Midwater Trawls and their Operation

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India, according to FAO of UN (1998) is overall third and fifth in marine fish production among the world's top ten producers of fish. Working group for revalidating potential fishery resources in the Indian EEZ constituted by the Dept. of Animal Husbandry, Min. of Agriculture, Govt. of India in its report released in Oct. 2000 came out with details which call for strict monitoring of resources especially region-wise and species-wise to enable rendering advice on management measures to be adopted and that the time has come to stop open access and evolve regulatory mechanisms for judicious utilization of resources'. The total potential yield of the marine fishery resources of Indian EEZ was revalidated to 39,34,417 tonnes consisting of

- 20,17,072 tonnes of demersal resources;
- 16,73,545 tonnes of pelagic resources; and
- 2,43,800 tonnes of oceanic resources.

One of the disturbing trend observed was the substantial reduction of some important conventional resources totaling 6.26 lakh tonnes.

Elasmobranchs	:	97,000 t
Cat fish	:	72,000 t
Clupeids	:	1,31,000 t
Ribbonfish	:	1,17,000 t
Carangids	:	2,09,000 t

Overfishing has been identified as the reason for this reduction in quantity of resources and effective control of fishing capacity ad fleet control are absolutely essential as preventive measures. Gear restrictions have an important role to play in making optimal use of a stock or a resource. Effective use of pelagic or semipelagic trawl, which are target specific, can prevent irresponsible exploitation and subsequent reduction of fish stocks to biologically and ecologically harmful levels. Under these circumstances, pelagic and semipelagic trawling techniques gain importance as regulatory measures since they have proven efficiency in target specificity.

Midwater trawling techniques

Since World War II mid water trawls also known as floating trawls or pelagic trawls have been introduced in the commercial fisheries to exploit concentration of fish in water layers away from the sea-bed.

First designed by Robert Larssen of Denmark in 1948, the net was four equal paneled operated by two boats (Bull trawls or pair trawls). Later considerable success was achieved in West Germany with one boat Mid water trawl of rectangular shape which had unequal side panels. Great progress took place since 1963 with the advent of stern trawling.

While bottom trawls are often towed for several hours together at a time and fish a large area, so capturing loosely distributed fish, the mid water trawl is towed for a relatively shorter period, in order to pass through and catch a particular shoal of fish. Successful midwater trawling required the effective use of various electronic aids, both to find fish and maneuver the vessel while catching them, the net must be set at the correct depth and the vessel proceed in a course that will ensure, the net passing through the school of fish and in the process of catching them. Due to density of fish shoal through which the net passes, the catch per tow is much greater than the bottom trawl with an estimated ratio of 10:1.

Both single or stern trawling and pair trawling are of importance in mid-water trawling. Pair trawling is particularly useful in 2 ways.

- It is more appropriate in smaller low powered vessels and is especially applicable in shallow water, where a single vessel passing over a shoal tend to scare the fish school downwards.
- Two boat trawling appears to be advantageous in that the towing warps do not pass through and frighten the school of fish before the net reaches them.

The depth at which the trawl fishes can be adjusted by

i. The vessel speed and
ii. The length of warp paid out.

There may also be some changes made in the rigging of the gear, depending on the depth of operation and whether the net is fishing near the bottom or surface. The towing speed depends on the species fished and is an important operating parameter.

For sluggish and slow swimming fishes 2 to 3 knots is sufficient while 4.0 to 5.0 knots is essential for fast swimmers. It is important that the size of the net is suitable for a particular application and matched to the vessels power. It is important in midwater trawling, to have a means of determining the position of net between bottom and surface. The net sonde, an acoustic instrument is used for this purpose. It has got a transducer unit fixed on the center of the headline which transmits the required information back to the vessel through signals transmitted by special towing warps with conductor cables built into them and the recording unit either separately or connected to the display unit of sonar in the bridge. The skipper by using them can adjust his trawling speed and warp length to ensure that the gear passes through the depth of the intended fish school. It is also common for vessels undertaking midwater trawling to be fitted with SONAR. (Sound Navigation and Ranging) for detecting fish school and maneuvering the vessel.

Mid water trawl nets resemble more of a cone than the flat bag of the bottom trawl, the mouth taking up an elliptical, circular shape depending on the design. Normally, the net does not come into contact with the seabed except in shallow water where the head rope is on the surface while the footrope scraps the bottom. The net is of a relatively lighter construction enabling the vessel to tow a larger midwater trawl net.

