



# Demersal Trawls

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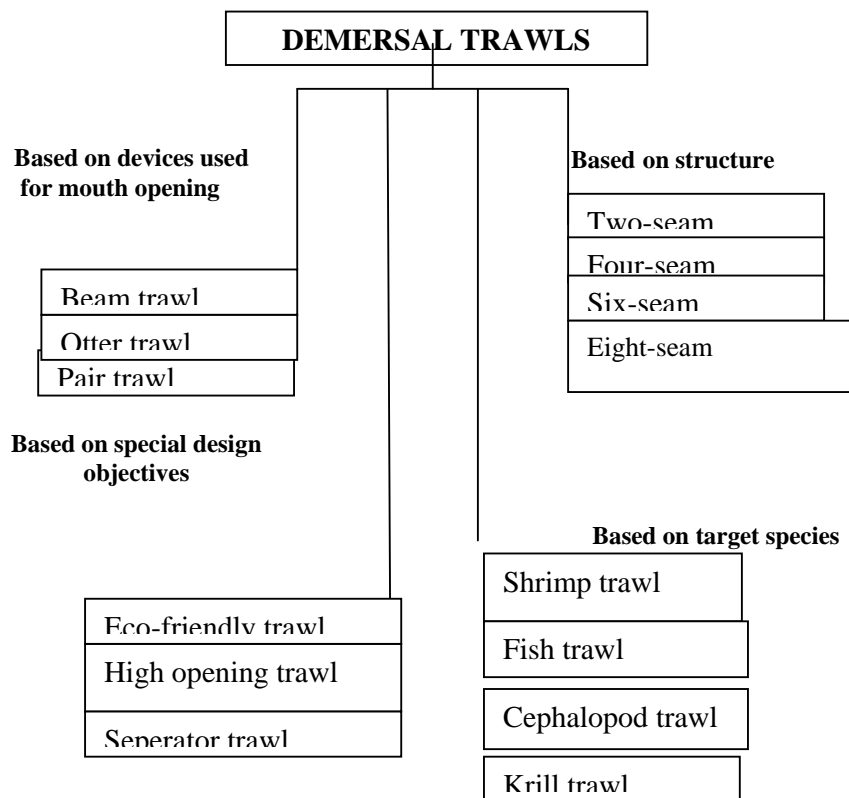
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Trawl is a bag net towed through water, the mouth of which is kept open horizontally by means of a beam or otter boards and vertically by means of floats kite and sinkers. Mouth opening is also effected by dragging with two vessels.

Demersal trawling continues to be one of the most important fishing methods of the world. In India bottom trawl fishing was first introduced in late 1940's by Exploratory Fisheries Project. It has taken several years to reach the trawl design, rigging and operational procedures to the present state.

## Classification



### Fig. 1 Classification of trawls

According to the device used for keeping trawl mouth open, demersal trawls are classified as below (Fig. 1):

**Beam trawl:** The mouth of the net is kept opened with the help of a rigid frame. Main drawback of the net is the size of the beam that can be safely utilized inside the boat and hence the size of the net is also correspondingly restricted.

**Otter trawl:** The mouth opening is achieved by the attachment of two otterboards on either side of the net. The towing warps are attached to these boards at an angle, so that while towing the water force acting on them tends to diverge them and thus keep the mouth of the net open.

**Pair trawl:** The net is towed by two boats cruising on a pre-arranged parallel course and speed. The distance between the two boats is also maintained constant, so that the diverging warps keep the mouth of the net open. Main advantage of this method is a much larger net can be used, as two boats are engaged.

