Chapter 11

Gill Nets and their Operation

Saly N. Thomas

11.1 Introduction

Gill nets which consume only 0.25 kg of fuel per kg of fish caught as against 0.8 kg by trawling, is a highly energy efficient gear (Gulbrandsen, 1986). Unlike trawling, which disturbs the sea bottom, gill nets do not cause any serious environmental problems with the exception of ghost fishing by lost gill nets. It is also considered as a very selective gear as very few fishes are caught in gill nets whose length differs from the optimum by more than 20% (Baranov, 1948). The simplicity of its design, construction, operation and its low energy requirement make the gear very popular in all the sectors especially in the traditional sector.

The gear is a vertical wall of netting, which is kept erect in water by means of floats and sinkers. It is mostly rectangular in shape whose upper end is mounted to a float line (head rope) and the lower end to a sinker line (foot rope). This is a very versatile gear, operated in the surface, column or bottom layers of the water column in inland, coastal and deep seas. The length may vary from 30 m with less than 1 m depth in gill nets operated in rivers and lakes to 60,000 m with depth ranging up to 60 m in gill nets operated in the high seas. The gill nets are operated for the capture of different groups of fishes such as sardines, mackerel, shrimps, hilsa, tuna, shark, seerfishes and carangids. Gill nets operated for large pelagics in the deeper oceanic waters, may extend to several kilometers. It is estimated that the combined length of the fleets of nets operating in the Pacific, Atlantic and Indian Oceans amounts to about 50,000 km (Anon, 1992). Aspects of classification, structure and operation of gill nets have been discussed by Brandt (1984), Karlsen and Bjarnasson (1989), Sainsbury (1996), Hameed and Boopendranath (2000) and others.

11.2 Mechanism of fish capture in gill nets

The fact that separates gill nets from all other type of fishing is that in gill nets the 'mesh' of the net serves the dual function of 'selecting' the fish to be caught and catching it (Anon, 1994). The capture of fish in gill nets depends on the net construction, its dimensions, and the shape of the fish body. When a fish approaches a gill net, it tries to pass through the mesh.

The meshes are just large enough to allow the fish's head but not the rest of the body to pass through it. When the fish tries to pull back, the pressure exerted by the mesh at the opercular region of the fish, opens the opercle and the twine of the mesh goes behind the opercle (Fig. 11.1). This characteristic capturing is designated as 'gilling'. The fish is also caught in gill nets by (i) snagging, when the fish is held tight by the twine of the mesh around its head, (ii) wedging, when the fish is held tight around its body, and (iii) entangling when the fish is held in the net by the teeth, opercular spines or other protruding appendages of the body without actually entering the mesh. The mode of capture depends on the looseness of the net and the body shape of the target fish.

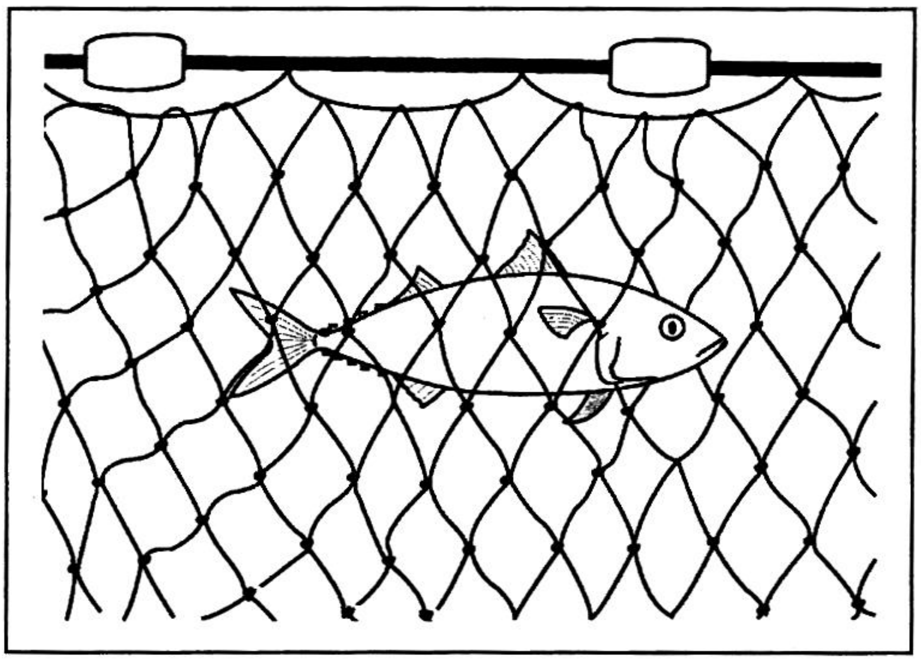

Fig. 11.1 Gilling of fish in a mesh

11.3 Types of gill nets

Gill nets can be classified into different groups depending upon the type of construction, area of operation, targeted fish and method of operation. (Fig. 11.2). Based on structure, there are single walled and multiple walled nets in which, simple gill nets, vertical line gill nets and frame nets are single walled while double and triple walled (trammel nets) nets come under the multi walled nets. Depending on the method of operation, there are drift gill nets (drifting freely or attached to a craft and floating), set gill nets (anchored or staked to sea bed) and encircling nets (the fishes are surrounded and driven from the centre by noise and other means).

Depending on the area of operation there are surface, column and bottom gill nets. Based on target species, nets are classified as nets for anchovy, lesser sardine, sardine, mackerel, prawn, mullet, crab, lobster, pomfret, hilsa, seer, tuna, shark, catfish, perch, snapper, rock cod, etc.

