SYNTHETIC FIBRES FOR FISHING GEAR

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INTRODUCTION

A variety of synthetic fibres are at present in use as fishing gear material, the earliest one being the polyvinyl chloride group introduced for traps in 1936 (von. Brandt 1957). Since then synthetic fibres became increasingly popular among the advanced fishing nations of the world. The latest synthetic fibre which has been successfully used in fishing is polypropylene developed in Italy in 1954.

The exact period when synthetic fibres became popular as a fishing gear material in India is not clearly known; however it has been stated that the first lot of nylon came to India in 1954-55 under the TCM aid. Terylene (polyester group of fibres) gill nets were subsequently introduced (Anon. 1958). In the initial years the country was depending on imports for these materials. In 1962 nylon multifilament yarn (polyamide group of fibres) suitable for making fishnet twines was manufactured in India. Subsequently polythylene group of fibres in the form of monofilaments and tapes were also manufactured in India. Production of nylon in the form of monofilaments has also been started recently.

CLASSIFICATION

Hans Stutz (1959) has made an elaborate classification of textile fibres based on the source of the fibre, the raw material and the process of manufacture together with the various trade names under which they are marketed, the classification is sohwn in table I. In India polyamide group of fibres is marketed under the trade names Garnyl and Jaykaylon, while polyethylene is marketed under the trade name Garfil and Marfil and polyethylene. Mostly the trade names are related to the manufacturer's name.

RAW MATERIALS AND PRODUCTION

The basic materials for production of yarns for synthetics are prepared from petroleum, natural gas, hydrocarbon, molasses, grain, cobs, oat hulls, lime and coal (Himmelfarb 1957).

Polyamide Fibres (*PA*) The discovery of polyamide 66 (Nylon 66) is credited to Dr. Wallace Hume Carrothers (Arzane 1959). Nylon 66 polymer is prepared by heating hexamethylene diamene and adipic acid. A polymer made from Caproluctum is the Japanese equivalent to nylon. The American Caprolactum polyamide is designated as nylon 6. Structurally both nylon 66 and nylon 6 consist of the same amide group differently arranged to constitute the long chain molecule (Himmelfarb 1957). Generally it can be said that type 66 can be made stronger than type 6 but the latter is cheaper.

Polyester Fibres (*PES*) The fibre is a British invention made by J. R. Whinfield and J. T. Dickson. Later the world patent rights with the exception of the United States of America were acquired by the Imperial Chemical Industries Ltd. U. K.

TABLE I

TEXTILE FIBRES

NATURAL FIBRES		CHEMICAL FIBRES				INORGANIC FIBRES	
		NATURAL POLYMERS		SYNTHETIC POLYMERS			
POLYCONDENSATION COMPOUNDS				POLYMERIC COMPOUNDS			POLYADDITIVE COMPOUNDS
Polyester	*Poliamide*	*Mixed Polymerics*	*Polyvinyl Alcohol*	*Polyvinyl Chloride*	*Polyacrylonitrile*	*Polyethylene*	*Polyurethane*
Terylene	Nylon	Dynel	Vinylon	PCV	Orlon	Polythene	Perlon - U
Dacron	Perlon	Saran	Kuralon	Pe Ce	Acrilan	Courlene	Fibre - 32
Terital	Grilon	Vinyon	Cremona	Rhovyl	PAN	Reevon	
Tergal	Kapron	Harlon	Mewlon	Thermovyl	Dralon	Wynene	
Terlenka	Enkalon	Verel	Synthofil	Vinyon - HH	Redon	Teflon	
Trevira	Amilan		Woolon	Pe Ce - U	Courtelle		
Diolen	Livlon				Crylon		
Lanon	Caprolan				Dolan		
	Delfion				Prelena		
	Steelon				Wolcrylon		
	Niplon						
	Rilon						
	Silon						

and the name Terylene became a registered trade mark, the property of the Imperial Chemical Industries Ltd. It is a condensation product of terephthallic acid and ethylene glycol but is actually manufactured by the ester interchange of glycol and dimethyl terephathallate.

Polyethylene Fibre (PE) The fibre is prepared by polymerising ethylene at high pressure (1500 psi)

Polypropylene Fibres (PP) This bas been known for many years as an oil although for various reasons it had no commercial importance. In 1954 Prof. Natta whose work has been concerned with stereospecific polymerisation of olefines using organometallic catalysts of Zeigler type discovered how to make isotactic materials with regular ordered molecular structure. The Imperial Chemical Industries recognised the great potential for the new material and negotiated a patent license from the Italian Chemical firm of Montecatini in August 1960.

Preparation of Yarn

Essentially it consists of two stages, melt spinning and cold drawing. It is effected by an extrusion technique followed by an orientation stage. The polymer from molted reactants is extruded as a ribbon, ground into pellets and remelted. The molten mass is fed by melting pumps through spinnerts which on emerging is solidified by cooling in a current of air. It is then condensed and wound into bobins as undrawn yarn. In a subsequent operation the filaments are cold drawn and wound to pirns. The extent to which yarn is drawn depends on the type of polymer and sometimes the same polymer is stretched to different degrees. Carrothers (1957) mentions that nylon manufacturers stretches the yarn 3-4 times the original length whereas Lohani (1961) states that the stretching is 4-5 times. For the polythylene group, the filaments are stretched to 8-10 times the original length in boiling water and then wound up under constant tension (Kloppenburg & Reuter 1964). The process has got some influence on the physical property of the finished product.

Types of Yarn

Usually synthetic fibre yarns that go to make up the net material is available as staple or spun and continuous filament yarns. A yarn is called staple when it is cut up into fibres of staple length of about 3″ (Carrothers 1957) and spun into a yarn just like cotton. It is a continuous filament yarn when filaments run through out the whole length. A continuous filament yarn is also described as 'drawn' since during the manufacture the material is drawn to specified lengths. A continuous filament yarn can be either a monofilament or a multifilament yarn. Another development in synthetic yarn production is the manufacture of tapes. It is initially prepared as a sheet of unoriented film, which is chilled and fed through the cutter, followed by passage through an orientation zone. Tapes are also produced in continuous lengths with a width of 2-4 mm and denier sizes of 750-1000. The conversion of tapes into split fibres that can be spun into sisal like cordage product was evolved by mid 1960, while Rummler (1954) reports the availability of Perlon in Germany as continuous, staple, tape and monofilaments as early as 1954. Production of synthetic tapes for fish net twines has been started recently in India.