Midwater trawl is made lighter with thinner material used for gear fabrication. The footrope is lighter compared to them bobbins & discs of bottom trawl. In Cosmos trawl the upper belly is made of bigger mesh size than the corresponding pieces of lower belly. In some other trawls like what was operated in Indo-Polish survey, jet bellies are used to get a maximum head rope lift.

Two-boat or pair midwater trawl

Each vessel tows one side of the net using twin warps attached to the upper and lower bridle legs. Horizontal opening of the mouth is maintained by the correct spacing of the vessels while in tow. Vertical opening of the gear is obtained by correct floatation and weighting. A front weight of approximately 20kg is attached to the lower bridles. The sinkers are usually chain weight distributed uniformly along the foot rope.

The most favourable condition of mid water trawling are those in which

i. Fish concentration are fairly large and remaining stationary
ii. The fish are relatively inactive either by virtue of low water temperature or their physiological state. (spent and spawning fish are generally inactive)
iii. The fish do not undergo rapid depth migration and their depth distribution is fairly constant over the fishing locality.
iv. The water is shallow and turbid or if clear contain low concentration of phosphorescent organisms; and
v. The light intensity is low

Midwater trawl is not to replace demersal trawl but are considered an additional fishing method as circumstances demand and is supposed to fill the gap between the working range of conventional near sea bottom fishing gear for exploiting the known fish stocks and opening up so far untapped resources.

The following three aspects determine the effectiveness of midwater trawl

i. Shape
ii. Twine thickness
iii. Towing speed

If the net mouth is not opened vertically high enough, the net may catch only part of a fish school or may even be trawled below the school. A very high vertical opening can be achieved by sacrificing to some extent the width, and for this purpose square mid water trawls are designed.

This method can be adopted without much capital investment and can be carried out even if the ground is rough, as the boards do not touch bottom.

Designing a mid water trawl is done for catching some particular fish by some particular trawls. The problem is to use the restricted trawler power to best advantage either by increasing the size of the trawl, decreasing the speed or vice-versa. It is always better to construct a bigger mid water trawl than a smaller one dragged in good speed.

Midwater trawl gear improvements are aimed at the attainment of maximum vertical opening which facilitates better guiding of fish into trawl with a smooth flow of water.

Fishing accessories for midwater Trawl

Otter boards

For all trawling operations, except for pair trawling, otterboards are essential for spreading the gear horizontally. It is also called the shearing force of the otterboards. The otterboards are designed on hydrodynamic principles and are specially suitable for achieving that force. The basic idea of otterboard design to shape them in such away that their shearing power is as great as possible but at the same time their resistance to motion is as little as possible. Bent or moulded boards meet these requirements better than conventional boards. Hydrofoil type, vertically curved otterboards are mainly used for mid water trawls and have efficiency for opening the net at low drag. They are also called Suber Krub boards named after the inventor. The shearing force of otterboards for midwater trawls should not be directed slightly downward by horizontally or even slightly upward unlike boards for demersal trawl. The lower width to height ratio is also advantageous in these type of boards. For Suberkrub doors, the aspect ratio is 2:1 (By height to breadth).

Front weights

To keep the opening of midwater trawls in the most effective form not only the doors but also floats on Head rope weights on the foot tope and front weights at the lower wing tips are needed. They are also called depressors and are intended to keep the gear open downwards.

Bridles

Increasing the vertical height of a midwater trawl is effected by adding light double bridles or by keeping the otterboards as remote as possible by long sweeps. They herd and concentrate the fish shoal into the path of the midwater trawl. 50m length of bridles has been found optimum for medium sized trawlers.

Detecting devices

Fish detecting devices like Echosounder and Sonar are essential pre-requisite for effective midwater trawling practices. As long as they did not exist, it could never be ascertained at what depth the fish sought were to be found. Many midwater trawls designed earlier failed because of this uncertainty.

The invention of net sonde in 1958 was an important step towards effective midwater trawling. This is an echosounder oscillator which propagates and receives impulses through a cable transmitting the same to the recording unit on the bridge. It is thus possible to continuously monitor the trawl performances.

The main benefits of having net sonde in mid water trawling are

i. The depth at which the trawl is functioning is known
ii. The vertical opening of the gear under tow is also known

iii. The behaviour of fish in the trawl path can be monitored

iv. To some extent the quantity of fish caught can be observed with the aid of netsonde. This is advanced technique better than depth telemeter. Since they enumerate the relation between the trawl net and bottom. The relation between trawl net and the fish shoal can be easily understood.