According to the construction, trawls are classified as

**Two seam net:** Nets having only two major parts- upper and lower and these are seamed together laterally to form the two seams. The upper part invariably includes the overhang or square and hence the two seam nets are always overhang nets. Two seam nets are generally operated from larger boats. Cross section of the net is elliptical in shape

**Four seam net:** These nets are having four parts, the upper, the lower and the two lateral sides. Four seam nets are with or without overhang. Overhang is attached only for fish trawls

Cross section of the net is rectangular in shape and hence the vertical opening of the trawl may be influenced by the width of the side panels

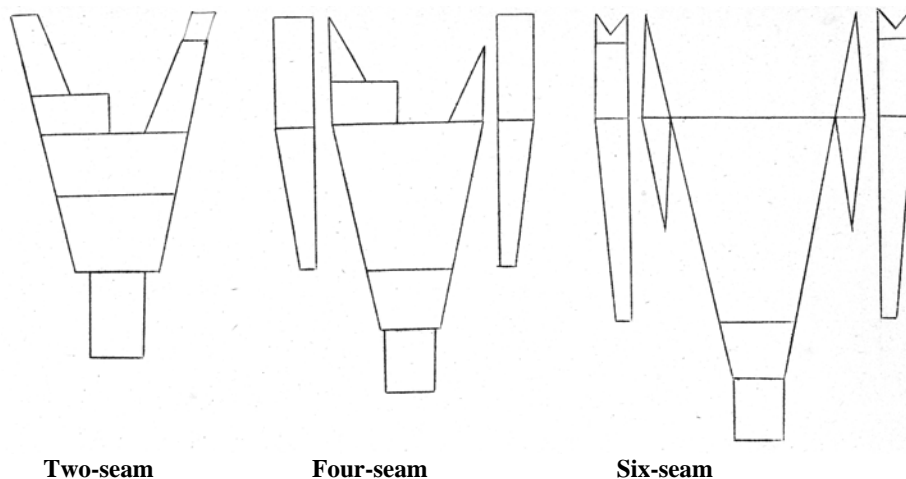
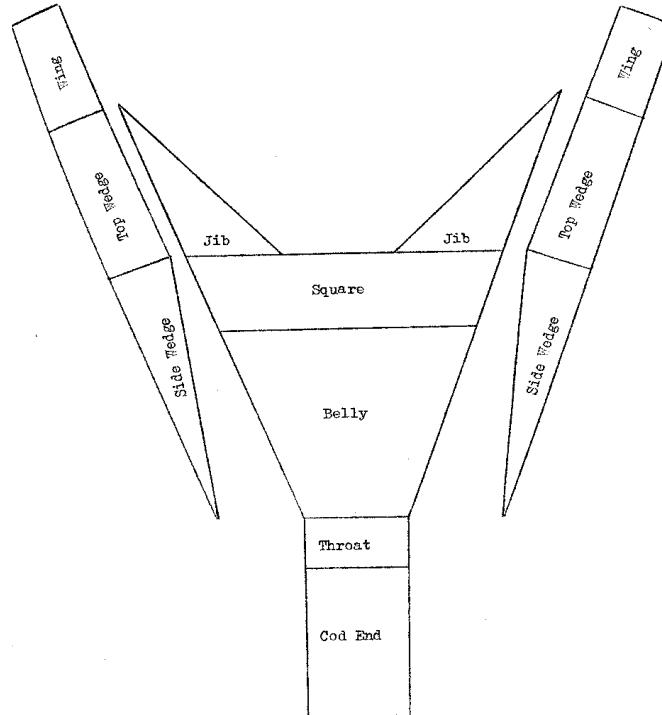


Fig. 2 Trawl types based on construction

## Constituents of trawl system



**Fig. 3 Parts of trawl**

Main parts of trawl construction are discussed below (Fig 2 & 3):

**Square:** is the front portion of the upper section of a trawl, which is fitted between the body and the two upper wings so that it is partially overhangs, the lower parts of the net. It is the cover, which prevent the fish from escaping the path of the trawl by swimming upward (Fig. 3).

**Wings:** Is the forward extension of webbing on either side forming major part of trawl mouth for guiding the fish towards the bag of the net. They are in pairs, one on either side. The head rope is attached from one top wing and across the centre part of the square and along the opposite top wing to the end. Foot rope is rigged to the lower wing in the same manner.

**Bosom:** Is the centre portion of trawl between the wings on upper and lower sections.

**Jibs:** are triangular pieces of webbing attached on either side of upper and lower bellies at their junction with wings to present a smooth shaping to the mouth of the net. These are made in pairs, one on each side.

