine to see what it looks like). Such twine is abnormally weak because most of the load is thrown onto the short ply. This defect occurs only rarely and then usually only in short lengths of twine. It is simplest just to cut out the defective bars and mend the net.

3. Frayed twine at the knots --- if the hooks on the netting loom are too sharp or if the netting has been stretched too much after knitting to square the meshes or tighten the knots, some of the individual filaments are often broken at the knot and filament ends stick out. Such netting should be tested for wet mesh strength before use.

4. K-mesh --- if the netting looms are not properly adjusted, they sometimes make uneven meshes. This unevenness is usually seen most easily when the net is on the rack, and looks as shown in Fig. 8. The name "K-mesh" comes from the fact that the bars from any one knot form the letter "K" when the netting is laid flat. Sometimes the factory will try to correct K-mesh by stretching the web. However, in such cases the knots are usually very hard, and some K-meshes are usually still present.

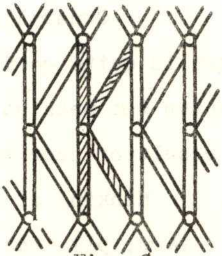


Fig. 8
K-mesh

5. Open knots --- if the knots have not been properly set at the factory they will tend to spring open and become very loose. If such a net is fished, the knots will slip and the meshes will be pulled out of shape. This defect may be corrected by putting the web back on the stretcher and tightening the knots, or by going over the net and tightening the knots by hand. The knots should then be set, preferably by moist heat, or by immediately fishing the net carefully before the knots have a chance to open up again.

6. Slip knots --- if one of the bars from one of the knots is pulled and that twine slips within the knot before it breaks, then the netting is subject to knot slippage. Slip knots occur more frequently in wet netting than in dry netting. They are considered to be as serious a defect as low mesh strength because a slipped knot means a distorted mesh which must be cut and mended just as much as if it had been broken.

7. Ease of knot inversion --- as pointed out in Section 1(h), the single knot, the "knot-and-a-half", and the double knots can sometimes be turned into slip knots by pulling on the two legs which come out of the bottom of the knots in Fig. 1. The knot can then easily be slipped along the twine which was pulled to form the slip knot. In such web, a salmon caught in one of the meshes may turn the knot at the top of that mesh into a slip knot. That mesh will not pull out of shape and the salmon should remain caught, but another salmon caught afterwards in either of the two meshes immediately above the mesh that caught the first salmon will be able to push through the net quite easily by slipping the knot.

8. Uneven colour --- as will be explained in Section 4, nylon is one of the more difficult fibres to dye. There are many problems in trying to produce the desired shade and a uniform shade throughout the net. If the strip of web has been dyed after it has been knit, sometimes the two ends of the net are two different shades. More often, the dye does not penetrate the knots so that, when the knots tighten during use, short lengths of white or light-coloured twine appear at the knots.

Also, if the knots are pulled too tight before dyeing, the nylon under tension in the knots takes less dye than does the slack twine in the mesh bars, resulting in the knots being a lighter shade than the rest of the net. These types of unevenness are avoided by dyeing the twine before it is knit into web. However, if the nylon is dyed in the twine and the colour varies from one end of the twine to the other, then streaky shades appear in the netting. This streakiness shows up most after the web has been "picked up" or when the net is on the rack. If the nylon is dyed in the yarn before the twine is twisted, then uneven dyeing results in a mottled appearance of the twine. Sometimes an uneven dye job is considered an advantage on the theory that such nets are less visible to the fish.

(j) Summary

When ordering nylon netting for salmon gill nets, the following things should be specified:

1. Brand --- this implies the type of nylon, yarn tenacity, yarn and twine constructions, twist hardness, methods of stabilizing and knot setting, and any other special treatment.
2. Type of knot --- usually single knot or double knot.
3. Twine size --- this usually follows the numbering system used in this manual, but watch out for exceptions.
4. Mesh length --- preferably measured on wet netting, between knots, and under minimum tension. In choosing your mesh size, allowance should be made for the increase in mesh length when the netting is wetted and for the extreme springy stretch of nylon.

5. Depth of the strip as indicated by the number of meshes between the selvedges.
6. The length of the strip in fathoms when the strip is stretched lengthwise.
7. The colour, even if you want a white net.

If, after the net has been delivered, the weight does not seem right, it may be checked with the help of the formula in Section 3(h). The general workmanship may be judged, watching for kinky, uneven, or frayed twine, K-mesh, knots which are open, slip easily, or turn easily into slip knots, and uneven colour. When testing for mesh strength, it is advisable to wet the netting thoroughly first, and machine tests are more accurete than hand tests.

4. What kind of dye job do you want?

(a) Why gill nets are often coloured, and some problems encountered

There are many different ideas concerning which colour will make a gill net catch the most fish. For linen gill nets, the natural, light grey-brown colour is used mostly for river fishing, and various shades of green are used for channel, strait, and ocean fishing. A mottled green, produced by dyeing some of the yarns green and leaving others the natural colour, was popular in some areas. The natural colour of nylon is a shiny white which is far too visible in clear water and which many fishermen consider too visible even in the river. Silt, suspended in river water, works its way into the nylon filament during the first two or three weeks of river fishing, gradually making the net a light brown colour. This colour is probably very good camouflage in the river, but many fishermen prefer to dye their nylon nets, even for river fishing. Many colours have been tried --- pale green, pale blue, pale yellow, pink, red, deep brown, etc. --- with varying degrees of success. For fishing in clear water, several shades of green ranging from light to nearly black have been used successfully on nylon nets. Very little controlled scientific work has been done to determine how fish react to different colours so that it is impossible to state, except in a most general way, which colour will result in the biggest catch under a certain set of conditions. Obviously as conditions change, so will the colour requirement. Therefore, it is best for the fisherman himself to decide what colour he wants, and the purpose of this section is to describe how that colour may be obtained.

The same properties which prevent nylon from soaking up much water and permit it to dry quickly also make nylon relatively difficult to dye. Ordinary dyes which do a good job on linen and cotton do not work well on nylon. Usually, they will tint nylon slightly, but most of the dye remains in the dye solution, and that which goes onto the nylon washes out quite quickly during fishing. Thus, it has been necessary to develop a whole new set of dyes specially for nylon, and only these dyes will do a good job on nylon. Some of them hold their colour very well through the fishing season, but others tend to fade. Most of them may be removed by suitable bleaches so that the net may be re-dyed a lighter shade if necessary.

The bluestone solution, often used to clean nylon nets, occasionally affects the dye on the nylon. It makes some of the "Direct" dyes more resistant to fading during fishing, but it also makes them more resistant to chemical bleaching. Further, some dyes change colour when a nylon net dyed with them is put into bluestone solution. These last dyes should be avoided.

Any hot water treatment, such as dyeing or bleaching, is almost sure to alter the mesh length of a nylon net. Whether the mesh length increases or decreases, and by how much, depends on what has happened to the net in the past. Used nets usually shrink, although sometimes the mesh length increases. New "stabilized" nets usually shrink slightly (not often more than 2% to 3%), whereas unstabilized nets sometimes shrink as much as 8% to 10%. "Hot stretched" nets usually shrink slightly more than "stabilized" nets. When a net has been bleached, the mesh length usually stays fairly constant through re-dyeing. If any change in mesh length is a serious matter, a piece of the netting should be soaked in cold water and measured for wet mesh length, boiled in water for about half an hour, cooled, and checked while still wet for change in mesh length before the whole net is dyed or bleached.

Besides changing the mesh length, these hot water solutions may also affect the knots. If the knots in new netting are well tightened, then dyeing will set the nylon twine into the shape of the knots, and slippage and inversion are not likely to occur after that. However, if the knots in new netting are coming loose, then dyeing will loosen them further. The knots in used netting are usually well tightened and set so that dyeing and bleaching do not have noticeable effect. Incidentally, the short lengths of undyed twine which sometimes appear at the knots after fishing a net that was dyed when new can be avoided if the new net is fished white for a couple of weeks before dyeing.

(b) Characteristics of different types of nylon dye

The art and science of dyeing nylon is very complex. Dozens of dyes are now available and they cannot all be used in the same way. Therefore, all the problems of dyeing nylon cannot be covered in a manual such as this. Instead, the most important types of nylon dye will be described and compared so that you will at least know the relative advantages and disadvantages of these different types.

The type of nylon dye which is the easiest and the safest to use is known as "Dispersed Acetate Dye". It is prepared by the manufacturer as a powder which can be dissolved directly in hot water. Nothing else needs to be added to the dye solution and uniform colours may be obtained at temperatures as low as 180°F. A good variety of shades is available by blending different colours and by changing the amount of dye in the solution, and more dye may be added to the solution during dyeing if the colour is too light. These Dispersed Acetate Dyes can thus be used safely with good results in the relatively simple equipment available at most net lofts. However, this type of dye tends to fade so that the colour of your net becomes lighter through the fishing season.