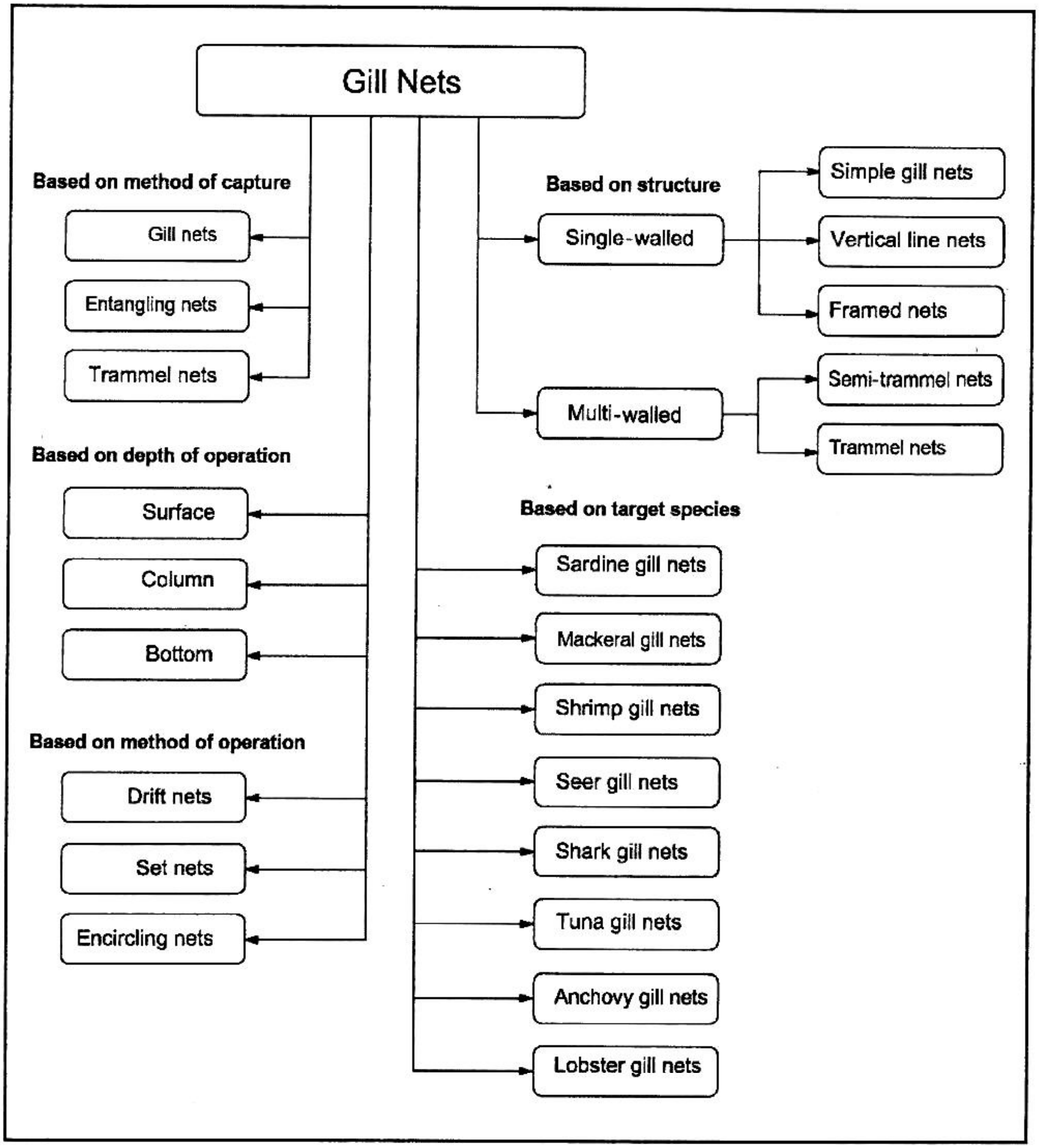

Fig. 11.2 Classification of gill net

11.3.1 Drift gill net

Drift gill net is used to catch fishes swimming in mid-water or near surface layer. In this type, the net drifts according to the force of the wind or current freely. During operation, one end of the net is tied on to a boat or to a buoy while the other end flows freely. A marking buoy should be tied to the net to indicate the location of the net. The depth of operation of net is adjusted in relation to the swimming layer of the fish.

11.3.2 Set gill net

Set gill nets are usually set to the bottom by using anchors, heavy weights or are tied to poles or sticks fixed to the ground. Surface set gill nets are used to catch fishes which swim near surface water and are commonly used in shallow coastal waters where the current is negligible. Bottom set gill nets are used for catching bottom dwellers and demersal fishes. In bottom set gill nets more weight is used and only a few floats are attached to keep the net without falling to the ground.

11.3.3 Vertical line net

The vertical line nets are simple gill nets, divided into different sections by passing vertical lines from the head rope to the foot rope through the meshes of the webbing (Fig. 11.3). The vertical hanging coefficient is reduced to 0.6-0.7.