**Quarters:** are two junctions where the top wings join the square.

**Side panels:** are two identical pieces of webbing attached on either sides of the belly to join the upper and lower portion of a four seam trawl. The portion of the webbing that comes above the belly is termed “top wedge” and the portion placed adjacent to the belly is termed as “lower wedge” or “side wedge”.

**Bellies:** (upper & lower) form the channel of trawl through which fish moves to the cod end. Upper belly is also called “top body” or “baiting”.

**Throat:** is the portion of webbing placed in between the belly and cod end. It is also known as “lengthener” or extension piece.

**Codend:** is the narrow rectangular end section of the trawl usually of heavy construction with small meshes.

**Flapper:** is small trapezoidal piece of netting whose wide front edge is laced in the fore-part of the codend to the upper panel, while the short rear edge remains free and forms the mouth of the codend. It acts as a safety device to prevent the escape of fish from the codend.

**Apron:** otherwise known as “Hula skirt” or “Chafing gear” is the thick piece of netting attached around the codend for protection

**Head rope:** Rope line forming the upper lip of the trawl to which the upper edge of the net is finally attached.

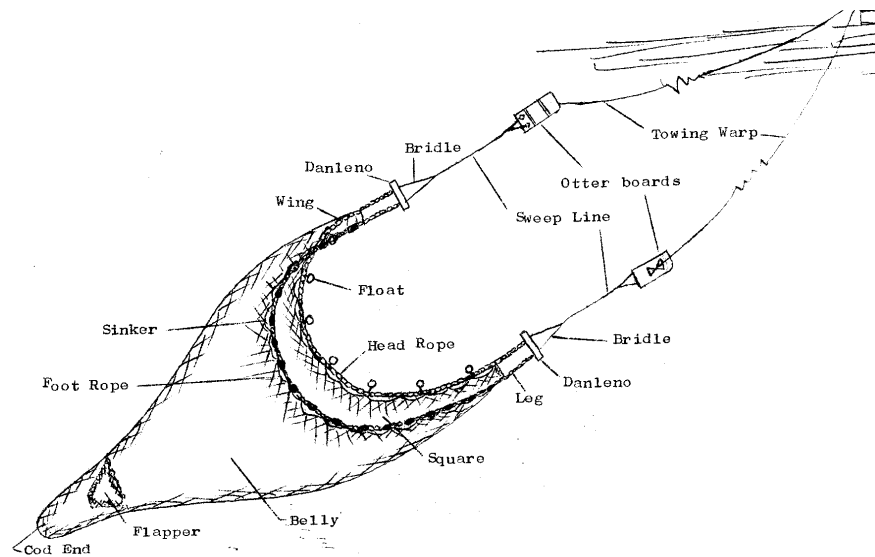
**Foot rope:** Rope line forming the lower lip of the trawl to which the lower edge of the net is finally attached.

**Bolch line:** is the thin rope to which the webbing is initially hung, prior to the rigging of the net to the HR and FR.

**Belly line:** is the strengthening ropes seized along the joining where the upper and lower panels are laced together.

**Cod line:** A rope of high breaking strength threaded through the meshes of the lower periphery of the codend so as to close the cod end

**Pork line:** A light fibre line attached between the hauling leg and the head line, in such a way that the hauling leg is easily retrievable when the trawl is on the surface



**Fig. 3 Main parts of trawl net**

## Trawl design

The efficiency of a trawl principally depends on the precision and symmetry in construction of the webbing and the body. A trawl is designed in such a way that

- i. It should offer minimum resistance to motion when dragged and the resistance should match the bollard pull of the boat
- ii. Should achieve maximum mouth opening
- iii. Least hindrance to the movement of fish towards the cod end
- iv. Although the designs vary different parts of the net should be proportionate to its size.