Yarn Numbering Systems

Basically there are two different systems of yarn numbering, the Indirect System and the Direct System. In the former weight is kept constant and length various hence higher the number thinner the yarn. In the latter the length is kept constant and the weight varies, hence higher the number the thicker the yarn. The yarn numbering systems followed in the textile industry as described by Gee (1954) and for netting yarns as described by Klust (1764 a) confirm to the above basic principles

1. Indirect System:

i)	When 840 yds of yarn	weigh	1 lb	it is	1	Ne (British Count)
	840 xn	”	1 lb		2 n	Ne
ii)	1000 m	”	1 kg	”	1	Nm (Metric Count)
	1000 xn	”	1 kg	”	n	Nm

2. Direct System

i)	9000 m	”	1 gm	”	1	D (Denier)
	9000 m	“	n gm	”	n	D
ii)	1000 m	“	1 gm	“	1	Tex
	1000 m	“	n gm	”	n	Tex

The British Standards Institution has drawn out standards for textile yarns and suggests the adoption of 'Tex' system recommended in the International Standards Organisation conference held in Southport in 1956. The two fishing congress also stress the importance of yarn numbering system with a recommendation for the adoption of 'Tex' given by the International Standards Organisation. The suggestions of Indian Standards Institution is also on the same lines as that of the International Standards Organisation. Eventhough the Tex system has been recommended for universal adoption this has not been fully implemented and for easy conversion of the different numbering systems to the Tex system the following formula is applied.

$$\text{Tex} = 0.111 \times \text{Total Denier}^{*} = \frac{590.5}{\text{Ne}} = \frac{1000}{\text{Nm}} = \frac{1{,}00{,}0000}{\text{Ms/Kg}} = \frac{496055}{\text{Yds/lb}}$$

Size of Yarn

The yarns are produced in standard sizes, mostly the size is specific to specific group of synthetic fibres. Nylon continuous filament yarn is available in 210 Denier, Terelene in 250 Denier, Ulstron in 190 Denier. Carrothers (1957) mentions about Terylene yarns made to several sizes of 50, 75, 100, 125, and 250 Deniers while Shimozaki (1959) describes the properties of Amilan (polyamide group of fibres) yarn of 60, 110, 210, and 250 Deniers and Teviron (polyvinylchloride group of fibre) of 300 Denier. Perlon (polyamide group fibre) is available in 210, 630, 750, and 840 Deniers (Perlonwarenseichenverband 1959). The different denier sizes and types of synthetics described by Honda and Osada (1964) are polypropylene 180 Denier, polyamide (Amilan) 210 Denier, polyester (Tetron) 210 Denier, polyvinylchloride (Saran) 360 Denier and Teviron 300 Denier. In India polyamide fibre (Nylon) is mostly produced in 210 Denier size. 420 and 840 Denier sizes are produced to a lesser extent.

A nylon multifilament yarn generally comprises of 24 filaments. Carmody (1968) mentions the production of yarns with 24, 18, 15, 12, 7, and 6 filaments and is of opinion that yarns with 15, 7 and 6 filaments are more suited for netting. Nylon yarns of 140 Denier with 68 filaments and Terylene yarns of 250 Denier with 48 coarser filaments or 144 fine filaments have been reported to be used for salmon gill nets (Carrothers 1957). In India Nylon of 210 Denier with 24 and 34 filaments are mostly used.

Monofilaments fall within the range of 100-4000 Deniers, the one in common use being 100-1000 Deniers per filament. The shape of the cross section is usually circular and sometimes rectangular. In those with rectangular cross section the length width ratio is approximately 50:1.

Staple fibres are usually designated by the metric yarn numbering system and it mostly correspond to the British 20 count yarn (Shimozaki 1959).

Construction and Specification of Twine

Netting twines from yarns may be obtained by twisting, plating or braiding. A twine is usually the product of two twisting operations, first twisting together two or more single yarns to form a strand and secondly by twisting together two or more strands to form a twine.

A twine is designated by different methods. The diameter has been used as a creterion to distinguish many netting twines and plaited materials, but these values are often nominal. In the case of twisted monofilament twines sometimes diameter of a single yarn or diameter of the twines will be indicated together with the number of yarns. Another common method of specifying the twine is runnage i.e. the length of twine in a particular standard weight. Gayhurst and Robinson (1959) mention that a simple yet effective and easily understood size description system is to state i) the yarn size, ii) the number of yarns in a strand, and iii) the number of strands in the twine. On this basis 210 Denier Nylon twines with 6 yarns per strand having three stranded construction will be described as 210/6/3. This is one of the popular systems followed for twines with continuous filament and staple fibre yarns. According to the system developed by the Central Institute of Fisheries Technology and accepted as Indian Standard (I S 4640–1968) the method of designating netting yarns is as follows:-

i) Linear density of single yarn in Tex System.,

ii) The number of single yarns in the first fold.,

iii) The number of folded yarns in the finished product or if suitable the number of folded yarns then cabled in the finished product.,

iv) Resultant linear density expressed in Tex System.,

v) The twist directions in the various stages up to the finished product.,

vi) The composition of the yarn.

The International Standards Organisation also reccomends the above method for specifying the netting yarns. Klust (1964 a) advocates an almost similar method but with the incorporation of the data for the amount of twists inserted at the various stages of production.

Properties

All synthetic have one property in common-rot proofness. Apart from this, properties vary from material to material. As such an assesment of the same is an essential prerequisite for the selection of material for a particular gear. In as far as the fishing gear materials are concerned, the properties which have special importance are diameter, weight, specific gravity, strength, knot efficiency, weather resistance and abrasion resistance.

Diameter. For determining the diameter of a twine usually the following formula is applied.

$$d = K \sqrt{n/Nm} \quad \text{(Andreev 1962)}$$

where d is the diameter of the twine, n the number of yarns, Nm the count number in the metric system and K a constant. The values of K have been worked out as 1.3, 1.5-1.6, and 1.4 for cotton, kapron and hemp respectively. The diameter of twine is an important factor to be reckoned with especially in the case of gill nets as it affects the fishing ability as reported by von Brandt & Liepolt (1955), Mohr (1961) Gulbadamov (1962), Steinberg (1964), Znamensky (1963), Nayar et.al (1967) and Sulochanan & Rao (1964). It is assumed that thicker twines are easily recognisable by the lateral line of fish than soft and thin material The influence of diameter also appears to depend on the schooling behaviour of fish: smaller schools being more sensitive to this factor than larger ones (Steinberg 1964). The most desirable combination between diameter of twine and mesh size for gill nets is when the ratio of diameter 'd' of twine mesh bar 'a' is 0.01-0.02. In trawls a finer and stronger twine reduces the resistance to drag which indirectly retards the fuel consumption or helps in using a bigger net.