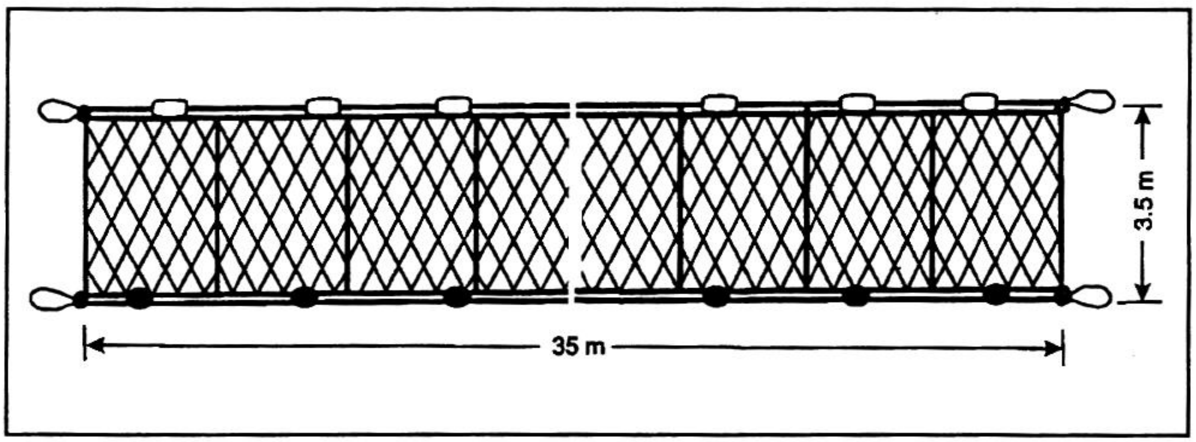

Fig. 11.3 Vertical line gill net

11.3.4 Frame nets

These are single walled nets whose slackness is increased by passing vertical and horizontal lines between the main lines dividing the main webbing into compartments of 1 to 1.5 sq.m (Fig. 11.4). In the frame nets, the horizontal and vertical hanging coefficient are 0.5. Because of the farming, looseness of the webbing is more and the vertical and horizontal lines passed through the webbing restrict distortion of the net to a great extent.

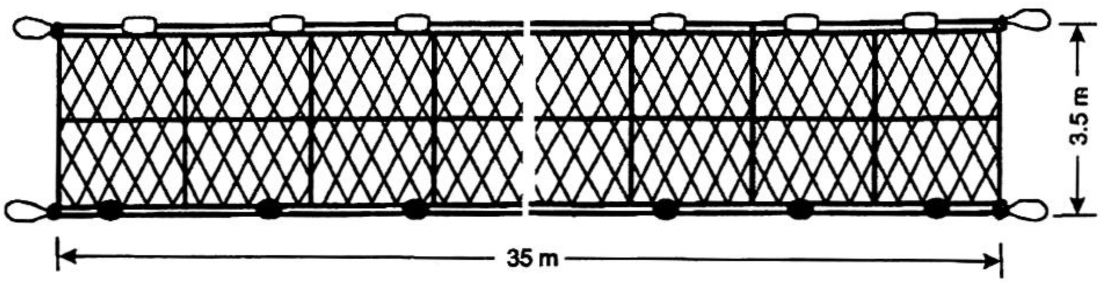

Fig. 11.4 Framed gill net

The frame nets and the vertical line nets are usually employed in areas where the fish concentration is not very dense. In India, these nets are employed mostly in reservoirs.

11.3.5 Trammel nets

Trammel nets are triple walled nets having a loosely hung center wall of small mesh netting which is bordered on each side by tightly hung walls of large large meshes. The mesh size of the outer wall of webbing is usually 4 to 5 times than that of the inner wall. All the three layers of webbing are mounted on a single head rope and foot rope. Fish swimming through the outer meshes encounter the center netting and push their way through the opposite outer meshes. Fish become trapped in the resulting pockets that are formed (Fig. 11.5). The outer meshes on one side of the net must be a mirror image of the outer meshes on the opposite side. Semi trammel nets are of same structure as that of trammel nets except that only one layer of outer webbing is present instead of two. Trammel nets are mostly used in freshwater fishing and also for coastal shrimp fishing.

11.4 Structure of a typical gill net

A typical single walled gill net is a rectangular piece of netting essentially having the main netting, selvedge (top and bottom), float line/ head rope, sinker line/foot rope, gavel lines/side ropes/brush line, floats, sinkers and buoys and buoy line (Fig. 11.6).

Selvedge, generally of thicker material than the main netting gives protection to the main webbing during handling and operation. The number of meshes in depth of the selvedge is determined according to the depth of the main webbing. Loop lines having double the breaking