Miyamoto (1959) developed a formula for designing four seam, non-overhang trawls for smaller trawlers.

$$H = \sqrt{43.6 p + 660}$$

where H = length of HR in feet  
P = horse power (hp) of the engine

Koyama (1970) developed formula for trawls operated from vessels of 300-40,000 hp.

$$H = 42 + 0.006 p$$

Length of the trawl is measured along the lestridges (side lines) from wing (jib) end to tip of cod end and it varies from 1.1 to 1.5 times the HR length.

The length of head rope will be distributed as

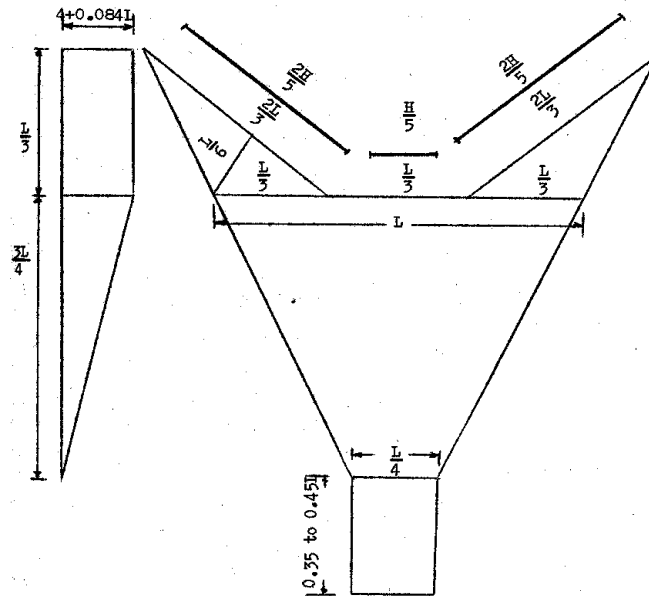
$$\begin{aligned} &H/5 \text{ for the bosum} \\ &2H/5 \end{aligned}$$

for the jibs. The mesh size and twine size is determined by the type of fishing and the size of target species.

## Construction

For joining of different panels, the proportion of the number of meshes on one panel's edge to the number on the other panel's edge is indicated as a fraction or ratio known as "take up" or joining ratio.

E.g.  $A/B = 3/4$  or  $A : B = 3 : 4$ . Three meshes of panel A to be joined with 4 meshes of panel B.



**Fig. 4 Dimensions of various parts**

After joining the panels the webbing must be affixed to the bolch line with required looseness (hanging coefficient). The correct hanging of the webbing to the bolch line is a very important factor to get the definite degree of opening of the meshes. Generally a hanging coefficient between 0.4 and 0.5 is used.

Eg. The hanging coefficient is expressed as  $a1/A = 4/5$  i.e. 5 m of webbing to be mounted on 4 m rope.

Then the mouth region of the upper part of the webbing is mounted to the head rope and the lower part to the foot rope. Sinkers are attached to the foot rope prior to rigging to webbing. Floats and sinkers are to be carefully distributed to head and foot rope to avoid excess sagging. For medium sized trawls the weight requirement per feet is 0.5 to 0.75 lbs. and the total buoyancy of float required is between  $1/2$  to  $2/3$  of the total weight of sinkers (Nair, 1970).

Various methods are in vogue for comparatively higher vertical opening. They are use of kite and triangular gusset, insertion of triangular wedges on the wings or splitting the wings along the selvages (Dickson, 1959) or use of float or float like devices having higher lift drag ratio.

According to construction the trawls can be divided into two seam, four seam, six seam and eight seam. Larger bottom trawls are of two seam construction. These nets are normally provided with an overhang, for the upper belly, to prevent the upward escapement of fishes from the net mouth.

Four seam and six seam nets can be made with or without an overhang. Here a square is attached to the forward part to serve the purpose of an overhang. Generally, most of the fish trawls are having overhang and it is not essential for shrimp trawls.

After mounting the net eyes are spliced at either ends of the ropes (legs) for connecting the net with towing warps.