Another type of dye, which largely overcomes the fading problem, is known as "Developed Acetate Dye". However, relatively few shades of colour are available, there is little control of the colour after dyeing starts, and the nylon must be put through three separate tanks before the dyeing process is complete. Because these dyes require special equipment and experienced operators for successful results, they will not be described further in this manual.

Certain dyes of the "Direct" and "Acid" types are available in a good range of shades and give colours on nylon which do not change noticeably during fishing. However, these dyes are relatively difficult to apply. Temperatures of at least 200°F. are required and often the nylon must be dyed under pressure. Further, the "Acid" dyes need to be applied from an acid solution which, if used improperly, can weaken the nylon. Also, nylon is not perfectly uniform. Slight variations in making the multifilament yarn, in stretching it, and in setting the twist and the knots can cause slight variations along the twine. These dyes, particularly the "Direct" dyes, are very sensitive to the variations in the nylon, giving corresponding variations in colour unless special care is taken during dyeing.

There is one type of "Acid" dye, known as "Premetallized Acid Dye" which, unlike the other "Acid" dyes, can give good results in a simple heated tank. However, it requires acid in the dye solution and must be used more carefully than the "Dispersed Acetate Dyes". The "Premetallized Acid Dyes" are available in a good range of shades and maintain a more constant colour through the fishing season than do the "Dispersed Acetate Dyes", but it is more difficult to get an even colour through the net in the first place. When a nylon gill net from one source has been mended with nylon twine from another source, the mends will often come out of the dye tank a different shade from the rest of the net, even if the net is dyed with great care.

The so-called "cold water" dyes are actually the same as the "hot water" dyes described above, usually of the "dispersed Acetate" type, the only difference being in the way the dye is applied and in the results obtained. The rate at which dyeing occurs is very much slower at low temperatures than at high so the instructions for "cold water" dye usually call for a stronger dye solution than is necessary for hot dyeing. Also, it is usually necessary to leave the net in the dye solution for a longer time. Further, the dye cannot penetrate the nylon nearly so well at low temperatures as at high so that "cold water" dyes wash out of the net during fishing more quickly than if applied hot. However, "cold water" dyes can be applied in a simple, unheated tank, so they are useful where fading is not objectionable.

The so-called "oil soluble" dyes are often also of the above types. Many of the dyes used for nylon are only slightly soluble in water, most of the dye being dispersed through the dye solution as very fine solid particles. However, many of these dyes will dissolve in oil. Unfortunately, the dye will not often pass from the cil to the nylon in quantities required for good dyeing, but prefers to remain in the oil. Therefore, nylon usually cannot be dyed properly from oil solution. However, some of the mixtures marketed to bond the nylon (see Section 1(i)) contain an oil-soluble dye. This due usually remains in the coating which the mixture leaves on the surface of the nylon, and wears off with the coating while the net is being used.

In general, then, there are two types of dye which can be used satisfactorily on nylon in relatively simple equipment. The dispersed acetate type is the safest and easiest to use, but its colour gradually fades. The premetallized acid dye has less tendency to fade, but it is harder to get uniform shades throughout the net and the nylon can be weakened if dyed carelessly. However, the most fade-resistant dyes are the hardest to use and are preferably applied by experts in special equipment at the factory. Thus, if the right colour is available, the best dye jobs are on factory-dyed nets, although it does not follow that all factory-dyed nets have the best dye job. Because so many dyes do not work well on nylon, and because so much can go wrong when dyeing nylon, it is suggested that dyed nylon netting and dyes for nylon be obtained only from reputable firms and that only the dyeing method which is recommended for that dye by that firm be used.

(c) How to apply dispersed acetate dyes

Usually, the best way to use a dispersed acetate dye is to get a tank large enough to hold your net plus at least 1 Imp. gal. of water for every pound of nylon in your net. Thus, a sockeye net weighing 75 lb. would require at least 75 gal. of water in the tank, and more water will give a more uniform dye job. The tank should be well washed out before starting. Heat the water in the tank to boiling. If an open steam line is used for heating, allow enough room in the tank for the steam to condense. Next, make a paste with the dye powder and a little hot water. Usually 2 to 4 lb. of dye per 100 lb. of nylon will give a good colour. However, different brands of dye and of nylon behave differently so it is wise to experiment with a small piece of netting first. A wetting agent may be added to the dye paste to help the nylon sink in the dye solution and to give a slightly more uniform colour, but this is not absolutely necessary. The dye paste is stirred thoroughly into the boiling water in the tank. If the water is left boiling in the tank for a few minutes after the dye paste has been added, the dye mixes in more thoroughly. Now, loosen the nylon netting from the bale so that the hot dye solution in the tank can reach all parts of the net easily and quickly, turn off the heat to the dye tank and put the net into the hot solution. It is convenient to make a rack consisting of a wooden frame covered with heavy netting to fit the bottom of the tank, and to lower the gill net into the dye solution on this rack. It may be necessary to put weights on the nylon to hold it down in the dye solution, and it is a good idea to cover the tank to keep the solution hot as long as possible. If the tank is heated by steam coils, the heat may be left on gently after the net has been put in the tank, but if live steam or dry heat such as open flame or electricity is used, the heat should be turned off. The net should be left in the hot dye solution for at least half an hour, and longer gives a more uniform colour. The net may even be left in the solution to cool overnight. It is quite important to move the nylon around in the solution, particularly during the first 10 or 15 minutes, otherwise the colour will be uneven.

If the net is getting too dark before 30 minutes have passed, it may be taken from the tank, but the colour is almost sure to be uneven. For lighter shades it is better to use less dye or to get a dye of lighter colour in the first place. If the net remains too light even after several hours, and the dye solution in the tank is still quite dark, the net may be taken from the tank, the dye solution reheated, common salt up to one pound per gallon dissolved in the dye solution, and the net put back into the tank. This will usually drive the dye from the solution to the nylon to give a darker shade. If the net remains too light and the water in the tank is nearly clear, the net may be taken from the tank, the dye solution heated to boiling again, more dye paste added to the solution and thoroughly mixed in, and the net put back into the tank for at least another half hour. The dyed nylon web should be washed before hanging to dry, otherwise colour may be lost on the first set.

(d) How to apply premetallized acid dyes

Usually, the best way to use a premetallized acid dye is to get a tank large enough to hold your net plus at least 2 Imp. gal. of water for every pound of nylon in your net. Thus, a sockeye net weighing 75 lb. would require at least 150 gal. of water in the tank, and more water will give a more uniform dye job. The tank should be heated by steam coils or, if live steam is used, the steam line should go right to the bottom of the tank, and the open end of the line should be covered with a grid so that steam cannot touch the netting directly. Heat the water in the tank to boiling, allowing enough room in the tank for the steam to condense if an open steam line is used. Make a paste with the dye powder and a little hot water. The amount of dye required varies between 1/2 lb. and 5 lb. per 100 lb. of nylon, depending on the dye and on the shade of colour required. A wetting agent may be added to the dye paste for better results, but it is not absolutely necessary. The dye paste is stirred thoroughly into the boiling water in the tank and formic acid, 3 lb.

for every 100 lb. of nylon, is added to the hot dye solution. If the hot dye solution is left boiling for a little while in the tank after the dye paste and formic acid have been added, the solution becomes more thoroughly mixed. Next, the nylon netting is loosened from the bale so that the hot dye solution in the tank can reach all parts of the net easily and quickly, and the nylon is put into the boiling solution. The tank should be covered as much as possible to keep the heat in, and the net allowed to simmer in the gently boiling dye solution for at least an hour. For uniform results, the net should be periodically moved about in the dye solution, particularly during the early stages of dyeing. If, after an hour at the slow boil, the nylon remains too light in colour and the dye solution remains too dark in colour, the net may be lifted from the dye solution and more formic acid or acetic acid, up to 5 lb. for every 100 lb. of netting, may be stirred thoroughly into the dye solution. The net is then returned to the slowly boiling dye solution for another hour. After the nylon has been dyed, it must be washed thoroughly with clean water (clean sea water is all right) before being hung up to dry otherwise the acid may concentrate on the net and weaken it. Mineral acids, such as sulphuric acid, when added to the dye bath in place of formic or acetic acid, will give better colours, but they are sure to weaken the nylon, even if used at much lower concentrations, so they are not recommended. If the dyed net is not a uniform colour, it should be put back into the hot dye tank and allowed to simmer for another hour or so. The addition of more dye to the solution will simply darken the net but will do little toward making the colour more uniform.