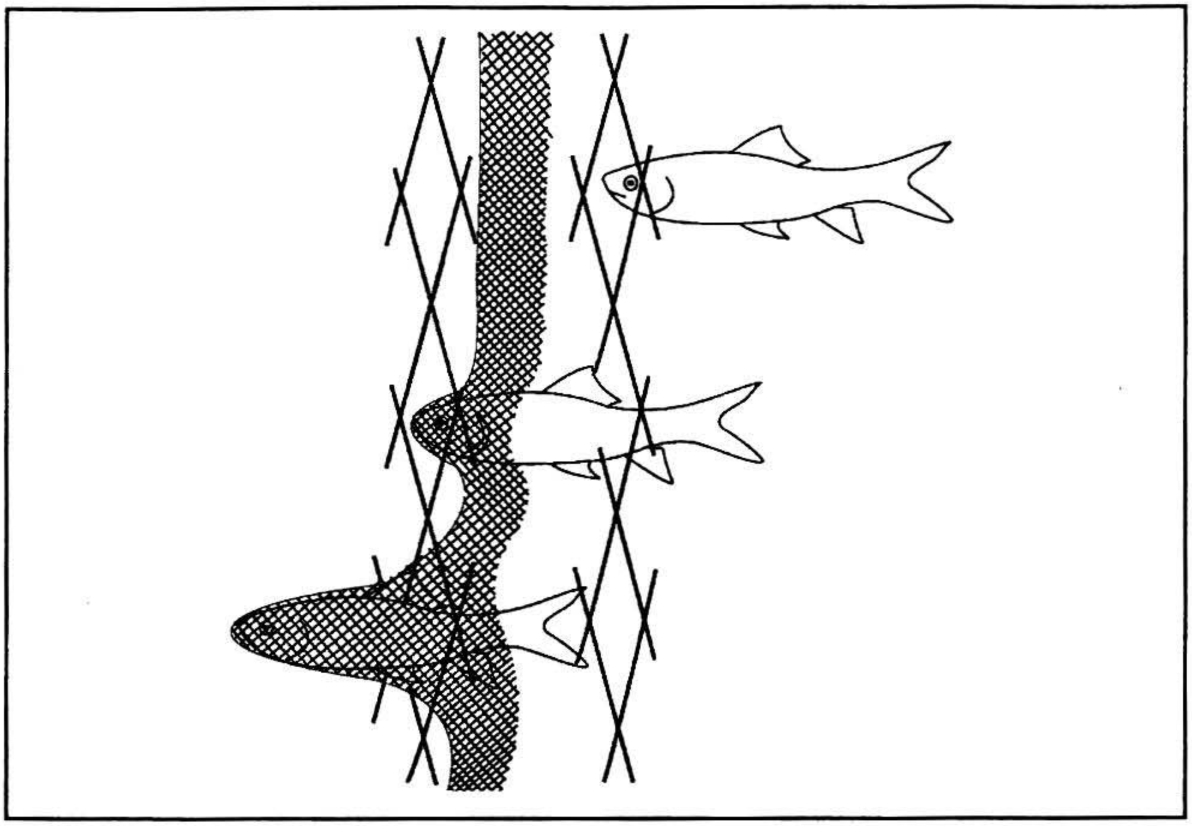

Fig. 11.5 Principle of operation of trammel net

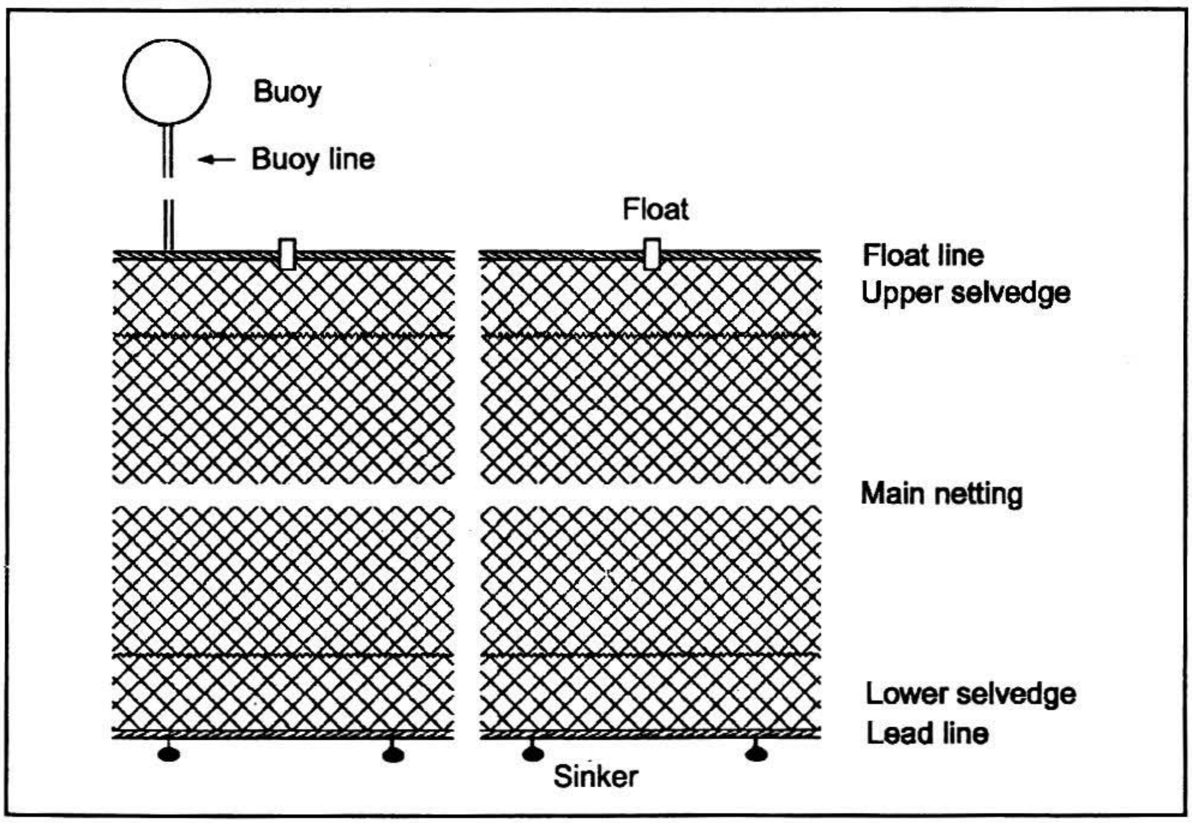

Fig. 11.6 Structure of a typical simple gill net

strength than that of the selvedge material are used to hung the selvedge meshes to the head rope. The netting is mounted to the ropes by a continuous hanging twine which is passed through the meshes and tied to the ropes using staples or loops. The netting is rigged to the float line according to a particular hanging ratio which determines the looseness of the netting and thereby the shape of the mesh and the hung depth of the mounted net. Usually the horizontal hanging coefficient employed for gill nets is 0.5. Floats are attached either directly to the head rope or to a separate float line, which runs along with the head rope. Sinkers are also attached likewise, either to the footrope or to a separate sinker line. Buoys attached through buoy lines to the head rope are for adjusting the floatation of the mounted net. Gavel lines or side ropes are attached to the side meshes of the netting. The main function of this is to protect the side meshes from wear and tear due to hauling. The length of the breast line must be 10 to 15% less than the depth of the main webbing in the stretched condition.

11.5 Design of gill nets

The main principle of the gill net designing is based on the mechanism of fish capture by the net. Since the fish is caught when it tries to swim through the meshes of the net, the size and shape of the mesh play a significant role in the catching power of gill nets. The main parameters to be considered while designing a gill net are: (i) size of mesh in relation to the size of the targeted fish, (ii) diameter of the twine in relation to mesh size, (iii) hanging coefficient of the net, (iv) visibility of the net, (v) softness of the material and the (vi) buoyancy and ballast given. The fishing height of the net has to be optimized according to the depth of the swimming layer of the targeted fish.