Specific gravity. Most of the synthetic fibres posses specific gravity lesser than natural fibres. Fibres with lesser specific gravity allows a greater length of netting for a given weight of yarn and may permit lighter fitting and savings in power and handling (Lonsdale 1959). On the other hand a low specific gravity may not be desirable where quick sinking of the net is required as in the case of purse seines and cast nets. Specific gravity also influences the form of the net while fishing. Among synthetics polypropalene has the lowest and vinylidenechloride the highest value of specific gravity. The specific gravity of a fibre is usually determined from the following formula.

$$\text{Specific gravity} = \frac{0.998}{1 - \frac{\text{Wt. in water}}{\text{Air dry weight}}}$$

The specific gravity of some of the commonly used fishing gear materials is furnished below.

Material	Specific gravity
Polyamide	1.14
Polyester	1.38
Polyvinyl alcohol	1.30
Polyvinylidene chloride	1.72
Polyvinyl chloride	1.40
Polyethylene	0.95
Polypropylene	0.91

Specific gravity and specific volume being reciprocally proportional, the diameter increases with decreasing density. Arzano (1959) illustrates this with examples. In the case of 125 Denier monofilaments the diameter expressed in 1/1000 ths of an inch are, Courelene 5.4, Nylon 4.9, Acetate 4.5, Viscose 4.5.

Twist. The quality of a twine is dependent firstly on the type of fibre and secondly on the number of twists imparted to the strand and twine. Two aspects are to be considered under twist (i) the direction of twist, and (ii) the amount of twist. The direction of twist is denoted as 'S' and 'Z'. In 'S' twist the slope of the components of the twisted product follows the direction of the central portion of the letter 'S' while in 'Z' the spiral follows the central portion of 'Z'. Divergent views have been expressed in designating the 'S' and 'Z' twist as right and left twist. Garner (1949) and Takayama (1959) recognise 'S' twist as right and 'Z' twist left while Himmelfarb (1957) and Linton (1957) describes 'S' as left and 'Z' as right. British standards (2052:1963) mentions 'Z' as right and 'S' as left. Indian Standards (832:1964; 5815 (part iii) 1970) indicate the direction of twist as 'S' and 'Z' without incorporating the usage right or left. The suitability of twine for a particular use is influenced by the amount of twists inserted to the strand and twine. The degree of twist is indicated by the number of turns per unit length and demarcated as soft, medium, hard and extra hard arbitrarily. The stability of a twine depends on the correct amount of twists imparted to the strands and twine. Twines with balanced twists show no tendency to snarl Tauti (1929) points out that the balance between primary twist for making strands from yarns and secondary twists to make twine from strands is very important because while an increased twist augments strength to a certain point an excessive twist produces an opposite effect. Konda (1938) and Koijumi (1954; 1955) pointed out to the same with regard to both cotton and synthetic fibres. Additional twists have the following effects, i) breaking strength is reduced, ii) extension at break is increased, iii) length per unit weight is reduced, iv) resistance to abrasion and general wear is improved (Gayhurst & Robinson 1959). Central Institute of Fisheries Technology has worked out the twist specifications for nylon fish net twines for gill nets and trawls and these have been accepted as the Indian Standards (IS 4401:1967).

Strength & Extension. Strength of a material denotes the loading capacity which together with extension gives an indication about its ability to withstand the strain. It is basically depended on the type of polymer, type of yarn, degree of stretching, the construction and the amount of twist. Strength of materials of different specifications are compared on the the basis of tenacity, tensile strength, or breaking length. Tenacity is the breaking force in terms of fibre or yarn denier, whereas tensile strength is the force in terms of unit area of cross section (Marsh 1957). The first is expressed as gms/denier and the second gms/sq. mm. The breaking force denoted by breaking length, according to textile terms and definitions is the length of the specimen whose weight is equal to the breaking load. The ratio of twine strength to aggregate yarn strength is known as doubling efficiency (Lonsdale 1959) and is 95% in the case of nylon.

Strength of nylon compared with other natural fibre twines indicates that it is twice as strong as Manila (Anon 1955 a) and thrice as cotton (Anon 1956). A nylon rope can withstand shock three times as great as that required to snap Italian hemp and five times as Manila rope. Klust (1958 a) arranges the various materials in the decreasing order of breaking strength as follows; polyamide continuous, polyesters, polyethylene, polyvinyl alcohol, polyvinyl chloride, and polyvinylidene. The dry tensile strength of nylon as reported by Lonsdale (1959) lies in the range of 4.5 to 9.0 gms/denier with an extension at break of 25 to 12%. The corresponding value for polyester continuous filament yarn is 6 to 7 gms/denier and staple yarns 3.5 to 4.0 gms/denier with extension values of 12.5 to 7.5% and 40 to 25% respectively. The tenacity of a polymer is maximum as multifilament yarns with monofilament and staple following in order as illustrated for polypropylene by Honda (1964).

Strength/denier of Polypropylene yarn

Multifilament	Monofilament	Staple
7.5 - 8.0	6.5 - 7.0	5.5 - 6.5

The tenacity values for some of the groups of synthetic fibres used in twines and ropes as monofilament are given by

Ede & Henstead (1964) and are reproduced below.

Synthetic fibre group	Tenacity g/d
Polyvinyl chloride	2.0
Polyamide	5.0 – 7.0
Polyester	5.0 – 7.5
Polypropylene	5.0 – 8.0.

In India there are only two groups of synthetic fish 'net twines; 1) polyamide as multifilament twines, 2) polythylene as twisted monofilaments and tapes. Indian Standards Institution has fixed yarn tenacity values for nylon as 5.5 g/d and polyethylene monofilament as 33.75 g/tex and tape as 40g/tex.

The strength of fibres change in the wet condition. In the case of natural fibres there is an increase in strength in wet condition, but opposite is the effect noted in some of the synthetic fibres. While discussing this aspect Himmelfarb (1957) states that the increase in strength of natural fibres is due to the water molecule in the amorphous region acting as a lubricant releasing internal stresses in the long chain molecule anchored to the crystalline region and thereby increasing the fibre strength by a more uniform distribution of stress. The decrease in strength of man made fibres is ascribed to the weakening of the lateral cohesion between the long chain molecule. Himmelfarb (1959) gives data for the difference in strength of cordage and twines by wetting.