Free end of the cod end is provided with loops made of thicker twine through which a smooth and strong line is passed and the two ends of the line are spliced together. This cod end rope is used for securing and releasing the catch

## Resistance of trawl gear

The bollard pull (towing power) of a trawler should be higher than the total drag at the maximum speed at which the trawl is towed. The drag of trawl gear is the power required to overcome the hydrodynamic resistance of the gear towed at a particular speed. Hydrodynamic resistance or drag is estimated from model studies and by scaling up the results so obtained to the actual size. It is also estimated through theoretical calculations by adding up the drags of individual components of the trawl gear (Boopendranath, 2000)

Trawl drag (resistance) is approximately estimated as follows

Net	: 68 %
Otter boards	: 24%
Sweeps and warps	: 08%

## Other trawl accessories

**Float:** Floats are essential component of the trawl net for maintaining the head rope always upward. Spherical floats of aluminium, plastic material (PVC) and fiberglass are used. In India, aluminium floats are made of 14-gauge aluminium manganese alloy. Ordinary aluminium floats are light and can fish only up to 80-90 m depth. High-density plastic floats are having high bouancy, less weight, can withstand high pressure and are comparatively cheap. As the size of the vessel increases, there is a tendency to tow the gear at great speeds. In such cases spherical floats are not sufficient to maintain the head line lift. Hence different types floats such as trawl plane float, hydrodynamic float, up thruster float, siamese twin float were developed

**Sinkers:** They are used for stretching the ground rope down to obtain the vertical gape and bottom contact. Iron and pig iron chains are commonly used in trawl net. The requirement of of an ideal material for sinker is that it should have high specific gravity so that it can sink faster, it can easily be made into different shape and easily available at low cost

**Pennants:** Also known as lazy line serves as the connection between shackle and connecting link of the warp. It is made of galvanized steel wire with same thickness of warps and bridles. The pennants, one with each otterboard, are used for hauling the net after the otterboard are detached. There is no strain on these lines when the trawl is being towed.

**Bridles:**

Bridles or sweep lines are the connecting wire linking the otter board and the legs of the net. Usually they are 10 to 20m in length and are used for achieving better horizontal spread of the net.

**Trawl warps:**

They are steel wire ropes of identical length, fully wound on the winch drum when not in use. While shooting the net the warps are connected to the otterboards by means of G-link assembly. The diameter of the warp may vary from 9 to 16 mm, depending on the size of the vessel and net. The rope must be flexible with lubricated inner fibre core. The length of warp to be released while towing the net depends on the depth of the fishing ground. Usually the depth and warp length ratio is 1:3 and it may go up to 1:5 depending on other sea conditions.

**Bobbins:**

For fishing on rocky and coral areas an additional rope with rollers or bobbins has to be fastened to the ground rope to protect the net. The rollers or bobbins can be wooden, rubber or any other hard materials. They may of various shapes, mainly round, disc or spherical.

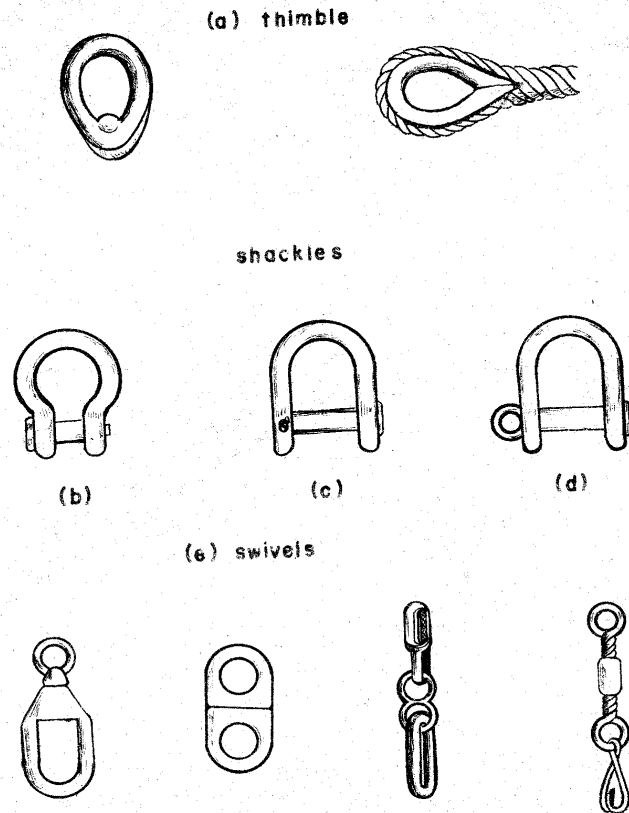
**Thimble:** It is a grooved ring set in the eye of a rope or cable. Thimble prevents deformation of eye and chafing of the material.