11.5.1 Mesh size

.Mesh size is the most important factor to be considered in the design of a gill net. It is proportional to the modal length of the fish caught (length of fish most frequently caught). As the gear is size selective for a given mesh size, catch decreases on either side of the modal length of the fish. A net of a particular mesh size catches fish of a particular length most efficiently and has considerably reduced catching efficiency of smaller and larger fish. The equation of geometrical similarity is widely applied in practice. Fish of the same species but of varying age groups are to a certain extent geometrically similar. Similarly the meshes of different size are similar, provided the hanging coefficient is the same. If it is known that a gill net with mesh size m_1 catches a fish of length L_1 best of all and the net with mesh size m_2, catches fish of length L_2 best of all, then according to geometrical similarity (Fig. 11.7),

$$L_2 / L_1 = m_2 / m_1$$

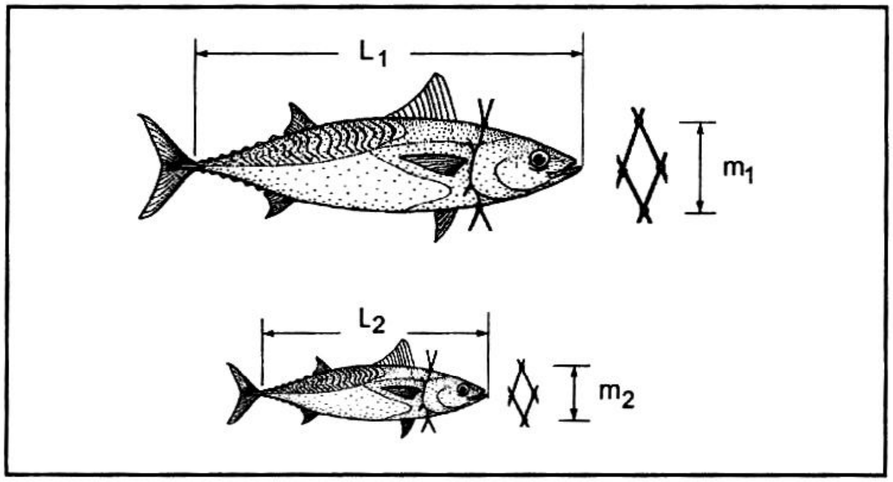

Fig. 11.7 Relationship between fish length and mesh size

Optimum mesh size for the target fish can be determined by selectivity experiments. CIFT has recommended optimum mesh sizes for gill nets targeted at several commercially important resources (Table 11.1).

Table 11.1: Optimum mesh sizes suggested by CIFT for gill nets

Species	Common name	Optimum mesh size (mm)	Common mesh sizes (mm)
Sardinella longiceps	Oil sardine	33.4	30-38
Rastrelliger kanagurta	Mackerel	50	38-52
Scomberomorous commersoni	Seer	152	90-140
Scomberomorous guttatus	Spotted seer	104	90-140
Pampus argenteus	Silver pomfret	126	110-130
Tenualosa toli	Chinese herring	102	
Penaeus indicus	Indian white prawn	38	32-52

According to Baranov (1914), the mesh size can be determined following the equation:

$$a = kl$$

where 'a' is the size of mesh bar, 'l' is the average length of fish for which the gear is designed, and 'k' is a co-efficient specific for a given species determined empirically and can be found out by length or girth measurements.

Length measurement

The length frequency distribution of catch obtained in 2 gill nets, of different mesh bars a_1 and a_2, fished simultaneously may be prepared and the frequency curve corresponding to these can be drawn on a single graph (Fig. 11.8).

If 'l_0' represent the length of fish, appearing in number in catches of both the nets, then the coefficient 'k' can be determined by the equation,

$$k = \frac{2a_1.a_2}{l_0(a_1 + a_2)}$$

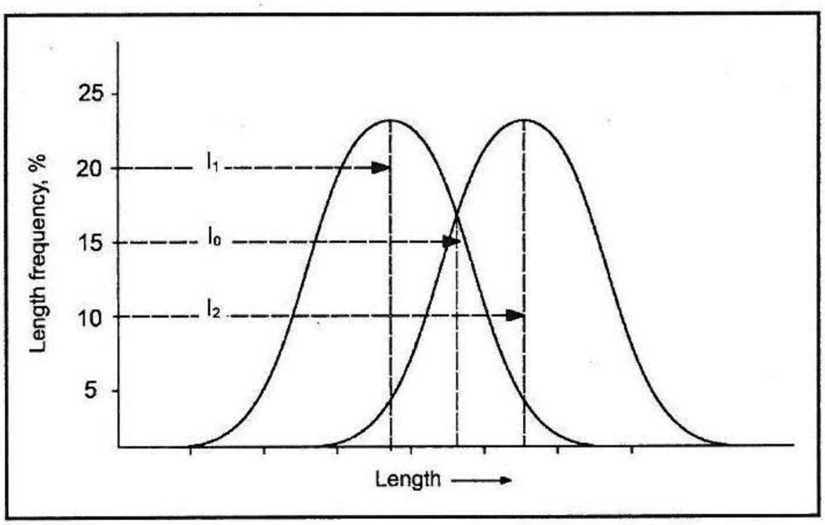

Fig. 11.8 Determination of l_0, from the length frequency distribution of fish caught in two gill nets with differing mesh size

Girth measurement

The mesh size is also proportional to the girth of the fish. When a fish is gilled, its body gets compressed and due to its efforts to escape, the twine of mesh stretches a little. Therefore, the perimeter of a section of body of fish where it is S_1 always exceeds the girth at gill covers S_2 (Fig. 11.9). But the place of gilling S_1 will be less than maximum girth S_3. The relation between the mesh perimeter and area of cross section where it is caught can be represented as