Type	Effect of wetting on strength	Measured strength ratio wet – dry
Nylon	Loss	0.7 – 0.95
Dacron	Slight gain	0.9 – 1.10
Polyethylene	Gain	1.0 – 1.15

Shimozaki (1959) reports that with Teviron, Envilon, Saran and Krehalon the twines are slightly stronger (3.5%) in the wet condition, while the polyamide shows a reduction in strength by wetting. Klust (1964 b) reports that polyester, polyethylene, and polypropylene have the same breaking strength in wet and dry conditions.

Arzano (1959) lists the comparative strength and extension properties of some of the synthetic fish net twines. Carter & West (1964) make a comparative statement likewise with the inclusion of some of the later additions of synthetic group of textile fibres which is as follows.

	Group of synthetic fibre				
Property	Polypropylene	Polyethylene	Polyester	Polyamide	Polyvinyl alcohol
Tenacity (g/d)					
Dry	8.0 — 8.5	4.5 — 6.0	6.0 — 7.0	7.0—9.0	3.0—7.0
Wet	,,	,,	,,	6.0—7.9	2.6—5.9

Property	Group of synthetic fibre: Polypropylene	Polyethylene	Polyester	Polyamide	Polyvinyl alcohol
Extension at					
break % Dry	18—22	25—35	6—14	12—18	15—28
Wet	,,	,,	,,	19—28	20—30

When a knot is tied to a twine it constitutues the place of weakness thereby reducing the effective strength of the twine. The reduction in strength by knotting is dependent on the type of polymer, type of yarn, type of knot; construction of twine as well as on the degree of stretching. Synthetic twines with high draw ratio though they are stronger than their lesser stretched counterparts, loose much of their strength by knotting (Klust 1957). The wet knot strength of polyamide twine is two and a half times more compared to cotton of equivalent size (Starr 1957). However Volkoe & Mikahilova (1957) maintain that the knot breaking strength of polyamide twines is on an average 1.5 times higher than that of cotton twines of similar specifications. Polyvinyl alcohol twines posses only 2/3 the strength of cotton when wet and made into knot (Carrothers 1955), eventhough as twines the former is twice stronger. A comparison of knot breaking strength of trawl twines made of different synthetic fibres with the same runnage shows a decreasing sequence from polyamide to polypropylene to polyester, polyethylene, and polyvinyl alcohol (von Brandt & Klust 1970).

Molin (1951) has made a comparison of the loss in strength by knotting and wetting of polyamide imported from different countries. His data indicate that strength loss is more for filament yarn than for staple. The same finding has been noted for polypropylene (Tani 1964). The change in breaking strength of twines due to wetting and knotting has been extensively studied by Volkov & Mikahilova (1955). The authors find that the initial high breaking strength of nylon go to make up for the loss due to wetting and greater reduction is strength by knotting.

Knot efficiency can be stated as the ratio between the dry knot strength to strength of dry unknotted straight twine (or alternatively wet knotted strength to strength of wet unknotted straight twines) (Lonsdale 1959). Knot efficiency changes with diameter and type of netting twine (Perlonwaren zeichenvervand 1959, Klust 1964 b). Studies conducted with perlon monofilaments *(opcit)* of different diameters reveal the following:-

Knot efficiency	70—80 %	for small dia (0.1 — 0.3 mm)
	60—70 %	,, Medium ,, (0.35 — 0.70 mm)
	50—60 %	,, large ,, (over 0.70 mm)

The influence of diameter on the knot efficiency together with variations due to type of knot and type of netting twines (twisted and braided) in the case of polypropylene has bexen studied by Klust (1964 b). His data reveal the following:-

	% Loss of strength by knoting.	
	English knot	Overhand knot
Finest netting twine (twisted)	24	30
Twisted netting twine of medium strength (approximately from R 130-500 Tex)	39	45
Thicker netting twines (twisted)	50	53
Braided trawl twines	49	49

Klust (1968) has also observed that twines with single overhand knot tied opposite to the direction of twist of the twine give comparable values of strength to that of the weavers knot.

Weather resistance. Both synthetics and natural fibres are weakened by exposure to sunlight. Unlike vegetable fibres different typs of synthetics show considerable variations in their degree of resistance to light and weathering. The degradation is due primarily to the effect of light in the visible voilet and blue ranges of wavelengths (Inderfurth 1953). Klust (1959 a) has compared the weather resistance of different groups of synthetic fibres. He concludes that for traps and other basket types of nets which stand partly on the water or close below the surface of water polyvinyl chloride, polyacrylonitrile, and polyamide monofilament will be suitable. Himmelfarb (1957) makes a comparison of weather deterioration of nylon as monofilament, multifilament, and staple yarn and concludes that nylon in monofilament form is more resistant than multifilament and staple yarn. The above findings have been corraborated by Koura (1963) and Radhalekshmy & Kuriyan (1969). The superiority of monofilaments in their weather resistance has been explained by Klust (1955 a). He attributes this to the favourable proportion between surface and volume of the material. Ede & Henstead (1964) makes a comparison of the loss in strength of different types of synthetic monofilaments by weathering and states that polyethylene can be safely used outdoors in temperate climates for many years. Radhalekshmy & Kuriyan (*op. cit*) have studied the action due to weathering of various types of synthetics at two test sites a temperate and tropical site. The authors endorse the views of Ede & Henstead *(op. cit)* that polyethylene monofilaments could be used in temperate regions without much deterioration. The same authors have found polypropylene as not much resistant to weathering at both test sites. Deterioration due to weathering is more rapid at certain locations than others because of difference in duration of that particular wavelength of light which damages the fibre (Inderfurth 1953). Filament sizes and thickness also affect the weather resistance. Fibres with high denier per filament are more resistant than fibres with low denier per filament. Normally the resistance is better with thicker ropes, as the layers below are protected by the degraded outer layers and since ultra voilet rays cannot penetrate more than 1 mm. Findings of Ede & Henstead (1964) on monofilaments also give evidence that thicker the monofilament better the resistance. To increase the weathere resistance certain dyeing techniques have been recommended. von. Brandt (1954) stresses that though the damaging effect can be reduced by dyeing care should be taken to select the proper dye as some dyes can even increase the effect of light.