Thimbles are usually made of galvanized forged iron or brass or gun metal (an alloy of brass and copper).

**Shackle:** It is used as a connecting link or device for fastening parts together, usually in such a manner as to prevent some motion. They are made of galvanized iron and are of different shapes. Each shape is used for a specific purpose. Anchor shackle is used for connecting the brackets of motherboards with warp. D'shackle is used for joining rope. Eye bolt shackle is joining all types of lines and wires.

**Swivel:** It is having two links that turn round independently on a pin or neck. Swivel serves as a connection between two parts, which are liable to cause twist and kinks. They are made of bronze, galvanized iron or steel. In trawls they are used in between the towing warp and otter board, behind the board between the back strops and sweep line.

**G-link assembly:** It is a clip link shaped in the form of the letter "G" and is made of galvanized iron. It is attached to the brackets of the otter board. The end of the towing warp is connected with the recessed link through the swivel. The 'G' link can be joined to the recessed link. This method of attachment of trawl warp to the otter board helps to save time in connecting and disconnecting the doors and warps while hauling and shooting the net.



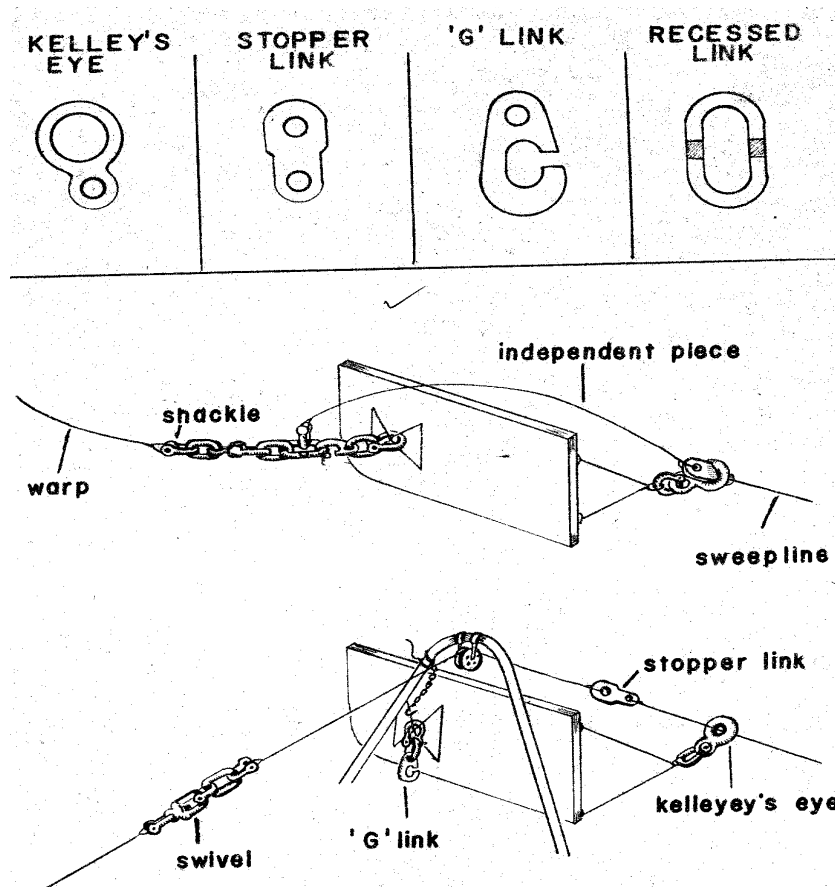
**Fig. 5 Thimble, shackles and swivels**

