The name trawl is derived from the manner of operating the net. The net is a large bag net, tapering from the mouth forming a flattened cone, with some device for keeping the mouth of the net open, while it is towed or dragged. Hence it is a dragnet. There are three types employed to keep the mouth open:

(a) Otter trawl with a pair of Kite like shearing boards known as otter boards, one at each side of the net. This is the most popular and widely used trawl all over the world.

(b) Two-boat (Bull/pair) trawl is towing a single large trawl by two identical boats, each of which is towing a single warp. (This method is officially banned in India as a conservation measure)

(c) Beam trawl is attaching the net to a rigid horizontal beam (Restricted to some parts of the world).

Trawls are broadly classified according to the depth of operation as:

i) Bottom trawls - otherwise known as Demersal trawls.
ii) Mid water trawls
iii) Pelagic trawls

Trawls are described as follows as per design and construction:

a) Two seam - with two panels
b) Four seam - with four panels
c) Six seam - with six panels
d) Multi seam - with more than six panels
e) Overhang - with a separate square in the upper panel
f) Non-overhang - without overhang
According to the species of fish caught, trawls are designated as:

i) Shrimp trawls - for prawns, other crustaceans etc.
ii) Fish trawls - for fin fishes
iii) Cephalopod trawls - for squids and cuttlefish.

Theories of trawl design

Size of trawl is determined by the head (rope) length (most common method). Size of trawl is again described as the number of meshes in circumference at the anterior end of the belly of the trawl with size of mesh.

Size of trawls depends on the power of the trawler. Miyamoto (1959) evolved a standard formula for the design of four seam non-overhang trawl nets for smaller trawlers.

\[ H = \sqrt{43.6p + 660} \text{ (in square root)} \]

where \( H \) is the head rope length in feet, \( P \) is the horse power of the engine of the trawler.

Koyama (1970) proposed a theory of design of trawl for higher range of horse powers. Trawl head rope length \( H \) can be calculated with the following formula:

\[ H = 42 + 0.006P \]

where \( P \) is the horsepower of the engine.

The formula is applicable in the case of trawlers with 300-40000 h.p. engines.

Matching the size of trawl gear to power of vessel:

The bollard pull (towing power) of the vessel (trawler) should be higher than the total gear drag at the maximum speed at which the net is towed. It may be roughly
estimated as 1 to 1.2 tonnes for 100 h.p. trawlers and it can be proportionately applied for h.p. ranges above and below 100 h.p.

**Bollard pull** is the towing power of a vessel to tow a load through water.

**Trawl Drag (Resistance)** An approximate estimation of the total trawl resistance (drrag) is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Net</td>
<td>68%</td>
</tr>
<tr>
<td>b) Otter Boards</td>
<td>24%</td>
</tr>
<tr>
<td>c) Sweeps and Warps</td>
<td>08%</td>
</tr>
</tbody>
</table>

The length of trawl is measured along the last ridges (sidelines) from wing (Jib) end to the tip of cod end and it varies from 1.1 to 1.5 times the head rope length.

**Part to a trawl**

a) **Body (Belly):** This is the main component of a trawl with varying mesh sizes (100-150 mm in the off part 40-50 mm in the forepart and 30 mm in the aftpart in shrimp trawls)

b) **Jib (wing):** This is the fore end part of a trawl. Size and shape varies according to the design and with large meshes (100-200 mm in fish trawls 50-60 mm in shrimp trawls).

c) **Cod end:** This is the fish collection bag of the trawl with the minimum mesh size recommended for each design as 20 - 25 mm in the case of shrimp trawls and 30 - 40 mm in the case of fish trawls.

d) **Square:** A rectangular or square piece of webbing in the upper panel of overhang trawls.

e) **Side panels:** Corresponding to Wing/Jib, square and belly portions in the case of four seam, six seam or multiseam nets.
Shape cutting of trawl webbing: Trawl webbings are either handmade or cut into required shapes by employing “point” and “Bar” cuts.

Joining: different trawl webbings are joined to for corresponding panels.

Lacing: after the formation of panels, lacing of panels are done sideways to complete the whole ruffing.

Mounting: Trawl webbing in the mouth of the trawl has to be mounted with required looseness (hanging coefficient) first to a line (rope) with smaller diameter (4 mm, 6mm, 8mm as the case may be). This line (rope) is known as Bloch line (fig.5). Then the Botch line will be fixed to the actual Head Rope or Foot Rope with larger diameter (14 mm, 16 mm, 18 mm, as the case may be)

Floats and Sinkers: The distribution of floats and sinkers to the ropes of the trawl has to be distributed so as to prevent undue sagging of the ropes.

Angle of attack: is the angle between the plane of otterboard in a trawl net rigging and the direction of motion. Optimum angle of attack for a rectangular otterboard is in between 27°28° (upto 35° - 40°)

Different types and shapes of otterboards:

1. Rectangular flat - conventional, Wood and Steel construction
2. Rectangular cambered - Wood and Steel construction
3. Oval flat - Wood and steel construction or all steel
4. Oval cambered - Wood and steel construction
5. V-form - all steel construction
6. Poly valent - all steel construction
7. Round - all steel construction
8. Rectangular vertical - Wood and steel construction or all steel construction curved (suberkrub type)
Items 1 to 5 are meant for Bottom Trawling
Item 6 can be used for both Bottom and Mid-water Trawling
Item 7 and 8 are meant for Mid-water and Pelagic trawling.