Klust (1955 b) advocates the use of cutch (4-6%) to secure protection against weathering. Tests conducted by the Central Institute of Fisheries Technology on Indian nylon showed that acid dyes of green and yellow impart a certain amount of weather resistance to the material.

A nylon twine exposed continuously to sunlight of normal intensity for 2 months can lose as much as 40% of its strength and a twine of Perlon staple without protection when hung in sunlight may lose strength up to 75% in the first three months (Rummler 1954). However other excellent properties of polyamide more than compensate for its lower resistance weathering. Besides, the intial high breaking strength of nylon makes it possible for polyamide to remain superior in strength after exposure for a certain period.

Abrasion resistance: Abrasion or wear to fishing nets is caused by two ways, one by friction with hard substances such as sea bottom hull of boat, and net line haulers and the other by friction between net twines at the seam and knots. The life of a net is influenced to a certain extent by abrasion resistance and it is dependent on the type of material, the kind of fibre, the construction of the netting and the thickness of the material. Among synthetics, polyamide posses the maximum abrasion resistance (von. Brandt, 1957). Polyamide filaments twines used in the German trawl fishery show that it is ten times more durable than manila nets. This is not only due to rot proofness but also due to greater abrasion resistance. Twines of polyester have only half the abrasion resistance of polyamide but the resistance is better than cotton and manila. Abrasion resistance is usually represented in arbitrary units on comparison with a material taken as a standard. In studying the abrasion resistance of different materials, identical runnage, diameter or breaking strength is taken as the basis. (Klust 1959 a). Klust *(op. cit)* has a made an elaborate study of the abrasion resistance of different materials, based on the above criteria. As per his studies the abrasion resistance of trawl twine having runnage of above 350 m/kg with the value of cotton taken as 100 are as follows:-

Manila 130.,
Hemp 280.,
Polyester continuous filament 230
Polyamide continuous filament 460.

For finer twines the same author has given the following figures taking the value of cotton of equivalent size as 100

Polyvinyl chloride	Rhovyl staple	50-55
	PCU Staple	75
Polyvinyl alcohol	Staple	50-60
	Filament	110
Polyacrylonitrile	Continuous filament	70
Polyamide	Staple	170-250
	Continuous filament	400-500

Ede & Honqstead (1964) have considered the abrasion resistance of monofilaments of different polymers having equal diameters and observes that the abrasion resistance is in the following order; polyamide, polypropylene, polyester, and polyvinyl chloride. Inderfurth (1953) attributes the high degree of abrasional resistance of polyamide (nylon) to the inherent toughness and natural pliability and its abiliiy to undergo a high degree of flexing without breakdown. Coupled with this the smooth filament surfaces do not readily create friction when rubbed against themselves or other surfaces. Among the various types of twines, monofilament is better than multifilament and between staple and multifilament, the latter is superior (Klust 1955 b, 1959 a). The relation of twist on frictional resistance has been explained by Shimozaki (1959), Klust (1959 a), and Ede & Honstead (1964). They observe that strand twist affects the abrasion resistance more as they seem to play the greatest role in increasing the rigidity of the twines. Preliminary studies conducted by the Central Institute of Fisheries Technology on the abrasional resistance of two groups of indigenously produced synthetic twines viz polyamide multifilament (nylon) and polyethylene monofilament indicate that the former posses a high degree of abrasion resistance compared to latter.

The second type of abrasion is interfriction between twines. When synthetics are rubbed against each other, abrasion between hard quality twines result in quick snapping. When a hard twine is rubbed against a soft one the latter breaks first; if both are soft the abrasion resistance of both seems to be improved. Between twines of the same kind the number of frictions to break them is mostly as many as, but sometimes a little more than the number required to break cotton (Shimozaki 1959).

Selection of Different Groups of Synthetic Materials for Fishing gear

As is evident from the foregoing, synthetic fibres are available in a wide variety of groups and forms with changes in physical properties and it is desirable to choose from among these a particular material which is most suited for a specific fishing gear. While there is no ideal material which can be used for all types of fishing gear, the various types of synthetics each having different properties provide a range of choice from which a selection can be made for what is best for each type of gear.

Synthetics are used either for the entire fabric of the net or part of it or as mounting ropes, or for the production of combination ropes with natural fibres. Firth (1950 a) states that one of the first commercial application of nylon is for the construction of gill nets. The use of Perlon monofilament for hand lines and gill nets and Perlon continuous filaments for tuna long lines and whale tow warps has been cited by Klust (1952). Rankovie (1957) mentions nylon as servisable for eel long lines in Lake Scutary. Examples of whale runners and purse lines of circling nets with man made fibres are cited by Klust (1958 a). Klust (1959 b) states that polyamide staple fibre twines are used for lines, scoop nets, fyke nets, caste nets, lift nets, drift nets, river stow nets and drag nets. Polyamide continuous filament twines are used for stronger or fine gill nets. Plaited twines of continuous multifilament perlon are specially strong and suited for large stow nets in the river fishery. When lowest possible extension is wanted (e. g. some pound nets, lift nets, gill nets and trammel nets) net twines of polyester are preferred. Klust (1960) is of opinion that polyamide and polyester are the two groups of chemical fibres that are most suitable for gill nets.

Eventhouh synthetics are widely used for gill nets their use for the fabrication of trawls is of a restricted nature. In sea fisheries trawls made of perlon are particularly used in herring fishery (von. Brandt 1956 a). While reviewing the properties of a particular type of synthetic twine, its application and suitability or otherwise to different classes of nets like purse seines, trawls, gill nets, ring nets, midwater trawls, drag nets etc have been stressed by various authors (Anon 1957, Teiko Rayon Co. 1959, Amano 1959, Carter & West 1964). Ruggerio (1960) mentions that trawls made wholly of 4.76 mm braided nylon cord were used in trawling over bottom which is considered too rough for natural fibres in Gulf of Mexico.