(e) Bleaching and re-dyeing

If you want to make your dyed net a darker colour, it may be re-dyed. It is possible to apply almost any suitable type of nylon dye directly over any other, but a small piece of the netting should be re-dyed experimentally first to find out what shade will result. If you want to make your dyed net a lighter colour, then it must be bleached before re-dyeing. Chlorine bleaches and other oxidizing bleaches cannot be used without harming the nylon. Instead, reducing bleaches of the hydrosulphite or zinc sulphoxylate types should be used. This last is sometimes preferred because it is the more stable in nearly boiling water. Usually, the best way to bleach your dyed nylon net is to get a tank large enough to hold your net plus about a gallon of water for every pound of nylon in your net. Thus, a sockeye net weighing 75 lb. would require about 75 Imp. gal. of water in the tank. Heat the water to boiling, make a paste with the bleach, using water and 3 to 5 lb. of bleach per 100 lb. of nylon, and dissolve this paste thoroughly into the boiling water in the tank. Add 3 lb. of formic or acetic acid per 100 lb. of nylon to the solution and mix thoroughly. The acid makes the nylon more sensitive to the bleach. Turn off the heat to the tank. Loosen the nylon web so that the bleach solution will reach all parts quickly, and place it in the tank. Keep the tank covered as much as possible to hold the heat, and move the netting every so often in the tank. It may require 1/2 to 1 hour at 180°F. to 200°F. to bleach the netting. The nylon is removed from the bleach solution, washed thoroughly, and then may be re-dyed another colour, or hung to dry.

Unfortunately, some nylon dyes return to their original colour when they are exposed to the air after bleaching. Such dyes cannot be bleached permanently, and nylon dyed with them cannot be kept a lighter shade than original without being weakened. White nylon nets which have become discoloured during use usually cannot be bleached satisfactorily, either. The discoloration is caused by dirt embedded in the nylon, and this dirt will not bleach out. However, this off-white seems to be quite a satisfactory colour for river fishing.

5. Several kinds of selvedging and hanging twine are available

(a) Desired functional properties

Hanging and selvedging twines are more than just pieces of string used to tie the netting to the lines. If the gill net is to give good service through the season, these twines must have certain, fairly-well-defined properties.

First, the twine must remain strong enough throughout the season to hold the netting to the lines without breaking under normal fishing loads. While fishing, the twine gets weaker through natural breakdown of the fibre, by wear against the bottom, and from cutting by silt embedded in the twine. Therefore, the size of new twine should be chosen with more than the minimum strength. However, it should not be so strong that the netting is torn if the lead line becomes caught on a snag. The selvedging twine or the hangings at the lead line should break a little more easily than the netting. It is easier to re-hang part of the netting to the lead line than to mend a major tear in the netting itself, particularly with nylon web, and the "re-hang" repair leaves the net in better condition.

Second, the twine should be easy to use and should form knots which are firm when first tied and remain firm under all conditions. As pointed out in Section 1(i), knots in twisted, continuous, multifilament, nylon twine tend to spring open unless bonded or specially set. Therefore, the type of nylon twine used in the web itself is quite unsatisfactory for hanging. Instead, hanging twines are relatively soft so that they can embed in themselves at the knot.

Third, the hanging twine should be able to take a firm grip on the lines. If the hangings slip along the lines, then the gill net no longer hangs properly in the water and its fishing ability is reduced. The effect of the properties of the lines themselves to prevent this action are described in Section 8(a), but the hanging twine should be able to "cling" to the lines as well as to itself. For this reason, staple twines are generally more satisfactory than continuous filament twines.

(b) Cotton twines

For years, soft laid and extra soft laid cotton twines served very well for hanging and selvedging linen gill nets. The size of the twine was chosen to give the right strength for each type of net, the cotton staple in the twine clung well to the cotton lines, and the soft twist combined with the four-ply construction allowed the twine to embed easily into itself at the knots. However, being made of a natural fibre, these cotton twines rot quite quickly if not kept clean. This does not create a problem with linen nets because the linen, too, must be kept clean to prevent rot. But nylon is not rotted by fish slime and so does not require the same cleaning. On nylon nets, therefore, cotton selvedging and hanging twines are not satisfactory because they will not remain strong enough throughout the season unless "bluestoned" regularly and frequently. There are claims that contact with nylon will rot the cotton, but this is not true. Where cotton hangings rot faster on nylon nets than on linen nets, the nylon nets have not been kept as clean as were the linen nets.

(c) Nylon twines

One answer to the rapid rotting of uncleaned cotton hangings is braided, continuous, multifilament nylon twine. These braided twines are very soft and embed well in themselves at the knot. Also, the bumps on the surface of the twine help to keep the knots from springing open or slipping. However, these braided, continuous, multifilament twines do not cling well to the lines unless they are tied very tightly. This situation is worsened by the property of nylon to increase in length when wetted so that the tie loosens in the water. Further, these twines tend to be a little too strong, often causing the web to tear when the lead line becomes caught.

These two major defects of braided, continuous, multifilament nylon are lessened when staple nylon yarn is used to make the braid. The staple yarns are rough and cling well to all but the smoothest lines, and, for the same weight, staple nylon twines are about 80% as strong at the wet knot as are continuous, multifilament twines.

Another twine which is suitable for selvedging and hanging nylon gill nets is staple nylon twine of twisted construction. These twines are usually fuzzier than the other types and have more "clinging" power. They have about 1-1/2 times as much wet knot strength as have cotton twines of the same size. However, sometimes, if they become saturated with fish slime or oil, there is sufficient lubrication to permit the nylon fibres to slip past one another under load so that the twine stretches and may even pull apart. This is eliminated in at least one brand of twine by twisting staple nylon yarns together with continuous multifilament nylon yarns to form the twine. Here, the staple yarns give the twine clinging power and the continuous filament yarns give the twine extra strength and minimize permanent stretch under adverse conditions.

(d) Manryo twine

Manryo twine is made in Japan from a synthetic fibre which is quite different from nylon. It is very similar to cotton in general physical appearance. Being synthetic, it is not rotted by the bacteria in the fish slime, but it can be weakened by alkaline conditions which sometimes exist in fish slime and in rotting fish flesh. It is weakened by sunlight slightly more quickly than is nylon and, like staple nylon twine, is subject to inter-fibre slippage when very dirty or otherwise lubricated. The dry, straight twine is very strong, but the wet knot strength is somewhat less than that for cotton.

(e) Physical properties of suitable selvedging and hanging twines

Table 5 in Appendix A at the back summarizes the results of tests applied to cotton, nylon, and Manryo selvedging and hanging twines. When choosing substitute twines for a given job, selection should be made on the basis of wet knot strength because the twine is wet and knotted when in use.

6. Should you bluestone your nylon net?

(a) Reasons for bluestoning nylon

The fish slime which is scraped onto the gill net from the salmon when it is caught is full of bacteria. Many of these bacteria are capable of feeding on natural fibres such as cotton, linen, and sisal, and can cause rapid weakening of netting, twine, and rope made from them. Many linen gill nets which were left soaking with fish slime over the week-end became so weak as to be useless after only a few days. Many preservatives are available which will slow down this rotting process, but there are so many bacteria in the fish slime that no known preservative gives complete protection. Instead, it has been found necessary to remove the fish slime from natural-fibre fishing gear. A 2% solution of bluestone (copper sulphate) in cold water removes the slime very effectively and kills most bacteria left on the net. Other cleaning agents such as lime and synthetic detergents have been tried but so far none seems to do as good a job as bluestone.

Nylon, unlike these natural fibres, is a completely artificial fibre, and no known bacteria are able to feed on it. Therefore, if nylon web is left soaking in fish slime, it is not weakened by the bacteria. However, if other things in the fish slime cause acid conditions, then the acid can weaken the nylon. Thus, cleaning fish slime from nylon web is a safe precaution, even though it is not always necessary. Besides, a clean net is much more pleasant to handle than a dirty one.

(b) Dangers in bluestoning nylon

Bluestone solutions can be harmful to nylon gill-net web. It is interesting that, if new nylon netting is placed in a fairly strong bluestone solution for a long time, the wet twine strength increases, but the wet mesh strength decreases. This decrease in wet mesh strength is faster in strong bluestone solutions than in weak solutions, and is faster when the nylon net is first put into the bluestone solution than later on.

However, the harmful effect of bluestone solutions during normal bluestoning is not so great as to cause noticeable weakening of nylon gill-net web. Thus, if the nylon gill net is hung to cotton or sisal lines, and particularly if it is hung with cotton twines, fish slime can cause more harm to these natural fibres than bluestone solution causes to nylon, and it is better for the net as a whole to remove the slime from the net with bluestone solution than to leave the net dirty.

Bluestone has the unfortunate property of changing the colour of certain dyes. However, most fishing gear suppliers in British Columbia are aware of this and avoid such dyes. If in doubt, test one end of your net or a piece of spare web in the bluestone tank before bluestoning your complete net.