Fish finding can be described as a pre-requisite for all rational fishing efforts and one of the determinates of economic efficiency. Even in highly developed trawling about 50% and in purse seining about 80% of the time available for fishing is expended for fish searching. Progress in instrumentation and fishing technique of fish detection is bound to have significant effects in this context. (In reducing the time utilized for searching). In short, midwater trawling involves dragging the trawl with one or two vessels in the area between ocean bottom and its surface to catch pelagic fish. Depth of trawl is regulated by towing speed and length of warp paid out.

i. With longer warp and lower speed the trawl sinks

ii. it rises with shorter warp and higher speed

Vertical adjustment midwater trawl net to the position of fish school is accomplished by 3 methods

i. by varying the length of warp paid out

ii. by varying the towing speed and

iii. by varying both

The first method is employed when the net is far above or below the fish school. The second one when the net is relatively close to the fish school and the third one when a fine adjustment of the net is necessary.

An important development that is called semi-pelagic trawling, a technique developed in the later part of 1980s. The otterboards remain in touch with the bottom but the trawl floats at some distance above it. Semi-pelagic trawls were constructed because fish often concentrate at a short distance from the bottom, outside the range of the usual bottom trawl with a low vertical opening. Some modern bottom trawl with more than 6 seams and specially constructed trawl for high opening are intended to achieve more vertical opening to exploit fishes which aggregate just above bottom and which are not exploitable by conventional bottom trawls, with less vertical opening.

A midwater trawl with its typical rigging can be used as a semi pelagic trawl with some alteration in the rigging of sweep lines and by using heavy otterboards.

For catching a semi pelagic fish the efficiency of a trawl can be expressed as the product of towing speed, wingspread and opening height. For catching semi pelagic species, the square and the upper part of the net together with the opening height play an important role. To get the optimal functional efficiency the strain paths of the trawl net should follow the framing lines and selvedges, thus allowing unrestricted opening of the netting panels.

Trawling speed

If a trawl speed is less than the cruising speed of the fish efficiency of capture is low. If the trawl speed is somewhat above the cruising speed, the fish in front of the foot rope will eventually rise and drop back to be caught in the net. It is quite clear that most of the fish caught by trawl could quite easily escape by using their 'panic speed'. The swimming ability of fish depends largely on their size and species. Understanding how a net works and of the underlying biological principles is of interest to both fishermen and designer of fishing gear.

Midwater trawling operation

There are four distinct areas for different fish reactions to the trawl in day light. The first are extends from otterboards to wing tips. The second lies between wing tip and back part of the belly. The fish (thus observed in West African grounds in general) made few attempts to escape through meshes of this area unless the netting actually touched the tail in which case it was tripped in its swimming and passed out through the large meshes. In general, fish in this area, seek for a big opening and finding none pass back into the bag. The third area includes the last part of the belly and the conical section of the trawl bag. In this critical area, the fish become concentrated, rush about and seek escape through the meshes. Fourth area is the cod end. The critical area in which fish, when there is a concentration of them, panic and seek escape through the meshes is thus relatively further forward in the net where the net is smaller or more rapidly tapered.

Much work remains to be done on the aspects of how species and size selection is dependent upon choice of mesh size in the forward parts of the trawl.

According to classical oceanography, the biological productivity of water decreases naturally as the distance from the shore increases.

Even in the open ocean there are conditions under which fish concentrations would occur.

Soviets developed a concept on the possibility of forming large and dense concentrations of pelagic fish in the open ocean. It was based on the fact that in some parts of the open ocean there are frontal hydrological zones ie. locations where warm and cold current interact which cause fish to concentrate. The south eastern part of the Pacific Ocean was considered to be a most promising zone, especially the area lying beyond the economic zone of Peru & Chile. Russian expedition run in 1978 proved a great success with considerable fish stocks of horse mackerel and other pelagic species being discovered. The stocks identified allowed the most modern soviet trawlers to work successfully for many years, their annual total catch sometimes reaching in excess of 1 million tones.

Designing of midwater trawl

There are several important aspects, which deserve careful attention while designing a trawl for a particular type of vessel.