In spite of being buoyant the possibility of using Ulstron for purse seines with proper rigging and weighting is cited by Carter & West (1964). While studying the characteristics of synthetic materials of bottom and mid water trawls, von Brandt & Klust (1970) enumerates the specific requirements with regard to bottom and mid water trawls. These authors hold the view that for bottom trawls the netting yarns should combine high wet knot breaking strength at smallest possible diameter, high abrasion resistance, relatively high extensibility under fishing conditions, good elasticity for withstanding shock loads and no knot slippage or inversion of knots. von Brandt (op. cit) also emphasised that for pelagic trawls apart from good wet knot breaking strength the netting yarn should combine high extension and elasticity. Klust (1959 a) suggests the selection of synthetic twines for a particular gear based on the strain on the net material and has classified all the fishing gear of Germany under three main groups viz, 1. low strain 2. medium strain 3. high strain. Fine gill nets belong to group 1, fishing lines, baskets, traps and box nets, scoops, gape nets, dragged gear, also bottom trawls of smaller vessels, floating trawls of cutters seiners and drift nets belong to group two, and bottom trawls of large vessels and gape nets set in fast moving rivers belong to group three. Based on the above criteria he suggests the following guidelines for the selection of synthetic fibre twines for the different categories of fishing gear.

Mamoi Fishing Net Manufacturing Co Ltd (1959) and Japan Chemical Fibre Association (1964,1970) have also made certain observations regarding the utility of different types of synthetic fibre twines for different classes of nets based on the properties of the different materials. The choice indicated by Japan Chemical Fibre Association (1970) is as follows:-

Polyamide	: Gill nets (Salmon & Trout) Purse Seines (Sardines & Tuna)
Polyvinyl alcohol	: Purse seines (Mackeral, Horse mackeral & Tuna)
Polyethelene	: Trawls
Vinylidene	: Set nets (Yellow tail) Lift nets (Mackeral & Pike)
Polyester	: Purse seines (Horse mackerals & Mackerals) : Set nets.
Polypropylene	: Entangling nets (Crabs)
Polyvinyl chloride	: Set nets & Lift nets.

Catch Efficiency of Nets

All over the world synthetic fibres have increasingly become popular mainly because of the spectacular increase in fish catches of synthetics over traditional materials- Among synthetics the most wide spread use of nylon is in gill nets. The extensive use of nylon in gill nets is due to the ability of nylon to catch much more than a gill net of natural fibre. Reports of the fishing experiments of Young (1950) on white fish in Great Lakes indicate that nylon has a superior catch efficiency of 3.2 : 1 over linen. With spring Salmon his experiment show that the fishes caught in nylon gill nets were 7.3 lbs average weight compared to 6.6 lbs in linen nets. Molin (1950) reports that nylon gill nets are 2–3 times superior over cotton nets, while Lawler (1950) finds its superiority as three times over comparable cotton and linen nets. Another instance of greater catches by synthetic nets is reported by Giesel (1953) equal to 7.5 times more than cotton nets in Lake Laach. It has been stated (Anon 1954) that for cod and coal fish also nylon has proved to be successful. The catch of 27 fishing days for cod indicates an average of 2·8 fish/net/ day for cotton net and 8.24 fish/net/day for nylon and 6.4 for Perlon.

TABLE II

Fibre	Trade names	Characteristics	Suitable for use in
Polyvinyl chloride	F. Rhovyl G. PCU, Rhovyl J. Envilon J. Teviron	Medium breaking strength Medium abrasion resistance Very good resistance to weathering	Group 2
Polvyinyl alcohol	J. Vinylon J. Manryo J. Kuralon J. Trawlon J. Cremona J. Mewlon G. PVA	Low price, medium strength medium abrasion resistance, good resistance to weathering.	Group 2
Polyester	GB Terylene USA. Dacron G. Diolen G. Trevira F. Teegal I. Terital J. Tetron	Very high breaking strengh low extensibility medium abrasion resistance relatively good resistance to weathering	Group 1 and 2 Group 3?
Polyethylene	GB. Courlene X3 GB. Drylene N. Nymplex G. Polyathylen Hoechst	High breaking strength very high abarasion resistance, wiry swimming in water	Group 2 Grouy 3?
Polypropy	I. Merkaklon USA	Low price, medium to high breaking strength, low resistance to weathering, swimming in water	Group 1a. 3?
Polyamide mono filament	Nylon-monofil Perlon-monofil Platil	Transparency (little vissible-ness in water) very good resistance to weathering wiry	Group 1., Group 2., Fyke nets
Polyamide staple	Nylon-staple Perlon-staple	High breaking strength high abrasion resistance good knot stability very high extensibility, low resistance to weathering	Group 2.
Polyamide Continuous	Nylon-filament Perlon-filament	Very high breaking strength very high abarsion resistance, high elastcity, low resistance to weathering	All 3 groups of gear

F=France, GB=Great Britain, G=Germany, I=Italy, J=Japan, N=Netherlands

The corresponding values for coal fish were 7.5 for hemp and 9·2 for nylon. According to Atton (1955) greater catch efficiency of nylon nets decreases with increase in mesh size and these nets caught fishes of somewhat larger average weight than cotton nets of same size. This the author attributes to the elasticity of the twines. He further stresses that the selectivity of nylon nets compared to cotton varies with species and with availability of size groups in the population, and the main selective action of nylon nets is in the capture of greater proportion of larger fishes of the same group which are also caught in cotton gill nets. The elasticity of nylon allows the fish to force the twines apart and become caught which account for the capture of larger size fish (Young 1950, and du Pont Nemours & Co 1959) or wider range of fish sizes (Saetersdal 1959) with a given mesh size. Results of comparative fishing trials with coastal gill nets made partly of Perlon and partly of cotton carried out by Fisheries School, Merwot yam Israel, are reported by Shabtay (1956). His results indicate that Perlon half of the net lands about 80% of the total catch. Anon (1957 is of the view that the greater catching ability of nylon gill nets is due to its translucency in water, use of finer twines for a given strength, surface smoothness and the possibility of dyeing to match the surroundings. The fishing power of nylon gill nets compared to cotton studied by Saetersdal (1959) indicates the values to be 2.5-4 4, 1.4-2.3 & 1.2-1.3 for 3 types of fishes cod, coal fish and mackerel. Effectivness of synthetic gill nets is reviewed in a comprehensive manner by Muncy (1960). Field trials were conducted during the spring of 1959 by the author to compare the difference in catch of soft rayed fish by synthetic fibre (nylon) and natural fibre gill nets. Statistical analysis revealed the superiority of nylon nets in numbers, length freqnency and length weight of fish landed by these nets over linen counterparts. George & Mathai (1972) have conducted comparative fisning trials with nylon and cotton gill nets in the inland waters of India. Their findings also establish the superiority of synthetic fibre nets, the ratio of catch being 9 times by weight and 7.6 times by number between nylon and cotton. However a counter argument for nylon is put forward by Runnstrom (1964). His results are based on the experiments in Sweedish lakes in '62-63. The author indicates that the flexibility of nylon net is not significantly higher than that of cotton. He attributes the ability of fish to dodge the net by experience, as the reason for the difference in results from other workers.