**Rigging of Trawl with otter boards:** The otterboards may be connected directly to the wings of the net or by wire/rope known as sweep line or ground cable.

**Speed of Trawling:** the speed at which the trawl is towed over the bottom varies, depending on the species being sought, from 1.5 knots to 2 knots in the case of shrimp trawls, 2 K to 3K for fish trawls and 3 to 5 knots for mid water and pelagic trawls. (A speed of 1 knot is equivalent to 0.5144m/sec.

\[
\text{1 nautical mile} = 6083 \text{ feet}, \quad \text{1 land mile} = 5280 \text{ feet}
\]

Towing trawl too slowly may cause the otter board to close together, leading to less spreading of the net which tends to sag on to the bottom. On the other hand, towing too fast could result in the net lifting off the bottom and "floating" and a "foul gear".

It must be borne in mind that a high trawling speed involves much larger fuel consumption (expenditure).

**Scope ratio:** is the relation between depth of water and length of warp to be released. In other words, it is the warp-Depth ratio which is approximately for bottom trawling as:

\[
F = \begin{cases} 
5 - 6D \text{ in shallow water upto 50 m} \\
4 - 5D \text{ in off-shore waters of 50-100m.} \\
3 - 4D \text{ in deepwater of 100-200m} \\
2 - 3D \text{ in deepsea of 200 m and more depths}
\end{cases}
\]
Where \( F \) - length of warp to be released
\( D \) - depth of water.

Vessel layouts:

(a) Stern trawlers: This is the most common, in which the operation takes place over the stern.

(b) Side trawler: very rarely exists in some parts of the world, in which the trawl is set and hauled over the side.

(c) Double rig and twin rig (multi-rig): In this, more than one trawl are towed by one trawler in place of one large trawl net. This is popular in shrimp trawling (e.g. gulf shrimp Trawlers, Australian shrimp trawlers etc.)

Twin trawling: The method of towing two trawls on a single cable (warp) is known as twin-trawling. It involves the use of a sled or dummy door in between two nets and the addition of a third wire to the briddles.

(d) Pair trawling: This is more common in mid-water trawling. Here no otterboards are used. By utilising the combined towing pull of two identical vessels, and as no otterboards are needed, a larger net may be worked than would be possible by a single vessel. The lack of disturbance due to propeller above the net is another advantage.

Disadvantages of pair trawling: It must be remembered that twice as much fish must be caught to support two boats. The two skippers must be capable of working amicably. Changing direction of tow and coming along side in bad weather are difficult and dangerous.

Special Bottom Trawls (Demersal Trawls)

(a) High Opening Bottom Trawls: There are two seam high opening trawls with prominent square and large top wings, and more vertical opening has been
attained by introducing side panels - thus evolving to four seam, six seam and multi-seam trawls.

(b) Highspeed Demersal trawls: Made of light materials and riggings and can be towed at a better speed.

(c) Large mesh Demersal Trawls: with large meshes in the forepart of trawls, can reduce net drag and tow at a better speed.

(d) Semi-pelagic Bottom Trawls: Ground Trawls have been designed with improved features to give greater ‘spread’ and much better ‘lift’ whilst still firmly in contact with the sea bed. These are generally referred to as ‘high opening trawls’. Usually three bridle rigging is used for semi pelagic trawling. Catch will be both demersal as well as semi-pelagic resources.

(e) Shrimp-fish separator trawls: These trawls separate shrimp from fish and debris by allowing unwanted fish and debris to pass through the net (Extruder Devices like TEDS, FEDS etc.). This will reduce laborious sorting of catch by hand aboard the vessel, and also conserve fish and improve the quality of shrimp.

Trawl efficiency (Fishing efficiency)

The catch per unit effort of a trawl is calculated as CPUE in Kg per hour of trawling.

The main aim of many experiments for improving trawl design is to increase its fishing efficiency. Fishing efficiency of a trawl can be both Technical (Gear) efficiency and catch efficiency.

The trawl is a selective fishing gear as shrimp trawl, fish trawl etc.
Technical (Gear) efficiency of a trawl: Can be taken as either the area of the bottom covered by a trawl per unit time or the volume of water filtered per unit time. In bottom trawling the former is more relevant, but in semi-pelagic and mid-water trawling the volume measure is more important.

The fishing spread of trawl (the distance between the wing ends and the distance between otter boards) ranges from 0.50 to 0.601 (1 = head rope length of trawl). Minor changes in fishing spread cause comparatively major changes in the fishing height. Decrease in the fishing spread causes increase in the fishing height and in the area of the mouth of the trawl net. Increasing towing speed may decrease the horizontal spread. High net resistance, very long bridles and heavy foot ropes reduce the spread.

Fishing height of a trawl is mainly determined by the distance to which the ends of the head line are raised above the bottom, the height of its otterboard or spreader. The rise of the headline depends on the drag of the trawl netting, which increase with increasing trawling speed.

Catch efficiency of a trawl is assessed by the catch obtained per unit time both qualitatively and quantitatively.