$n_1 = 4a / S_1$, where 'a' is the mesh bar

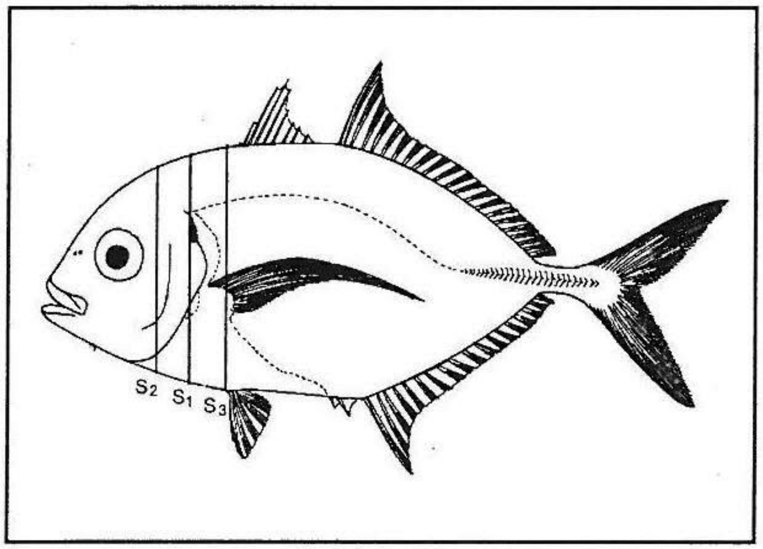

Fig. 11.9 Girth measurements

If the fish has to be caught firmly, S_1 must be greater than S_2 and less than S_3. Taking into account this inequality, the value of the perimeter S_1 to the maximum girth of the fish S_3 can be arbitrarily set as,

$n_2 = S_1 / S_3$

The relation of maximum girth of fish to its length can be represented as,

$n_3 = S_3 / l$, where 'l' represents the fish length.

Then the coefficient 'k' can be determined by applying the formula,.

$$k = \frac{n_1 n_2 n_3}{4}$$

11.5.2 Hanging coefficient

The shape and looseness of netting depends on the coefficient of hanging. The hanging ratio is defined as the length of frame line 'L' (head rope) relative to the stretched length of netting.

Hanging coefficient, $E = L/(N.m)$

where, L the length of the float line, N is the number of meshes and m is the mesh size.

The hanging ratio is expressed in decimal and is known as 'hanging coefficient'. The hanging ratio is also expressed by another term, hang-in or take up. This refers to the amount of excess webbing (loose netting) expressed as percentage of total length of webbing

$$H = \frac{\text{length of netting - length of rope}}{\text{length of netting}} \times 100$$

In order to design a net, it is important to know the hung depth of the netting after it is mounted to a rope. The theoretical hung depth, D can be worked out by applying the equation:

$$D = N.m. \sqrt{(l - E^2)}$$

where E is the hanging coefficient; N is the number of meshes in depth and m is the stretched mesh size.

Generally, the horizontal hanging coefficient is about 0.5, for gill nets. If it is smaller than 0.5, the net will tend to tangle fish and it will reduce the selectivity of the gear. On the other hand, if the hanging coefficient is greater than 0.5, the net will tend to gill the fish and be more selective than in the preceding case. The former method is practiced in the case of set nets and the latter in the case of drift nets. The hanging coefficients commonly given to different types of gill nets are given in Table 11.2.

Table 11.2: Common hanging coefficients for gill nets

Type of net	Coefficient of hanging	
	Horizontal (E_1)	Vertical (E_2)
Simple gill net	0.5	0.87
Trammel net		
Inner layer	0.4 - 0.5	
Outer layer	0.7	
Frame net	0.5	0.5
Vertical line net	0.5	0.7

11.5.3 Material characteristics

The choice of proper material is very critical to the success of gill net fishing. The material should be as thin and as soft as possible but at the same time sufficiently strong to withstand the struggle of the fish to escape. The firmness of fish body and extensibility of the material are also to be considered while choosing the material. These conditions are fulfilled by synthetic twines especially monofilaments.

Thickness

The thickness of material and its visibility determine the efficiency and strength of the net. Thinner material is less visible and being less rigid reduces detectability by lateral line sense organs, but it cuts deeply into fish body and has shorter life. Increase in the diameter increases the cost as well as durability of the material, whereas the catchabilty decreases. Besides, thicker material especially multifilament twine has a tendency for rolling which would enable the escape of fishes caught. Thinner twines are recommended when fish concentration is less, and thicker twines when high concentrations exist. The ratio of material diameter 'd', to mesh size 'a', is of decisive importance. The value of twine diameter should be proportional to mesh size. The ratio 'd/a' is generally 0.0025, for calm waters and low catches, and 0.01, for rough waters or bottom set gill nets. The average ratio is 0.005.

Softness

The gill net should have the maximum possible softness and smallest swell. Solid objects strongly reflect the waves pushed forward by a swimming fish and the return swell is recorded by the lateral line sense organ of the fish. Therefore to reduce the swell, more slackening has to be effected and the material should be made as fine as possible.

Visibility

The efficiency of gill nets depends on the visibility of nets (Hamley, 1975). An ideal net is one, which is invisible to the fish. Use of right colour and transparent monofilament material would reduce the visibility, so that it should contrast as little as possible with the surroundings. The measures to be adopted to decrease the visibility include use of (i) thinner material, (ii) transparent monofilament and (iii) appropriate colour of netting. Depending on whether the net is to be used in shallow water or deep water, at night or in the day, it is important to choose a colour that does not stand out from its surroundings. Studies in India have shown that yellow colour is appropriate for gill nets operated in Gobindsagar reservoir and yellow, green and grey colour is appropriate for gill nets operated in Hirakud reservoir (Narayanappa et al., 1977; George et al., 1979). Gill nets with yellow colour are reported to be efficient for catching hilsa (*Tenualosa toli* and *Tenualosa ilisha*) and gill nets with white and yellow colour for pomfrets (*Pampus argenteus* and *Parastromateus niger*), in northern Arabian sea (Kunjipalu et al., 1984).