Studics on the catch efficiency of gill nets with synthetics of different yarn types such as spun, monofilament and multifilament have been made by various authors (Anon 1952, Molin 1955, 1956, von Brandt & Liepolt 1955). Catch efficiency for spun and filament nylon nets is discussed on comparison with cotton in the experiments conducted by the Sweedish Institute of fresh water research, Drottingholm (Anon 1952). It is in the ratio of 1:2:7 for cotton, spun nylon and filament nylon. Molin (*op. cit.*) distinguishes separately the output of spun nylon and monofilament nylon over cotton. Monofilament nylon superseded spun nylon and cotton by 3 & 7 times respectively in the case of shallow nets. Superiority of monofilament nylon diminishes with the depth of the net and these nets will have the same efficiency as spun nylon nets at depths of about 6.1 m. Molin (1956) takes into account the catch efficiency with regard to two types of fishery, white fish and pyke perch. For white fish the tolal catch on monofilament nets was 50% higher than spun nylon nets. However the higher fishing power could not be compared with that shown by the more shallow nets tested earlier but it was illustrated that monofilament nylon is advantageous for deep water nets as well. The size of monofilament used for earlier experiments (Molin 1955) was 0.2-0.22 mm while it is 0.16 mm for the later studies, which accounted for the disparity in results. With pyke perch nets the results were negative as monofilament nylon gave even smaller than spun nylon. Rahm (1955) states that monofilaments recommend themselves by the greater efficiency, better utilization and longer life. His results based on 7 months operation indicate a catch efficiency of 1:1.9 for cotton and nylon gill nets. von Brandt & Liepolt (1955), in their investigations in the Coregone fishery gill nets, have found that identical nets of cotton, Perlon and Platil recorded catch in the ratio of 1:1.2:1.9. The authors add to say that thickness of monofilaments is a factor to be reckoned with since with increasing thickness, effectiveness reduces. This is illustrated with regard to the catch in trout fishery.

Material		Catch efficiency
Cotton		1.0
Perlon monofilament	0.15mm	4.9
	0.25mm	4.3
	0.30mm	3.3
	0.40mm	2.8

Carrothers (1959) distinguishes the catch efficiency between monofilament and multifilament nylon gill nets. He reports that the catch/day is better with monofilament nets but no appreciable difference was noted between the nets during night operations.

Comparative catch efficiency between various types of synthetic twines has also received attention at the hands of various research workers (Teikoku Rayon Co. 1959, Zaucha 1964, Honda & Osada 1964). Investigations by Teikoku Rayon Co. with Teviron and nylon drift nets for salmon and trout in North sea reveal teviron nets to be as efficient as nylon. Number of fishes caught in each operation was 2.27 for Teviron and 2.22 for nylon. Zaucha (op. cit.) cited the example of Polyvinyl alcohol and polyamid and opines that in spite of many good qualities of polyvinyl alcohol has better overall utility for herring drift nets. Between polypropylene and polyamide the latter possesses better catch efficiency (Honda & Osada 1964). The latest development in the material for gill nets is single yarn nylon. It was introduced in 1963 by Japanese fishermen in Lake Bawa, Honolulu Island. The single yarn net is made of continuous nylon twisted into a yarn of 102/1 of 34 filaments for smaller fishes up to 16 cms length; 110D/1 of 30 filaments for 10-20 cms fish; and 210D/1 of 24 filaments for larger fish (Anon 1967). Experience has shown that the catching ability is twice as that of nets made of multi stranded twines.

With regard to trawl nets also, advent of synthetics has effected some improvements. Firth (1950 b) mentions that nylon trawls were about 4-5 times more effective than ordinary cotton trawls in Norwegian fishing experiments. The possible explanation is that nylon is light, does not absorb much water and is smooth offering less resistance during towing, and it is likely that nylon trawl gives a larger opening. Miyazaki (1962) comparing the efficiency between Amilan and cotton beam trawls reported that in term of catch per drag the Amilan net had, in catching bottom swimmers efficiency twice as high as the cotton net, while there was no significant difference for the bottom burrowers. The trawl net operated by the United States Bureau of Commercial Fisheries in their experimental vessel in 1961 where the top wings, top belly and square were made out of polypropylene twine of size equivalent to the diameter of 42 thread cotton, fetched 57% of the catch while the comparative data for a trawl made out of Manila was 43%. Based on these experiments it has been suggested that the upper portions of trawl can be replaced by buoyant synthetic materials. Black polypropylene trawl used by the Bureau of commercial fisheries at Gloucester, Massachussetes accounted for 67 & 58% compared to 33 and 42% for trawls made out of Manila of the same size under similar conditions (Anon 1965). The explanation put forward for the higher rate of catch is that the buoyancy of polypropylene in the top sections allowed the head rope to rise higher reducing water resistance and allowed the trawl to be dragged more easily. Kuriyan (1965) while reviewing the trends in the development of prawn fishing technique in India mentions about the comparative trawling experiments in Indian waters with cotton and nylon. In the words of the author' in fact the cotton net caught more. Being a heavier material the cotton net might have dragged more on the mud'. The present authors feel that since in these experiments nylon twines indigenously produced for gill nets have been used, which being of a soft and flexible nature might not have retained the desirable mesh shape while trawling. This may be the reason for the apparent inferiority of nylon trawl net. Miyazaki & Tawara (1970) have investigated the feasibility of nylon and polyethylene monofilament trawls for semi pelagic and demersal fishes. The experiment establishes the superiority of polyamide monofilaments for semi pelagic nets while for demersal fishery both the nets had equal efficiency. The lower visibility of the former materials is cited as the cause for better efficiency.

Central Institute of Fisheries Technology has conducted comparative fishing trials with cotton polyethylene monofilaments and a combination trawl net of polyethylene (in the upper part) and cotton (in the lower parts). The studies indicate higher catch rate for polyethylene and combination net over cotton.