(c) Recommended bluestoning procedure

If normal precautions are taken while bluestoning a nylon net, there is no noticeable damage. First, the bluestone tank should be reasonably clean and the solution should be reasonably fresh. If in doubt, make up a fresh solution --- bluestone is cheaper than nylon. Second, the solution should contain not more than 2% bluestone --- 30 lb. of bluestone crystals in half a tank of water (150 Imp. gal.) is about right. The bluestone crystals should be dissolved completely and the solution well stirred before putting the net into the tank, otherwise the bluestone solution will be too strong in some places and too weak in others. Bluestone crystals usually supplied to the fishing trade are relatively free of acid but, if only low quality bluestone is available, a little alkali such as washing soda should be added to the bluestone solution --- just enough to cause a slight cloudiness. Third, the net should be left in the bluestone solution only long enough to cut the slime. Leaving nylon gill nets in the bluestone solution over the week-end is not recommended. Fourth, the net should be washed thoroughly with clean water to remove all the bluestone solution from the net before the net is allowed to dry. If any of the bluestone solution is left on the net while it dries, that bluestone solution becomes more concentrated in the netting as the water evaporates and it can weaken the nylon. After washing, the net may be dried or may be put back on the drum while still wet.

(d) Preservatives for natural fibre lines and hangings

Because there is a tendency to bluestone nylon nets less frequently than linen nets, it is advisable to protect any natural fibres in the lines or hangings with a preservative. Many wood preservatives are not satisfactory on fishing gear because they wash out far too quickly and leave the fibres unprotected.

Since World War II, many commercial preservatives using copper naphthenate as the active ingredient have become available. This is a good preservative, but it gradually loses its effectiveness over two to three months of fishing, even though it does not lose its colour, so that re-treatment each season is recommended. Some of these copper naphthenate preservatives also contain a binder which helps to hold the active ingredient on the fibre. At least one commercial preservative uses copper-8-quinolinolate as the active ingredient. This is generally a better preservative than copper naphthenate but, until recently, has been more difficult to apply. The creosote-base preservatives also protect the natural fibres quite well, but they usually leave the net messy to handle. Some of the tar acids in these creosote preservatives are known to harm nylon, but so far there is no evidence of the preservatives themselves weakening nylon gill nets.

7. Several things can weaken your nylon net --- if you want it to last, take care of it

(a) Normal strength loss during use, and how to minimize it

As pointed out in Section 2(e), common experience is for a nylon net to lose about 25% of its new wet mesh strength during the first season, and yet to lose only about a further 10% of its wet mesh strength during the second season. Why nylon should lose so much of its strength when first put to use is not fully understood, but research is being done in an effort to learn more about this. However, certain things are known to weaken nylon, and these should be avoided as much as possible. The harmful conditions most commonly experienced by nylon gill nets are sunlight, acid, drying oils and oxidizing bleaches. During the fishing season, the nylon net should be kept out of the sun and acids avoided as much as practical. For the winter, the nylon net should be cleaned thoroughly, dried, and stored in a dry, shaded, well-ventilated place.

(b) The effect of sunlight and suggested precautions

Probably sunlight causes more weakening of nylon gill nets than any other factor. It is impossible to foretell exactly how fast a nylon net will weaken in sunlight because the sun is stronger in southern areas than in the north, it is stronger at noon than at any other time of day, it is stronger in summer than at any other time of year, cloudy skies vary the amount of damage considerably and fine twines are weakened faster than coarse twines. However, comparison tests have shown that nylon weakens in sunlight about twice as fast as does linen or cotton.

Usually, if a gill net is cleaned and racked in the sun only long enough for mending, any weakening will be too small to notice. But the net should not be left on the rack in the sun longer than is necessary, and it should be protected from the sun by a net cover when it is on the drum. Further, it should be stored in a place where the sun cannot fall on it, even briefly or even through a window.

(c) The effect of acid and possible sources

Probably the second most common thing to harm nylon gill nets is acid. Some acids, such as the electrolyte from a storage battery, are obvious. These should be washed from a nylon net immediately and then should be neutralized with a solution of baking soda, or washing soda, or even soap. Acid clings to nylon and cannot be removed completely by water alone. Other acids are not so obvious. For example, engine exhaust and certain industrial fumes are acidic and can be carried to the net in the air. These are particularly harmful if the net is wet, so it is advisable to dry the net before storage. Some acidic industrial wastes are discharged into the water, but where these are strong enough to harm the net, there are not likely to be fish anyway. As mentioned in Section 4, some dyes must be applied to nylon from an acid solution. When used properly, these solutions are too weakly acidic to harm the nylon during the time required to dye the net, but when used improperly, they can weaken the net quite quickly. Further, only those acids which evaporate with the water instead of concentrating during drying should be used. Because bluestone solutions can become harmfully acidic under certain conditions it is wise to make a fresh solution when the old one becomes too dirty or looks too strong. Tar acids are the active ingredients in the creosote-base preservatives which are sometimes used on the lines and hangings. When pure, these acids are known to harm nylon but so far there is no evidence that such preservatives on the lines harm the nylon web in any way.

(d) The effect of drying oils

There is evidence that prolonged exposure to drying oils such as linseed oil can gradually cause a weakening of nylon. It is therefore suggested that preparations containing such oils not be used to colour the web or to bond the knots and that preservatives containing such oils not be used on natural fibres which contact nylon.

If a drying oil accidentally becomes spilled on a nylon net, it may be removed with dry-cleaning solvent, or naphtha gasoline (taking adequate fire precautions) or with soap and water if the oil is still liquid.

(e) The effect of chlorine and oxidizing bleaches

Chlorine and peroxide can be harmful to nylon. Such bleaches, when used carefully according to manufacturers' instructions, can brighten nylon clothing in the home without noticeably weakening the fabric, but when used on nylon gill nets under the conditions required to remove dyed colour, they almost always damage the nylon. Instead, as described in Section 4(e), reducing bleaches such as hydrosulphite or zinc sulphoxylate should be used when removing colour from nylon web.

8. Lines, floats, and leads

(a) Desired functional properties of cork lines and lead lines

As with the selvedging and hanging twines, the cork line and the lead line should have fairly-well-defined properties if the net is to operate properly.

The cork line should not only be strong enough to withstand the load of bringing the net out of the water and onto the drum, but it should also have an extra margin of strength to withstand the load of towing the net in the water whenever such an emergency arises. Further, it should be able to withstand these loads without experiencing excessive permanent stretch. However, it should not be so large in diameter that it takes up too much room on the drum or that standard floats cannot be threaded easily onto it.

The lead line, on the other hand, need be only strong enough to withstand the load imposed while the net is being lifted, and to hold the leads which keep the net hanging properly in the water. This line requires a little more strength than the minimum when new so that it will remain strong enough to operate properly through the season in spite of rot and wear against the bottom, but it should be weak enough that, if it catches on a snag, it will break and free itself before the whole net becomes torn and lost.

Both the cork line and the lead line should be able to hold the hangings firmly in place, otherwise the web will pull out of shape and will catch fewer fish. It is not enough that the hangings be tied tightly around the lines. When a line is pulled, it becomes smaller in diameter, and the harder it is pulled the smaller it gets. Unfortunately, the same forces which exert a pull on the lines and make them smaller in diameter also try to make the hangings slide along the lines. In other words, sliding is easiest when the effort to cause sliding is greatest. Therefore, the lines should be able to cling to the hangings by more than simple friction. This is particularly true of synthetic fibre lines which do not swell against the hangings when wetted as do natural fibre lines, and also of braided lines which become smaller in diameter under tensile load than do twisted lines.

In ordinary twisted lines (no matter what the material), the fibres, yarns, and plies all lie in the form of spirals within the lines. Any swelling in the line causes these spirals to expand and, as a result, to untwist, unless held in place by outside forces. This action is greater in natural fibre lines, particularly cotton, than in synthetic fibre lines which do not swell appreciably in the water. In salmon gill nets, the hangings are tied firmly to the lines so that any twisting of the lines carries the hangings around the lines and, if excessive, causes undesirable roll-ups. Therefore, cork and lead lines should not untwist enough in the water to tangle the net.

There are several ways for preparing new lines to minimize this tendency to untwist in the water, all of which remove some of the twist from the line before the net is hung. Many fishermen soak the lines in water first, then remove all the kinks from the wet lines before hanging the net. Always, new lines should be taken from the coil in such a way as to remove twist from the rope, but many fishermen re-coil their dry lines several times after that in such a way as to remove twist each time. This is known as "Siwashing". Also, many fishermen fasten one end of the line securely through a swivel then pull on the other end of the line with a winch or with their fishing vessel until enough twist has run out of the rope through the swivel. When this last method is used, there is danger of over-stretching and weakening the line. The load applied should not exceed half the breaking strength. Appendix B at the back describes a safe procedure for prestretching new cotton lines with the fishing vessel, limiting the propeller and engine speeds during towing according to the diameter of the line and the diameter of the propeller.