11.5.4 Buoyancy and weight

In order to keep a net suspended in a given position, there must be a balance of the floatation created by the floats, the sinking force created by the sinkers and the weight of the netting and ropes. In addition, a number of other factors such as weight and pulling force of the fish caught in the net and the force of tide and current are also to be taken into account. Float line with integrated floatation and lead lines with lead core are also available which spread the buoyancy and ballast uniformly along the net. The buoyancy and weight given to a net depends mainly on the fishing conditions. In surface gill nets, the buoyancy to ballast ratio is typically of the order of 2 and in bottom gill nets it varies from 0.2 to 0.3 (Hameed and Boopendranath, 2000). In bottom set nets, the buoyancy is usually 3 to 6 times the weight of netting and lines under water and ballast is 3 to 6 times the buoyancy. The ratio of buoyancy and weight per unit length for surface drift net for sardine was 0.65 (Thomas, 2001).

11.5.5 Float line and floats

Gill nets must have surplus buoyancy compared to the total sinking power of the gear with fish entangled. Bottom set nets have lesser buoyancy than that of drift net. Even though there is no standard for the buoyancy to be provided to a net, as a general rule, it will be equivalent to the weight of webbing in water plus 20 to 25% of the webbing used, as sinkers or lead line. Additional buoyancy can be given according to the fishing conditions. According to Fridman (1986) for bottom gill nets,

Buoyancy requirement, $Q_f = K_Q.Q_n$,
where Q_n is the weight of netting and main line in water and K_Q is a coefficient between 3 and 6.

The buoyancy coefficient K_Q should be greater in stronger currents and lower for calm waters. The float line used for mounting the netting and attaching floats provides uniform buoyancy to the net. The diameter of the rope depends on the strain, which in turn is determined by the number of units, depth of operation and current. Ropes with small floats or other buoyant material braided as a core are also used as float line. The floats should be strong enough to withstand pressure, prevailing at the depth of operation. Small floats in large numbers give necessary buoyancy to provide better shape to the net whereas larger ones avoid entangling of the floats with the meshes. The distance between floats should not be more than 75% of the depth of the net to prevent sagging between adjacent floats. The floats are available in oval, disc, cylindrical, apple and irregular shape and in varying dimensions. The materials include wood, cork, aluminium, glass, plastic and poly vinyl chloride.

11.5.6 Lead line and sinkers

While fishing for bottom fish, the net has to be ballasted more so that the net moves heavily hugging the bottom. The net has to be ballasted less if targeted to fish which live above the bottom.

Weight of sinkers in water, $Q_s = K_B.Q_f$

where K_B is the ballast coefficient which may vary from 1.25 to 6, depending upon local conditions; Q_f is the buoyancy used (Fridman, 1986).

Heavy materials like PVA and PES, can be used as lead line for gaining extra weight. A rope with braided or twisted in lead core will serve as sinkers. The rope termed as leaded rope ensures uniform distribution of weight along lead line. The sinkers are prepared out of iron, lead, rock, clay, stones or concrete. These sinkers are mounted directly by strops or threaded to the rope.

11.6 Operation of gill nets

Gill net operation is a relatively simple compared to operation of other fishing gears. Nets are set across the current and in the path of fish migration. The method of operation varies with fishing condition, depth and area of operation as also the species to be caught. Gill nets are operated mainly as set, drift, and also as encircling gear. In certain cases, the net is dragged with the help of two boats. The nets are held at the bottom, mid water or surface, depending on the vertical distribution of fish. The soaking time of the net varies from 1 to 6 h for drift nets and 12 to 24 h for set nets. In set gill net, both ends of the gear are secured to bottom by means of sinkers or anchors. In drift nets, one end is tied to the boat and the other end with marker buoy and weights.

The nets are shot mostly from the side and sometimes from the stern of the vessel. The nets stored in the vessel with the float line and floats, buoy line and buoys to one side and sinker line and sinkers to the other side are thrown overboard manually to either side of the vessel to prevent tangling. In the case of strong wind and current the net has to be shot in the same direction, and the net could be set across, if the current is weak. The boat has to go ahead, slowly while the net is paid out over the side that faces the wind. The net is positioned at the optimal fishing depth by adjusting the length of the buoy lines. Speed of the vessel is not a critical factor and as a general rule, nets are not allowed to run out faster than the moving vessel, the speed of which during shooting could vary between 1 and 6 knots. One end of the net is tied to the vessel and the vessel drifts along with the nets. Nets operated during night have a lamp attached to a flagpole at the extreme end of the fleet to keep track of the net.

Hauling is generally done by the side of the vessel by pulling the float line and the nets are cleared out and stored in the shooting position. While hauling, the anchor and the net are pulled over the front of the boat. With the advent of synthetic fibres and consequent increase in the length of fleet, gear operation is mechanised in recent years especially in the developed countries. This enables reduction of manpower requirement for handling the gear. Two types of operations are in practice: nets set on stern and hauled over the side and nets set and hauled over stern.

11.6.1 Nets set on stern and hauled over the side

In this case the net is set over a transom roller and hauled up by a gurdy mounted to starboard just forward midship. When ready to set the net, the starboard anchor and buoy are placed overboard, followed by the free end of the net. The vessel then moves slowly along the setting course. When the net rolls over, the anchor and buoy are laid. The vessel may remain or leave to return for hauling. While hauling, the vessel approaches the leeward end of the net, and retrieve the buoy and anchor together with the net. The net is guided to a gurdy by rail roller with end guiders. As the net is brought aboard, the gilled fish is shaken or taken out and net passes to stern side. An alternate means of hauling is by davit mounted power block so that the block extends outside the rail.