Synthetic twines have been used successfully for the construction of other types of gear as well. von Brandt's (1956 b) experiments in a Lake in West Germany have shown that the catch ratio of cotton and polyamide monofilament fyke net is 1:1.8 Kajewski (1957) points out that a Perlon trap produced 4350 kg of eel off Baltic coast while traps of cotton caught on an average 3355 kg. Perlon traps catching lesser amount of smaller eels. Rankovie (1957) made some attempts to as certain how long lines made of cotton, flax, hemp and nylon could influence the yield. The results indicate that thinner nylon not only yielded the largest output but also no hook was lost and when the season was over nylon lines had not lost strength as compared to natural fibres.

Guide Lines for Replacement of Natural Fibre Twines with Synthetics

Klust (1954 a), 1958 b) and Sunna (1956) give tabular statements as reference to replace cotton with nylon continuous filament twines based on equal wet knot strength. Sunnana *(op. cit.)* adds to say that the approximate correct number of nylon is got by increasing the runnage by 50% in the case of cotton. For equal weights, the net surface of nylon will be 2½ times more than that of cotton (Klust 1957). The Central Institute of Fisheries Technology has found that for equal wet mesh strength the runnage values of cotton and nylon conform to the ratio of 1:2.34 and between polyamide multifilament and polyethylene monofilament twines with equal runnage in both will have almost equal wet mesh strength.

ECONOMICS

The main factor that deserve consideration in the case of fish net materials are efficiency, durability, price, maintenance, operational costs and saving of material by way of runnage. These factors in turn influence the economics of using a particular net material. In the case of synthetics the price relation with natural fibres is so unfavourable that the use of it would apparently endanger the profitability of fishing enterprices. A nylon net is cited as lighter by 28% (Klust 1954 b) or 1/3 the bulk (Anon 1955 b) of corresponding cotton nets and 16-38% lighter than Manila. The weight of cotton and Perlon trap is given as 3280 and 2000 kg respectively in Briestenstein and Jager's (1953) investigations. Fontan (1958) makes a comparison of the price/length relation of hemp and nylon. 1 kg of hemp with running length of 176 ms costs $1.50 while the price of nylon rope of equivalent thickness is $6.3/kg with 600 m of length showing that the latter is 3½ times longer for equal weight. Ulstron Granton Trawl in braided monofilaments costs £160-210 compared to £130 for Manila based on equivalent diameter. But on a price life basis Ulstron trawl have an advantage of 50% over Manila (Carter & West 1964), also a bottom trawl of Ulstron weighs 250 lbs compared to 450 lbs in the case of Manila. With the introduction of different types of synthetic fibres it has been found useful to compare the price/length aspect with regard to different kinds of synthetic materials. Ulstron is in the same strength bracket as polyamide and polyester ropes and considerably stronger than polyethylene and possesses greater runnage for a given weight. (Carter & West 1964)

Material	Ropes of 1″ circumferances		
	lbs/120fms	Breaking load in lbs	Cost/100ft-
Ulstron	16.0	2100	37s 6d
Nylon	21.5	2240	48s 9d
Terylene	24.75	2100	58s 8d

In India the price of nylon is Rs. 45/kg compared to Rs. 20-25 for cotton. However the price of polyethylene monofilaments is much less coming to about Rs. 18/kg. Taking the example of a 1 mm twine, in the three cases, the rnnning lengths will be 1600, 1465 and 1320 m/kg respectively for nylon, polyethylene and cotton. This indicates, that nylon is lengthier by 15% and polyethylene by 10% than cotton of equivalent size for a given weight.

ii) Operational cost and maintenance:

Low weight, flexibility, and fineness make it easy to handle synthetic fibre nets and finer twines considerably reduce the tow drag. Nylon exceeds hemp by more than 50% in its resistance to pull and weight it can support (Fontan 1958). Reduction in the total weight of equipment, no expenditure on net preservation, less labour to handle the gear, water saturated nets can be safely stowed with a useful life of at least double to cotton nets are some of the advantage claimed for Perlon staple purse seine (Perlon warenzeichenverband 1959).

iii) Durability:

Various reports are on record pertaining to the greater service life of synthetic nets over those of natural fibres. The data are based on comparative fishing trials with two type of nets. Klust (1954 b) gives the comparative life of cotton and

Perlon purse seine in Portugese fishery as 450-500 and 900 fishing days respectively. A cotton bag net is sreviceable only for 2 years with 7-10 preservative treatments while synthetics last for 3 years with no damage and by this service life the initial cost could be recovered. A Perlon trawl was found to be serviceable even after 14 voyages with an output of 45,000 baskets of herring (Klust 1955 c). Briestenstein and Jagers's (1953) investigations with braided continuous Perlon and cotton traps show that after the first fishing season cotton nets have become useless but Perlon traps are useful for a span of 5 years with a price relation of 1:4. A Perlon trawl after 5 years 1056 fishing days) has been found to be serviceable even with a loss of 54.5% (Klust 1956) of its strength. Perlon is 15 times more useful than Manila, while the price is only 3-4 times more, thus establishing its superior profitableness (Klust 1956). A Perlon rope $3\frac{3}{4}''$ dia. with a breaking strength of 11,800 kg retain 4460 kg after 916 fishing days (Klust 1956) Perlon warenseichenverband (1959) reports the service life of Perlon continuous filament purse line of 30 mm dia as 19 times to that of sisal rope where as the price of the former is only 5 times the latter. The author also mentions about a bottom trawl of Perlon which landed 12800 cwt. of herring and having a useful life of 8-10 times more than that of manila trawl. He has also refered to the merits of Perlon in the case of purse seines and stow nets. Cotton purse seines have a useful life of 400-500 fishing days while Perlon staple net was operated for 1300 days without becoming unserviceable. Cotton stow nets have a useful life of 2 years only if treated 7-10 times with coal tar to preserve and stiffen while stow nets of Perlon can be used for 6 years, with only two treatments during the period. Cost of the latter which is serviceable amounts only to DM 1625.00 during which period at least 3 cotton nets would have to be purchased costing DM 3270.00. Mugaas (1959) referes to the tests conducted by Directorate of Fisheries, Norway. Tests indicate that Kurlon traps had been in use continuously for 4-5 months with no sign of reduction in strength in the twines. Traps made from hemp and cotton had to be renewed every 7th week. Carter & West (1964) report that in coarse fishing grounds the average life of braided Ulstron trawl is about 5 weeks. Making allowance for accidental losses by snagging or submerged objects and similar mishaps the average life is reduced to 2 or 3 weeks. The corresponding average life of Manila trawl is $1\text{-}1\frac{1}{2}$ weeks.

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