They can be classified as follows :

i. Formulation of technical requirements
ii. Behaviour of fish and fishing condition
iii. Calculation of mesh size
iv. Technical parameters of the trawler
v. Selecting the prototype
vi. Trawling speed and
vii. Improving an established trawl.

Formulation of technical requirements

For documenting the required characteristics of a new trawl, we should bear in mind

i. the behaviour of fish for which the net is designed
ii. the technical characteristics of the vessel from which the gear is to be operated
iii. the fishing condition in the grounds where the net is to be fished.

Compromise decisions must be taken in the formulation of technical requirements and should involve a review of

i. Characteristics of fishing ground and species to be caught
ii. Characteristics of trawler to be employed
iii. Desired characteristics of possible trawl prototype a criteria for selecting the most suitable one.
iv. Characteristics of trawl operation like trawling speed, depth and low duration
v. Special requirements of trawl performance such as rough or smooth ground.

After these technical parameters are formulated, principal dimensions of the net, drag and shear forces, buoyancy and ballast needed for the desired performance can be tentatively met.

Behaviour of fish and fishing condition:

i. Information on the distribution of the relevant species of fish and their critical migration is the basis for selecting the type of trawl (bottom, pelagic or semi pelagic).
ii. The form of trawl mouth is selected to the horizontal and vertical dimensions of schools to be fished. In bottom trawl, the wing spread exceeds the vertical opening by the factor 2 or 3 while in midwater trawl the vertical opening and horizontal opening may be equal (spherical or elliptical).
iii. The swimming speed of fish shoal or individual fish determines to a large extent the required trawling speed and hence trawl resistance and the maximum trawl size for available trawling power.
iv. Mesh size is decided by the size and body shape of the desired fish.

Calculation of mesh size

For this purpose, the trawl netting can be divided into two parts:

i. The fore part from wings through bellies leads the fish to codend and
ii. aft part or the codend which retains the fish catch.

In the forepart especially in midwater and semipelagic trawls, they are calm, while in the codend, they get panicky to escape through the meshes. So, the mesh opening in the cod end (MOC) should be such that the smallest commercial size will not get gilled.

Cod end mesh size can be estimated from the formula

MOC = 2/3 mog

Where mog is the mesh opening of the gillnet designed to capture fish of the same species and size.

In turn, mog can also estimated from

mog = L/Km

where L is the length of fish body from tip of snout to the base of the caudal fin and Km the empirical co-efficient depending on the morphology of the fish found by experimental fishing with gill nets.

At the first approximation, the value of

Co-efficient (Km) : 5 for narrow fish
3.5 for medium fish and
1.5 for thick or deep bodied fish

Technical parameters of the trawler

While designing a trawl net and determining its size, the following parameters must be known and specified.

i. Dimension of vessel and its architectural design
ii. Method of hauling the gear and the height to which codend is to be lifted to bring it aboard
iii. Bollard pull and
iv. The capacity of its winch

The total propeller thrust of a trawler fp can be equated to the total resistance of the system.

As fp = Rt + Rv

Where Rt is the total resistance of the gear and accessories and Rv is the total hull resistance.

Thus the total drag Rt may be expressed in terms of the available towing force Ft(max) at any given towing speed as

$$Rt = Et(tp-Rv)\ max$$

where Fp = Propeller thrust
Rv = Hull resistance

or $Rt = Et(Ft\ max)$
where Et = towing force utilization co-efficient
Ft max = available towing force

If the available towing force is fully utilized for trawling.

$$Et = 1$$

But if it is expedient for some reason to maintain a reserve capacity like in the case of aimed midwater trawling, $Et < 1$.

Even in the case of normal bottom trawling Et is kept at 0.8 or 0.9 to avoid overloading of the engine.

Selecting the prototype

While selecting the prototype, special attention should be paid to the aspect of fish behaviour.

For example long sweep lines are used on trawls for fast swimming fishes not only to reduce angle of incidence to improve herding of fish but also to increase the width of zone between doors for maximum fished volume of water. Shrimp trawls must have more horizontal opening to increase the swept area while vertical opening is of no consequence and the body of shrimp trawl can also be shorter.

A basic technical parameter of trawl performance is the mouth opening coefficient (Kt).

$$Kt = Am/Rt$$

Where Am is the area of trawl mouth in meter square and Rt is the total trawl drag in kgf.

A basic fishing characteristic for comparing prototype trawls is their relative fishing power.