11.6.2 Nets set and hauled over stern

The gear is rolled out over stern, and is hauled from stern using a davit mounted or boom mounted power block. Drums are also used for hauling and shooting of gill nets. While a drum holding the net is removed for repairs, another could be fitted into the vessel without interfering with fishing. In order to minimise the labour involved, for removing large quantity of fish, shaking machines have been developed. With the help of drums, the net with the gilled fish is pulled through the machine, thus shaking the fish out of the meshes.

Gill netting is generally done on a daily basis in artisanal operations. Mechanised gillnetters may undertake multiday operations of 14-21 days duration combining driftnet and long line operations. A mechanised gillnetter operating in Indian water is shown in Fig. 11.10.

Fig. 11.10 A mechanised gillnetter

11.7 Management issues

The gill net which a hundred years ago was considered as environmentally safe, has in the latter part of the 20th century aroused much controversy, mainly due to considerable expansion in the volume of the gear used in the high seas gillnetting. The adoption of synthetic material and hydraulic net handling systems enabled operation of gill nets extending to several kilometers.

11.7.1 Capture of non-target species and juveniles

Loosely hung gill nets capture by entangling leading to mortality of non-target species and juveniles. Gill nets deployed for oceanic fishing when allowed to drift with winds and currents, gill and entangle a wide range of marine organisms such as seabirds, sea turtles and small cetaceans. In tropical coastal waters, gill net may consist of units of more than one mesh size, resulting in poor size and species selectivity (Luther et al., 1994; Thomas and Hridayanathan, 2003).

11.7.2 Ghost fishing

Segments of netting, which are lost accidentally during fishing or deliberately discarded, may continue to fish for an indefinite period of time and is capable of entangling birds, sea turtles and cetaceans. This phenomen is known as ghost fishing. Existing evidence suggests that lost gill nets continue to actively fish at a rate of approximately 15% of the commercial rate of capture. It is estimated that an average of 0.06% of the Japanese drift net is lost and not recovered from water during each set of the net (Eisenbud, 1985).

11.7.3 Dropouts and reduction in quality

A proportion of fish caught in the nets will fall from the net (dropouts) while hauling the net onboard and a further proportion may escape from the net injured. Fishes, which are caught in drift and set gill nets, are often left in the water for several hours prior to retrieval on deck which may affect the quality of a certain proportion of the catch.

Most of these issues are concerned with large-scale drift net fisheries in the high seas. UN (Wellington Convention) has defined large-scale drift net fisheries as only those using nets of more than 2.5 km or only those fisheries conducted outside the EEZs. Gill netting is considered to be a selective and energy efficient fishing system, if operated responsibly.

References

Anon. (1992) Drift-net fishing on the way out? Awake 73(10): 14-16

Anon. (1994) Gillnet Fishery in Japan, Yamaha Fishery Journal: 42: 6-7

Baranov, F.I. (1914) The capture of fish by gill Nets, Mater. Pozaniyu Russ. Rybolov. 3(6): 56-59

Baranov, F.I. (1948) Theory of fishing with gill nets, In: Theory and Assessment of Fishing Gear (Translated from Russian), Maple. Out: 45 p.

Brandt, A.V. (1984) Gill Netting, In: Fish Catching Methods of The World (3rd edn.) Fishing News Books Ltd., London: 355-367

Eisenbud, R. (1985) Problems and prospects for the pelagic driftnet, Boston College Environmental Affairs Law Review 12(3): 473-490

Fridman, A.L. (1986) Calculations of Fishing Gear Designs, FAO Fishing Manual, Fishing News Books (Ltd), Farnham: 264 p.

George, N.A., Khan, A.A. and Pandy, O.P. (1979) Catch efficiency and selective action of coloured gill nets, Fish. Technol. 12: 20-63

Gulbrandsen, O. (1986) Reducing Fuel Costs in Small Scale Fishing Boats, BOBP/WP/27, Bay of Bengal Programme, Madras: 18 p.

Hameed, M.S. and Boopendranath, M.R. (2000) Modern Fishing Gear Technology, Daya Publishing House, Delhi: 186 p.

Hamley, J.M. (1975) Review of gill net selectivity, J. Fish. Res. Board. Can. 32: 1943-69

Karlsen, L. and Bjarnasson, B.A. (1989) Small-scale fishing with driftnets, FAO Fish. Tech. Pap., (284): 64 p.

Kunjipalu, K.K., Boopendranath, M.R., Kuttappan, A.C., Pillai, N.S., Goplakrishnana, K. and Nair, A.K.K. (1984) Studies on the effect of clour of webbing on the efficiency of gill nets for hilsa and pomfret off Veraval, Fish. Technol. 21(1): 51-56

Luther, G., Rao, C.V.S. and Sumithrudu, M.S. (1994) The role of gill nets in the exploitation of lesser sardines, Mar.Fish. Inf. Serv. T&E. Ser., 128: 10-14

Narayanappa, G., Khan, A.A., Naidu, R.M. (1977) Coloured gill nets for reservoir fishing, Fish. Technol. 14: 44-48

Sainsbury, J.C. (1996) Commercial Fishing Methods-An Introduction to Vessels and Gear, Fishing News Books (Ltd), Farnham: 352 p.

Thomas, S.N. (2001) Gill Nets of Kerala: A Study on Technological and Operational Aspects, Ph.D. Thesis, Cochin University of Science and Technology, Cochin: 189 p.

Thomas, S.N. and Hridayanathan, C. (2003) Catch analysis in small mesh gill nets, Indian J. Fish., 50(3): 387-393