A practice quite common in the Great Lakes is to use two lines, each half as strong as (two-thirds the diameter of) the single line otherwise used, but twisted in opposite directions from one another. Both lines are the same size, but one has a right-hand or "Z" twist and the other has a left-hand or "S" twist. These two lines are then firmly lashed side by side by the hangings so that any tendency for one line to untwist in one direction is offset by an equal and opposite tendency for the other line to untwist in the other direction. Braided lines overcome the tendency to untwist when wetted in a similar way, the forces in the yarns which spiral along the line in one direction being nearly offset by the forces in the yarns which spiral along the line in the other direction. A coil of braided rope should be mounted or hung so that it can be turned freely, then the rope should be pulled straight off the outside of the coil without changing the twist in the line in any way. Most braided lines have an ink mark which was drawn along the full length of the line during manufacture. This mark should be kept straight when the net is hung to the line, otherwise twisting and kinking may occur during fishing.

Ideally, the lines should have only enough stretch to absorb the shock of motion between the vessel and the net. There are many objections to stretch, particularly in the cork line. As already mentioned, any increase in length causes a decrease in diameter, so that more stretchy lines are generally less able to hold the hangings in place. Most gill nets are very carefully hung with just the right amount of "hang-in". If the lines stretch, the effect is the same as reducing the "hang-in". Often, gill nets have to be re-hung in the middle of the season because the lines stretch. With some materials the stretch is quite elastic; that is, the lines stretch when pulled, but spring back to their original length when released. Such lines stretch while the net is being towed, but have their correct length while the net is being fished and the lines are slack. This behaviour does not affect the fishing efficiency of the net but it may cause trouble on the drum. The lines are under tension when first wound onto the drum. If the line has relatively little elastic stretch, this tension disappears with relatively small movement of the line on the drum. However, if the line has a lot of elastic stretch, this tension does not disappear even with relatively large movement of the line on the drum. The lines under tension then try to compress and cut into the floats and may even damage the drum. Thus, the lines should not have too much elastic stretch. Where the lines are relatively springy, the floats should be rigid to resist damage, but where the lines have less elastic stretch, the softer sponge plastic floats are satisfactory.

Unfortunately, most materials which make low-stretch lines also make fairly stiff lines, but both the cork line and lead line should be fairly flexible if the net is to fish properly. Stiff lines, such as wire rope, besides giving difficulty on the drum, would hold the net too firmly in the water so that many fish would feel the net before being caught and many others would be able to break the mesh in their fight for freedom.

Only rarely does a line go through its useful life without breaking. This means that practically every line has to be joined to itself or to another line at one time or another. Despite their many disadvantages as cork lines and lead lines, twisted lines may be spliced relatively easily to give a strong and neat join. Braided lines, despite their many advantages, cannot be joined so well or so easily. Splicing is very difficult, knotting gives a bulky join and creates a weak spot, and lashing leaves the join subject to slip under load. The braided sleeve join is satisfactory in many ways, particularly with synthetic fibres, but it joins only the braided cover leaving a weakness at the join if the line contains a core.

(b) Characteristics of different materials in cordage

Table 6 in Appendix A gives data on the dry weight and the wet strength of ten styles of cordage in sizes suitable for gill-net lines. Data otherwise supplied by the manufacturer can be confusing and even misleading. Some manufacturers quote the minimum dry strength on the basis that a rope is only as strong as its weakest point. Other manufacturers quote average strengths and hence give higher test results or poorer quality goods for the same size line. All manufacturers quote dry strengths, and this can be misleading for gill-net lines, particularly when comparing lines made of different materials. Gill-net lines are necessarily wet when in use, and wetting affects different fibres in different ways. For example, the strength of a cotton line increases about 15% when wetted whereas nylon weakens about 15% and Manryo weakens about 20%. Dry strength data can therefore lead to serious errors when choosing substitute lines. The figures quoted in Table 6 are based on manufacturers' data, considering as many brands as possible and allowing for the effect of wetting on tensile strength. They are believed to be the most reliable available as the basis for selection of the best style and size for gill-net lines.

In the past, cotton lines were used almost exclusively on linen gill nets. These lines provided a good compromise between weight, strength, diameter, flexibility, price, etc., and cotton hanging twines can be firmly secured to them. Correctly selected cotton lines give good service if they are properly prepared when new (that is, soaked, siwashed, stretched, etc.) and if they are given proper care during use. However, modern fishing methods have created two problems with cotton gill-net lines. In the first place, nylon gill-net web does not have to be bluestoned, so that nylon nets are cleaned much less frequently than were linen gill nets. As a result, cotton lines often weaken more quickly than in previous years, not because they are inferior but because they experience more severe rotting conditions. There are several preservatives available which may be applied to cotton lines to improve this situation (see Section 6(d)), but these cannot stop the rotting altogether. Even the best preservative is able only to slow the rotting process. In the second place, modern gill-net boats are being equipped with larger engines than ever before. This means that the gill nets can be pulled onto the drum faster than before and can be towed behind the vessel harder than before. As a result, the lines, particularly the cork line, are being loaded more than ever, and a line which was satisfactory ten years ago is often not tough enough to meet the requirements of modern fishing. Cotton lines are damaged by overloading even though they may not actually be broken. Unfortunately, if larger cotton lines are used, the added strength is not so great as the added weight, so there is a practical limit to the size of cotton lines which may be used for gill nets.

Manila lines are used very extensively for gill nets on the Great Lakes and in the Atlantic Ocean. Compared with cotton, manila is stronger, particularly in the larger sizes, and has less stretch, but it clings less strongly to the hanging twines. The lower stretch means that the net distorts less when pulled and that the floats are compressed less on the drum. However, it also means that manila lines are less able to withstand sudden loads than are cotton lines of the same size. Although hanging twines cling less strongly to manila than to cotton lines, no trouble is experienced if the hangings are tied tightly to the manila lines. Like cotton, manila swells when wetted so that if the net is hung to dry lines, the hangings tend to tighten further when the net is put in the water. Because of their greater strength, manila lines may be used instead of cotton lines on nets for the more powerful vessels where the cotton line would be too large if chosen with sufficient strength. Manila, like cotton, is rotted by fish slime. Thus, if the manila line is to last, it has to be cleaned regularly or treated with a preservative. Manila rope should be treated at the factory while it is being manufactured so that the preservative is right through the rope and not just on the surface. Only special "net rope" should be used for gill-net lines because regular lay manila rope changes too much when wetted, becoming too stiff and awkward to handle and having a tendency to twist.

Sisal lines are somewhat similar to manila lines in general appearance. They are cheaper and weaker than manila lines, but stronger than cotton lines in the larger sizes. The same cleaning precautions are advisable, and a preservative, preferably factory applied, is recommended. As with manila lines, a special "net rope" construction is necessary for satisfactory performance.

Generally speaking, nylon rope has too much stretch to perform satisfactorily in gill-net lines. Staple nylon is able to cling to the hangings so they do not slip, but it can experience a permanent stretch under load, particularly if it is soaked with fish slime or other lubricant. Continuous filament nylon experiences less permanent stretch than does staple nylon, but it does not hold the hangings well. Neither style of nylon line swells when wetted so the hangings do not tighten appreciably when the net is put in the water. Further, when the line is pulled, the load stretches the rope, decreases its diameter, and loosens the hangings. Nylon has the advantage over the natural fibre lines previous mentioned in that it is not rotted by fish slime. It serves very well as tow rope and tie-up line, but should be used for gill-net lines only where the hang of the net is not critical or where the fisherman is prepared to handle his net with extra care to prevent the hangings from slipping. Where a nylon net-rope is being chosen as a substitute for another material, the wet strength data in Table 6 should be used as a guide, otherwise the dry strength data published by the manufacturers will result in too light a line being selected.

Terylene (Dacron) rope has some advantages over nylon rope for gill-net lines, but it also shares some disadvantages. Continuous filament Terylene, like continuous filament nylon, has a smooth surface which does not cling well to the hanging twines. Thus, if the net is to hold its proper hanging, staple or spun Terylene lines should be used. In the water, Terylene is the strongest rope of its size suitable for gill-net lines. Terylene has less elastic stretch than nylon, but if overloaded, can experience as much permanent stretch. Like nylon, Terylene rope does not swell when wetted so that hangings on Terylene rope do not tighten in the water. Further, as Terylene rope stretches under load, its diameter decreases, and the hangings loosen. Terylene, like nylon, is not rotted by fish slime, and it is harmed less than nylon by the sun, but it does not resist wear so well as does nylon. Where the fishing vessel is too powerful for the largest practical cotton line, staple Terylene rope would probably solve the problems of overloading, but where cotton rope is serving satisfactorily, it is an economic question whether or not staple Terylene rope would give sufficient extra service to warrant the higher price.

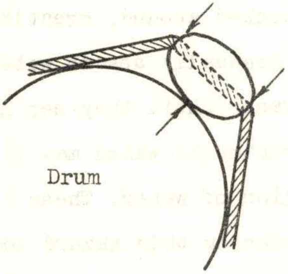
Manryo (Kuralon, Vinylon, Kanebiyan, Cremona) rope is available from Japan. This rope looks very much like cotton rope and is cheaper than the other synthetic fibre ropes. When wet, it is weaker than cotton rope in the smaller sizes but is slightly stronger in the larger sizes. It is not rotted by bacteria in fish slime, thus requiring no preservative, and, if not given prolonged exposure to alkaline conditions, holds its strength through use better than does cotton, particularly when the net is not bluestoned. It clings well to ordinary hanging twines, but it can be overloaded about as easily as cotton rope.