Trawling speed

It is a widely accepted fact that the trawling speed should be proportional to swimming speed of fish. Lower trawling speed for slow swimming fishes (normally bottom dwellers) and higher towing speed for fast swimmers (pelagic fish). Experiments conducted have shown that there is an optimum towing speed for each species of fish and trawl design, which provides maximum catch, all other things being equal.

Improving the established trawl

The most feasible way to attain a desired new trawl design is by modifying the prototype. This can be done by model tests of successively improved variants of the original prototype.

For example if a trawl with a larger mouth area is required, otterboards and lifting devices with greater shearing force may have to be tried.

The hydrodynamic quality of a trawl (Kr) can be improved by increasing the mouth area (Am) at the give drag (Rt) and my decreasing the Rt while maintaining the Am or by combination of both. This (reducing the drag Rt) may be obtained by

i. Increasing the mesh size
ii. Decreasing the twine thickness or
iii. By replacing the forepart of the net by ropes (as in rope trawls)

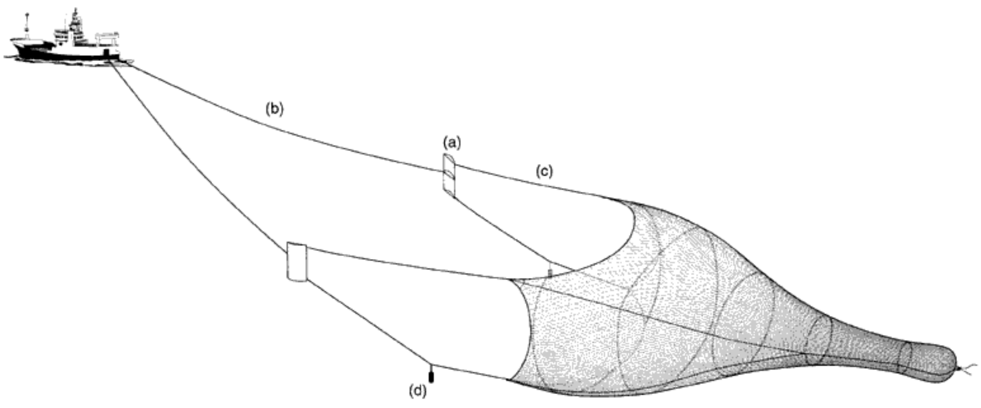
In this way, mouth opening can be increased without increasing the Rt(trawl drag). Such modification leads to a reduced drag co-efficient Kr).

$Kr = Rt/Am\ V^2$

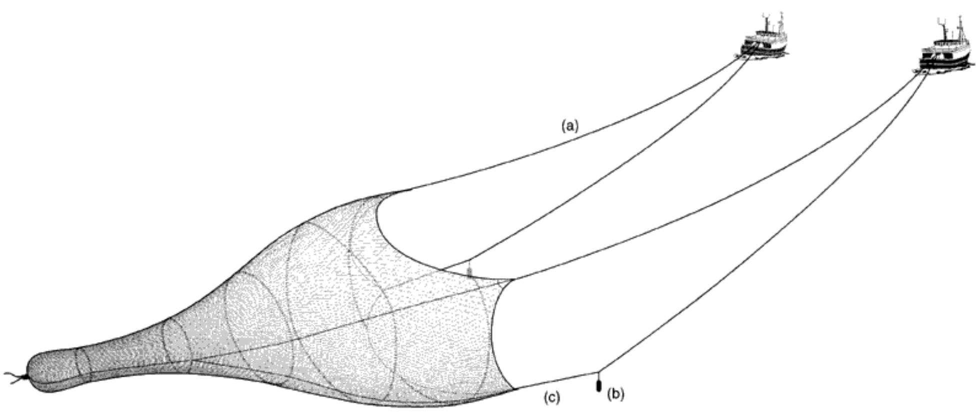
where Rt is total drag in kgf
Am is frontal are (m^2)
V is towing speed in m/sec

Such reduction of trawl resistance co-efficient (Kr) by increasing the taper of netting may increase the hydrodynamic quality and consequently increase the available towing speed which is important for smaller trawlers with limited power.

To sum up, Rt representing the sum of drags (net, auxiliary components, sweep lines, Otterboards and warps) should not exceed the available tractive force. Ft max from the vessel at the prescribed towing speed or in other words the condition Rt = Ft (max) must be observed.



Single boat midwater trawl



Two boat midwater trawl