**Kelley's eye and stopper link ("8"link):**

Kelley's eye (Fig. 6) is a combination of two metal rings one is bigger and the other is small. The small ring is for a shackle, which in turn is connected to the double end of the back strops. The other link is for jamming the "8" link. The "8" link is attached in between the independent piece and the sweep line. The sweep line is taken through the big eye of the Kelley's eye. During trawling the strain is taken by the Kelley's eye and back strops. The independent piece connects the sweep line with the warp. When the trawl boards are disconnected from the warp, so that the sweep line and net can be hauled by the winch. Material used is galvanized iron.

**Dan leno:** Consisting of iron bobbin, swiveled on one end to the butterfly (an iron bar with wide angle to spread the wing vertically) and the other end to the bridle on each side to achieve the horizontal spread of the net

**Banana link:** This prevents the main connecting shackle from slipping down the bracket and so causing the boards to take up an undesired angle while in operation



**Fig. 6 Kelley's eye and stopper, G link and recessed link**

**Tickler chain:**

It is used to stir up the seabed in front of the trawl net which brings up the burrowing species like shrimp, flat fishes etc by frightening and induce them to enter the net. Tickler chain, running from one end of the foot rope to the other end slightly smaller in length. From ecological point of view, the use of tickler chain is harmful to the benthic ecosystem.

**New designs of trawls**

**High Speed Demersal Trawls (HSDT)** :Commercial exploitation of active, multispecies low population density fishery resources requires encountering of fish at a high speed. CIFT has developed 3 high speed demersal trawls for the same purpose. HSDT-1 & II are two seam trawls and HSDT-III is a four seam net. These are made with light material, large meshes, with appropriate angle of attachment of webbing at the wings, trawl mouth and belly region to get a smooth catenary of the framing rope. Smooth tapering along the belly facilitating even distribution of stress along the entire net to allow a wide opening of mesh from square to diamond shape from wing to codend is the main features of high speed trawls. Due to the even distribution of force all along the net from wing to codend, it opens horizontally and vertically to the optimum thereby facilitating smooth water flow and herding of fish to codend without gilling at any part of the net (Panicker,1990).

**Hybrid trawl for squid:** This trawl was designed for exploitation of neritic squid and cuttle fish as a diversified fishing, as demersal and pelagic/midwater trawl

**Scrape trawl :** Designed for capturing ground fishes in Ireland and Scotland. They are constructed with long wings, large cover sheet and typically low head line height and are basically an extension of the traditional shrimp trawl used in Ireland. The modern scraper trawl is generally fished with long combination rope bridles, giving as much ground coverage as possible.

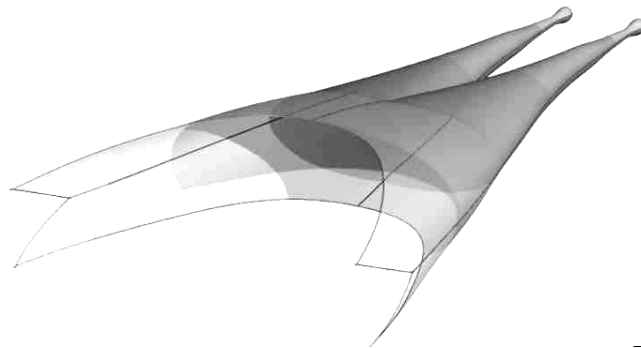
**Twin crown or double bosom trawl:** This trawl was originally designed in Scotland as an alternative to twin rigging for prawn and ground fish species. This type of gear incorporates a tongue in the center of an extended bosom. This tongue divides this large crown into two smaller section. Advantage of this system is the increased ground coverage without distortion of the bosom of the net.