Continuous filament, high-tenacity polythene (polyethylene) rope has recently been made available. Compared with nylon or Terylene, the individual filaments of the polythene are quite coarse. Polythene is the only synthetic fibre which floats on water, although its buoyancy is not sufficient to support a net. Its lightness also contributes to the relatively high specific strength reported in Table 7. For equivalent diameter lines, high-tenacity polythene has about the same strength as has staple nylon or staple Terylene. Its resistance to acid and to alkali is good and its resistance to sunlight and to wear is fair, but there is quite a bit of stretch under load, and hanging twines have little on which to cling.

At the present time Saran has little to recommend it for gill-net lines, although work is being done to improve its strength and the picture may change quite soon. It is weaker than cotton in most sizes. Like polythene, Saran has a relatively coarse, continuous filament and a fair amount of stretch. Thus, hangings can be expected to tend to slide along Saran lines. It has good resistance to acid and to alkali but is weakened by sunlight. Of all synthetic fibres, Saran is the most dense, so that for its size a Saran line is heavier than any other.

(c) Floats

In order that the salmon gill net can be handled properly on the drum-equipped vessels commonly used in British Columbia, the floats should be oval in shape. The absence of edges resulting from this shape minimizes the tendency for the floats to catch in the web and on the vessel or drum while the net is being set or hauled in. Also, each float should be able to withstand a fairly large bending moment on its longitudinal axis. When the net is wound onto the drum, the cork line is necessarily under tension so that the float is bent by the line against parts of the net already wound onto the drum as shown in Fig. 9. This bending is greatest near the centre of the drum. The floats should also be able to withstand fairly large compressive forces, even though they are at the surface of the water while the net is being fished. As the net is being wound onto the drum, each successive layer compresses the layers already on the drum so that the bottom layers of net are squeezed quite considerably, particularly if the lines have a lot of elasticity. It is sometimes advisable to use two styles of float on the gill net, a more rigid but less buoyant float on the "inside" end and a more buoyant but less rigid float on the "outside" end. The floats should not be such as to chafe or cut the hangings excessively while the net is working, nor should they be cut too easily by the hangings if they become caught while the net is being set or hauled in. The floats should be as light as strength requirements permit because lighter floats are more buoyant and make less work for the fisherman. And last, but not least, the floats should keep their buoyancy for as long as possible, even continuously immersed in water.



Cutting and bending action of the cork line on the floats

Fig. 9

Table 8 gives the measured properties of several suitable salmon gill-net floats when new. At one time, red-cedar floats were used almost exclusively, and they are still used fairly extensively because of their low cost. They are rigid and withstand the bending and compression experienced on the drum. However, they suffer three disadvantages. First, they are two to five times as heavy as plastic floats of similar buoyancy, even when new and dry. This means more work while the net is being fished, cleaned and racked. Second, they sometimes form slivers, particularly when knocked around, creating a hazard for the fisherman. And third, they gradually absorb water during use, becoming heavier and losing buoyancy until they can no longer support the net. There are several treatments which may be applied to cedar floats to slow this absorption of water. These often also help to hold down the slivers, reducing this hazard too. The most commonly used treatment is seine tar. This is a refined coal tar designed as a preservative for cotton seine web. The tar should be heated until quite fluid, then the cedar floats are immersed until well coated. The floats should be well dried before treatment and should be left in the hot tar as long as practical to achieve maximum penetration. After dipping, the floats should be hung to allow excess tar to run off and to permit the tar to dry. Besides sealing the pores of the wood, seine tar is a preservative which slows down rotting. Pine tar, creosote, and roofing asphalt may also be used, but these are usually less effective than seine tar. Varnish is often used to seal cedar floats. However, it is more expensive than seine tar, it must be allowed to dry thoroughly before the floats can be used, it does not penetrate into the wood so well as do some other treatments and loses its effectiveness when knocked off, and it has relatively little preservative action against rot. Polyester resin can form a good tough coat on red-cedar floats, but it is expensive and awkward to apply. Paraffin wax may be used as a temporary sealer, but the floats need to be heated before waxing and the wax is easily knocked off.

Plastic floats overcome many of the disadvantages of red cedar, but they are more expensive and cannot always withstand the forces of normal fishing. The sponge plastic floats are the lightest and the most buoyant, but they tend to become cut at their ends by the cork line and hanging twine, and if permanently compressed on the drum, they lose much of their initial buoyancy. However, these floats do not water log, even under constant immersion, so that, so long as they keep their original size, they also keep their original buoyancy. They do not rot and require no special care other than to avoid physical abuse. The hollow floats made of hard plastic are not cut by the cork line and hangings or squeezed by compression on the drum as are the sponge plastic floats, but they are usually less buoyant than the sponge plastic floats, even for their size, and if they spring a leak, they fill with water and eventually sink. If improperly constructed, they may break open at the seam, and if overloaded can crack or become broken. Cracked floats soon lose their buoyancy by filling with water, and broken floats can cut the fishermen.

(d) Leads

There are three types of leads which are used successfully to hold salmon gill nets down in the water. At one time, the commonest practice was to cast the leads directly onto the cotton lead line. In this way the leads may be fixed rapidly and permanently to the line, and do not cut the hangings. The big disadvantage of this type of lead line is that the weighting is inconvenient to change once the leads are cast. Further, pure lead melts at about 620°F. so this method cannot be used with most synthetic fibres without damaging the lines. Cut-and-bent leads are simply sheet lead which has been cut to size and bent into a U-shape. The line is then set down into the "U" and the lead hammered firmly into place around the line. These leads have the advantage over cast leads that some may be removed if the line is too heavy or more may be added if the line is too light and, of course, they are fixed while cold so there is no danger of overheating the line. However, cut-and-bent leads take longer to fit than do cast leads, and if not fastened properly, can become loose enough to slide along the lead line and cut the hangings. Recently, the braided lead line has become available. This is a sisal, manila, or nylon sheath braided over a notched lead wire. The sheath is made strong enough to carry the load, and the lead wire of the correct weight is notched to increase flexibility. The advantages of the braided lead line are that the weighting is distributed uniformly along the length of line letting the net hang better in the water, and there are no individual leads to become caught in the web while the net is being set. The disadvantages of the braided lead line are that its weight cannot be changed once the line is manufactured and that it cannot be spliced when it becomes broken. This line may be knotted or lashed with some loss of length and/or weight.

9. Other materials for gill-net web

(a) Terylene (Dacron)

Terylene and Dacron are basically the same material, Terylene being made in Great Britain and Canada and Dacron in the United States. This fibre has many properties which recommend it for gill-net web, and it is being used successfully in many areas for this purpose. Many of the variations of nylon described in Section 1 also exist in Terylene twines. There is only one basic chemical type of Terylene, but this is spun into several yarn weights (50, 75, 100, 125, 150 and 250 denier), and several filament finenesses are available. For example, 250-denier Terylene yarn is available with 48 coarser filaments or 144 finer filaments per yarn. Like nylon, Terylene is made into regular tenacity and high tenacity yarns, it may be left as continuous filament or it may be stapled and spun, it is twisted into many different twine sizes and to different twist hardnesses, it may be given a hot stretch or a stabilizing treatment to set the twist and prevent shrinkage, and it may be made into netting with any of the knots shown in Fig. 1. As with nylon, only the continuous filament, high tenacity yarn should be used for salmon gill nets. Fig. 5 shows this Terylene to be weaker than Type 66 nylon on an equal weight basis. However, Terylene salmon gill-net web usually is made of 250-denier yarn which is about 19% heavier than the 210-denier yarn used in nylon gill-net web, and this greater weight nearly offsets the lower specific strength of the Terylene. Table 4 in Appendix A gives the results of physical tests applied by me at this Technological Station to high tenacity Terylene netting. Comparing this table with Table 1 for Type 66 high tenacity nylon, it will be seen that, for twines having the same number of yarns, Terylene has about 18% fewer yards per pound of twine than has nylon, is about 9% stronger in the wet twine, but has about 4% lower wet mesh strength in double-knot web. Returning to Fig. 5, it will be seen that, at loads up to about 40% of its wet mesh strength, Terylene has about half as much stretch as has Type 66 high tenacity nylon and that at very low loads it has nearly the same load-elongation characteristics as has wet linen. This lower stretch may account partly for Terylene's relatively low strength efficiency of the knot, particularly in single-knot web. Terylene is even more difficult to dye than is nylon, and it is recommended that Terylene nets be ordered factory-dyed where permanent colour is desired. Like nylon, Terylene resists damage by rot and mildew, but it is weakened by sunlight, though more slowly than is nylon. Unlike nylon, Terylene is relatively resistant to acid, but is weakened by alkaline conditions.

(b) <u>Silk</u>

As a result of reports from Japan that some of their fishnets are made of silk, it is sometimes asked if this fibre could be used for salmon gill nets. Silk is about 60% as strong as high tenacity nylon so that silk nets would have to be heavier than the nylon nets used at present. Silk has slightly more stretch than nylon so that it would probably catch fish, but it is weakened by sunlight, is subject to rot, and could be attacked by moths during winter storage.

(c) Glass fibre

Because glass fibre is reported to be very strong and very resistant to rot and sunlight, it is sometimes suggested as a possible material for making salmon gill nets. However, on an equal weight basis and when wet, glass fibre is only about 19% stronger than the high tenacity nylon fibre used to make gill nets at the present time. Further, the knot strength of glass twine is relatively low so that netting made of glass fibre would probably be weaker than equal weight nylon netting, or, if made of similar wet mesh strength, it would have to be heavier. Also, because the individual filaments must be made finer, there is relatively more space between the filaments in the twine. Thus, the glass fibre twine would probably have nearly as large a diameter as the nylon twine it replaced, in spite of glass fibre being over twice as dense as nylon fibre. Twine made from glass fibre has very poor wear resistance. Probably the action of the netting looms would cause considerable fraying at the knots, and the wear and tear of use would soon make the net look very ragged. These fibre ends would break off very easily and would stick into the hands of anyone handling the net. This is a very irritating condition as will be confirmed by anyone who has handled glass wool. Finally, glass fibre has very little stretch, even less than linen. This means that a glass fibre net would probably catch fewer fish than would a nylon net and it would definitely be more selective in the range of fish sizes caught. The low stretch also means relatively little toughness, so that a fish caught in a glass fibre net could break the mesh more easily than it could break the mesh of an equally strong nylon net.

The one place where glass fibre may be used to advantage is in the core of braided cork lines. There, the high, straight strength and low stretch would help to keep the net in shape and the cover of other fibre would protect the glass fibre core from wear. Generally speaking, then, the disadvantages of glass fibre for gill-net web at present seem to far outweigh the advantages when compared with high tenacity nylon.

(d) Orlon

Of all synthetic fibres, Orlon has exceptional resistance to weathering. In view of nylon's relatively poor performance in this respect, the possibilities of Orlon are worth examining. In the water, Orlon is about 2/3 as strong as high tenacity nylon and has nearly as much stretch. However, more of the stretch is permanent than is the case with nylon. That is, Orlon does not spring back so well as does nylon when the load is removed. A new Orlon net would be weaker than a new nylon net of the same weight, but it would be interesting to see how the strengths compare after a season of use, and to see if fishing loads caused appreciable permanent increase in mesh length.

(e) Rayon

More rayon is manufactured than any other man-made fibre, and its price is lower. However, even high tenacity rayon is only 35% as strong as high tenacity nylon in the water --- rayon loses about 40% of its strength when it gets wet. Rayon has about 2/3 as much stretch under load as has nylon, but much more of this stretch is permament. Therefore, rayon cannot be expected to stand up in salmon gill-net web.

(f) Saran

Saran is being used quite extensively in fish nets in Japan. However, it is too weak and too stiff to perform satisfactorily in salmon gill-net web. In the water, it is about 1/2 as strong as high tenacity nylon, even though it does not lose strength when wetted. Also, it has not been possible, so far, to make Saran in as fine filaments as is common with nylon. Therefore, the Saran twines and netting tend to be stiff. Compared with nylon, Saran does not make good gill-net web. However, it shows promise in seine web, particularly if twisted with nylon for added strength. Saran is quite a dense fibre so that it helps to hold seine web down in the water and its stiffness improves the handling properties of seines. Its stretch characteristics to rupture are very similar to those of nylon, but it is relatively difficult to dye. Thus Saran has a place in the fishing industry, but not for salmon gill nets.

Appendix A

Physical Properties of Materials Used in Salmon Gill Nets

Table 1. Type 66, high tenacity, multifilament nylon twine and netting (210-34 yarn)

" 2. Type 6, multifilament nylon twine and netting (210-15 yarn)

" 3. Premium grade linen twine and netting

" 4. High tenacity, multifilament Terylene (Dacron) twine and netting (250d yarn)

" 5. Selvedging and hanging twines

" 6. Cordage for gill-net lines

" 7. Specific strengths of twine, netting, and cordage

" 8. Properties of unused gill-net floats

Appendix B

Procedure for Prestretching New Cotton Lines

Table 9. Maximum safe propeller speed with vessel stationary for prestretching new cotton lines without permanent damage to the lines

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TABLE 1

Results of Tests on Type 66, High Tenacity, Multifilament Nylon Twine and Netting (210-34 yarn).

Twine Number (210d/)	Yards per Pound of Twine	Twine Diameter (1/1000 in.)	Tensile Strength (lb.)					
			Twine		Mesh			
					Single Knot		Double Knot	
			Dry	Wet	Dry	Wet	Dry	Wet
2/3	3200	19	20	17	19	17	21	19
3/3	2130	23	30	26	29	26	32	28
4/3	1600	26	40	35	39	35	43	37
5/3	1280	29	50	44	48	44	54	47
6/3	1070	32	60	53	58	53	64	56
7/3	910	35	70	61	67	61	75	65
8/3	800	37	80	70	77	70	86	75
9/3	710	39	90	79	87	79	96	84
10/3	640	41	100	87	96	88	107	93
11/3	580	43	110	96	106	97	118	103
12/3	530	45	120	105	115	105	129	112
13/3	490	47	129	114	125	114	139	121
14/3	460	49	139	122	135	123	150	131
15/3	430	51	149	131	145	132	161	140

TABLE 2

Results of Tests on Type 6 Multifilament
Nylon Twine and Netting (210-15 Yarn).

Twine Number (210d/)	Yards per Pound of Twine	Twine Diameter (1/1000 in.)	Tensile Strength (lb.)					
			Twine		Mesh			
					Single Knot		Double Knot	
			Dry	Wet	Dry	Wet	Dry	Wet
2/3	3420	18	11	10	14	13	16	14
3/3	2280	22	17	15	21	19	23	20
4/3	1710	26	23	21	29	26	31	27
5/3	1370	29	29	26	36	32	39	34
6/3	1140	32	34	31	43	39	47	41
7/3	980	34	40	36	50	45	54	47
8/3	850	37	46	41	57	52	62	54
9/3	760	39	52	46	64	58	70	61
10/3	680	41	57	52	71	64	78	68
11/3	620	43	63	57	79	71	86	74
12/3	570	45	69	62	86	77	93	81
13/3	530	47	74	67	93	84	101	88
14/3	490	49	80	72	100	90	109	95
15/3	460	50	86	77	107	97	117	101

TABLE 3

Results of Tests on Premium Grade Linen Twine and Netting (Salmon Twine Construction)

Twine Number	Yards per Pound of Twine	Tensile Strength (lb.)			
		Twine		Double Knot Mesh	
		Dry	Wet	Dry	Wet
50/4	1660	27	35	24	38
50/5	1330	33	44	30	48
50/6	1110	40	53	36	57
50/7	950	46	62	42	67
50/8	830	53	71	48	76
50/9	740	60	80	54	86
50/10	660	66	88	60	95
40/4	1460	30	40	27	42
40/5	1170	37	50	34	53
40/6	970	44	60	40	63
40/7	830	52	70	47	74
40/8	730	59	80	54	85
40/9	650	67	90	61	95
40/10	580	74	100	67	106
40/11	530	81	110	74	116
40/12	480	89	120	81	127

TABLE 4

Results of Tests on High Tenacity, Multifilament Terylene (Dacron) Twine and Netting (250d yarn).