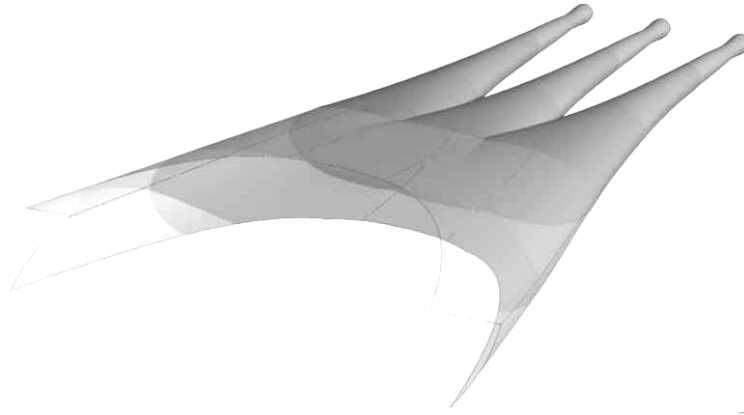
**Long wing trawl:** The net is provided with long wing and short body. This helps to sweep a wider area for the capture of prawns

**Bulged belly trawl:** In this wider side panels are provided to increase the vertical openings, and at the same time tapering of the belly is so streamlined so as to give maximum mouth opening to reduce the resistance to the minimum and retard the rate of escapement to the maximum.

**Four panel trawl:** The salient feature of this trawl is that all the four panels are identical. The net is also provided with detachable wings, so that when the wings are removed the net can operated as midwater trawl.

**Trawls with multiple codends:** Nordsea Limited has developed and tested two new trawl designs the **Duplex** with two cod ends, and the **Triplex** with three cod ends (Fig. 7). The designs are based on the premise that increased footrope swept area; as is the case with twin trawling, can be achieved using a single net.





**Fig. 7 Perspective views of Duplex (top) and Triplex shrimp trawls (below)**

The new trawls feature a wide horizontal opening for harvesting shrimp or other ground fish species near the bottom. The design also allows a footrope spread area comparable to that achieved by twin trawls, and offers a ‘middle road’ alternative to owners that for financial or technical reasons, are unwilling to convert to twin trawling. Compared to a single trawl of a given size, Nordsea’s trawl simulation program indicates that it may be possible to achieve a 20% increase in strategic footrope spread area with the Duplex design, and a 47% increase using the Triplex. The horizontal spread or footrope swept area of the new designs compares favorably with data obtained by Nordsea during a recent successful twin trawling project. This increase in lateral spread justifies the decrease in headline height compared to a single trawl - a 24% decrease for the Duplex, and 32% for the Triplex. There is no requirement to maximize the vertical opening, as is the case for designs targeting round fish. Drag does not necessarily increase with multiple cod ends. Less netting is required in the new designs, compared to that needed for a similar footrope increase in traditional trawl.

## **Technological innovations to improve trawl selectivity**

All the previous innovations have concentrated mainly on increasing the fishing efficiency. Increasing awareness on responsible fishing methods has resulted in studies to improve the selectivity of the trawls.

### ***Separator trawls***

In 1963, French research workers introduced the first separator trawl designed to separate shrimp from flat fish based on the difference in their swimming behaviour. The selection process of this device is based on the fact that various species behave differently when they tired of swimming in front of the trawl, and fall back towards the codend. Inserting a horizontal panel in the trawl offers the potential to separate the higher and lower/ swimming species. Studies conducted in UK and Ireland has shown that separator trawls are effective.

CIFT has designed a separator trawl which is a modification of 4 seam trawl without lower belly but with large mesh separator attached along the entire length of side panels, midway between the vertical height. The bottom edges of the side panels continue as the footrope up to the codend region with sinkers and ropes (Panicker, 1976). By-catch Reduction Devices (BRDs), square mesh cod end and windows, Radial Escapement Device,

Fish eye, Rigid grids and Turtle Excluder Device (TED) are the other technologies developed for improving trawl selectivity which will be dealt in detail separately.

## **Conclusion**

In changing situations it might become necessary to incorporate modifications of varying degree to the existing patterns. While doing so, the aim should be to produce a net with which can catch large quantity of fish for the smallest cost. Different factors have to be taken into consideration such as strength and elasticity of webbing, resistance to the water flow, weight and bulk, speed of operation, cost of materials, condition of fishing ground etc.

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