Twine Number (250d/)	Yards per Pound of Twine	Twine Diameter (1/1000 in.)	Tensile Strength (lb.)					
			Twine		Mesh			
					Single Knot		Double Knot	
			Dry	Wet	Dry	Wet	Dry	Wet
2/3	2630	22	18	19	15	16	18	18
3/3	1750	27	28	29	23	24	28	27
4/3	1320	31	37	38	30	31	37	36
5/3	1050	35	46	48	38	39	46	45
6/3	880	38	55	57	46	47	55	54
7/3	750	41	65	67	53	55	64	63
8/3	660	44	74	76	61	63	73	71
9/3	580	47	83	86	68	71	82	80
10/3	520	49	92	95	76	79	92	89
11/3	480	51	101	105	84	87	101	98
12/3	440	54	111	114	91	94	110	107
13/3	400	56	120	124	99	102	119	116
14/3	370	58	129	133	106	110	128	125
15/3	350	60	138	143	114	118	137	134

TABLE 5

Results of Tests on Selvedging and Hanging Twines

Style	Twine Size	Yards per Pound	Diameter (1/1000 in.)	Tensile Strength (lb.)			
				Straight		Single Knot	
				Dry	Wet	Dry	Wet
Soft Laid Cotton	10/12	600	51	25	28	15	20
	10/16	450	59	33	37	20	27
	10/20	360	66	41	46	25	33
	10/24	300	72	50	55	31	40
	10/28	255	78	58	65	36	47
	10/32	225	84	66	74	41	53
	10/36	200	89	74	83	46	60
	10/40	180	93	83	92	51	67
	10/44	165	98	91	101	56	73
	10/48	150	102	99	110	61	80
Extra Soft Laid Cotton	10/16	460	56	32	37	21	29
	10/20	365	63	40	47	26	37
	10/24	305	69	48	56	32	44
	10/28	260	75	56	65	37	51
	10/32	230	80	64	75	42	59
Braided Continuous Multifilament Nylon	#15	365	55	147	123	75	62
	#21	270	62	190	153	98	84
Braided Staple Nylon	#15	445		68	57	50	41
	#21	345		91	80	69	55
Twisted Soft Laid Staple Nylon	10/9	790	43	35	33	27	24
	10/12	595	50	46	44	36	31
	10/15	475	56	58	55	44	39
	10/18	395	61	69	65	53	47
	10/21	340	66	81	76	62	55
	10/24	295	70	92	87	71	63
Manryo	20/32	460	60	77	55	30	25
	20/40	365	67	96	69	37	31
	20/48	305	74	115	83	44	37
	20/56	260	80	135	96	52	43
	20/64	230	85	154	110	59	49
	20/72	205	90	173	124	66	56

TABLE 6

Weight (lb./100 fm.) and Wet Strength (lb.) of Different Kinds of Cordage for Gill Net Lines

Diameter (inches)	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8
Cotton								
Dry Weight	7.0	12.1	18.3	26	34	43	52	62
Wet Strength	450	680	920	1170	1440	1730	2070	2400
Manila								
Dry Weight	8.5	11.7	16.4	22.7	32	44	60	80
Wet Strength	450	690	1050	1510	2060	2800	3600	4500
Sisal								
Dry Weight	8.8	12.3	17.0	23.5	32	44	59	79
Wet Strength	390	560	810	1160	1600	2200	2950	3800
Staple Nylon								
Dry Weight	5.5	9.8	15.3	22.2	30	40	51	63
Wet Strength	520	920	1420	2030	2700	3500	4400	5400
Continuous Nylon								
Dry Weight	5.5	9.8	15.3	22.2	30	40	51	63
Wet Strength	610	1080	1670	2400	3200	4200	5200	6400
Staple Terylene								
Dry Weight	5.6	10.1	15.9	23	32	42	54	67
Wet Strength	560	980	1510	2150	2900	3700	4700	5700
Continuous Terylene								
Dry Weight	6.8	12.0	18.5	26	36	46	57	70
Wet Strength	660	1150	1770	2500	3400	4300	5400	6600
Manryo								
Dry Weight	5.1	9.0	14.1	20.3	28	36	46	57
Wet Strength	350	610	960	1380	1870	2440	3100	3800
H.T. Polythene								
Dry Weight	4.6	8.2	12.8	18.4	25	33	41	51
Wet Strength	590	1020	1540	2150	2840	3600	4400	5200
Saran								
Dry Weight	8.7	15.6	25	36	49	65	82	103
Wet Strength	270	490	760	1090	1480	1940	2450	3000

TABLE 7

Specific Strengths of Twine, Netting and Cordage for Salmon Gill Nets

	Average Specific Strength (Yards)					
	Twine		Mesh			
			Single Knot		Double Knot	
For Netting	Dry	Wet	Dry	Wet	Dry	Wet
Nylon, Type 66, High Tenacity, Multifilament (210-34 yarn)	63700	56000	30800	28100	34300	29900
Nylon, Type 6, Multifilament (210-15 yarn)	39100	35200	24400	22000	26600	23100
Terylene (Dacron), High Tenacity, Multifilament (250d)	48600	50200	20000	20700	24100	23500
Linen, Good Grade, #50 Yarn	44000	58800			19900	31600
#40 Yarn	43200	58500			19700	30900

	Twine			
	Straight		Single Knot	
For Selvedging and Hanging Twines	Dry	Wet	Dry	Wet
Cotton, Soft Laid	14800	16500	9100	11900
Extra Soft Laid	14500	17000	9600	13400
Nylon, Braided, Continuous	53000	43000	27000	23000
Staple	31000	27000	23000	19000
Twisted, Staple	27400	25900	21100	18600
Manryo	35200	25200	13500	11300

	Cordage	
For Cork and Lead Lines	Dry	Wet
Cotton	6800 to 11200	7800 to 12900
Manila	9800 to 12400	10600 to 13300
Sisal	8200 to 9400	8800 to 10000
Nylon, Staple	20300 to 22500	17200 to 19100
Continuous	23900 to 26400	20300 to 22500
Terylene, Staple	16900 to 19800	16900 to 19800
(Dacron) Continuous	18800 to 19300	18800 to 19300
Manryo	16800 to 17100	13400 to 13700
Polythene, High Tenacity	20700 to 25500	20700 to 25500
Saran	5900 to 6300	5900 to 6300

(Varying with rope diameter)

Note: Figures for netting and twine are based on tests performed at this Station. Figures for cordage are based on manufacturers' data.

TABLE 8

Properties of Unused Floats for Salmon Gill Nets

Style	Nominal Size			Displacement (cubic inches)	Dry Weight (ounces)	Buoyancy (ounces)
	Length	Diameter	Hole			
Red Cedar	6"	4"	1/2"	41	9	15
Sponge Plastic						
Aerobuoy	5-1/2"	3"	1/2"	37	1.7	16
"	6"	3-1/2"	1/2"	51	2.3	22
Pama	6"	3-1/2"	5/8"	39	4.4	18
Spongex	6"	3-1/2"	3/4"	38	2.0	20
Hollow Plastic						
Morrison	4-3/4"	2-3/4"	1/2"	21	3.3	9

Appendix B

Procedure for Prestretching New Cotton Lines

When prestretching new cotton lines using the fishing vessel to exert the necessary pull, the general procedure is to fasten one end of the line through a swivel to some firm object, such as the dock, and to secure the other end of the line to the vessel. The vessel is then moved away from the dock until the line is suspended in the air, and the propeller r.p.m. is increased until the pull reaches the desired value. Under this pull, twist will run out of the line through the swivel. It is important that all the slack be taken out of the line with the propeller turning at low speed, then the propeller r.p.m. may be increased gradually to the safe speed only while the line keeps the vessel from moving. The line can easily be damaged or broken if the vessel is run out at high speed.

Table 9 gives the maximum safe propeller r.p.m. which may be used to prestretch new cotton lines of different diameters with propellers of different sizes. These figures were calculated from information kindly supplied by Mr. E.A. Drake. For example, if a 3/8 in. diameter new cotton line is to be prestretched by tying one end through a swivel to the dock and fastening the other end to a fishing vessel which is fitted with a 22-in. diameter propeller, then the maximum speed to which the propeller may be turned without overstressing the line is found in Table 9. In the column under 3/8 in. rope diameter and in the line opposite 22 in. propeller diameter, Table 9 says that the propeller may be turned up to 700 r.p.m. when pulling steadily against the line, vessel not moving, without damaging the line.

If the propeller is coupled directly to the engine, then the engine tachometer indicates propeller speed as well as engine speed. But, if the propeller is coupled through a reduction gear, then the engine speed is greater than the propeller speed by an amount equal to the ratio of the reduction gear. The engine may then be turned to a speed equal to the ratio of the reduction gear multiplied by the maximum safe propeller r.p.m. given in Table 9. If, in the example given above, the propeller is driven through a 2:1 reduction gear, then the engine may be turned to a maximum of 2 x 700 = 1400 r.p.m. when pulling steadily against the line, vessel not moving, without damaging the line.

Table 9 may also be used in the same way to estimate the maximum engine speed for towing the net in the water without harming the line, or, conversely, the size of cork line required to withstand certain towing conditions. Of course, considerably higher engine speeds than these are required to break the new line, but the line can be damaged without being broken. Further, old lines will not be able to withstand these maximum safe loads for new lines.

TABLE 9

Maximum Safe Propeller Speed with Vessel Stationary for Prestretching New Cotton Lines Without Permanent Damage to the Lines

Diameter (in.) of Line → of Propeller ↓	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8
	Maximum Safe Propeller R.P.M. at Dead Pull							
14	1100	1350	1550	1750	1950	2150	2350	2550
16	850	1050	1200	1350	1500	1650	1800	1950
18	650	800	950	1050	1200	1300	1400	1500
20	550	650	750	850	950	1050	1150	1250
22	450	550	650	700	800	870	950	1050
24	350	450	550	600	670	750	800	850
26	300	400	450	500	570	650	700	750
28	270	350	400	450	500	550	600	650
30	240	300	350	400	430	470	500	550
32	210	260	300	340	370	400	450	500
34	180	220	260	300	330	360	400	430
36	160	200	240	270	300	330	360	390