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Fiskeridirektoratet

International Council for the  
Exploration of the Sea

Biblioteket  
C.M.1981/ B:34

Fish Capture Committee

Engineering and fish reaction aspects of gillnetting - a review.

by

Karl Kr. Angelsen

Institute of Fishery Technology Research  
Box 1964, N-5011 Nordnes, Norway.

#### ABSTRACT

Gill net fishing is affected by a lot of factors, each of which influence the efficiency of the gear both directly and interactively. The tactics used in gill net fishing depend on how well the skipper knows the environment and the fish behaviour. Determining factors are size of vessel and equipment, e.g. gear handling equipment sets limits in no. of size and the thickness of the threads. Type of thread and colour are chosen in relation to fishing depth, light and bottom conditions.

Vertical fish distribution decides height of nets and their position in the water, at the bottom, surface or in mid water.

Government regulations may also effect gill net catching efficiency. Fuel consumption in gill net fishing is low compared with trawling and additional oil savings seem possible.

#### 1. INTRODUCTION

Gillnetting is commonly referred to as a passive fishing method, i.e. the gear itself is more or less stationary relative to the fish, which become captured by swimming into the net wall. Sometimes the fish may also be chased or frightened to swim into the net, but in general the capture process is determined by the action of the fish themselves.

A gillnet can hold a fish in one of three ways (Baranov 1914):

- a) Wedging - The fish is held tight by a mesh around the body.
- b) Gilling - The fish has entered a mesh and cannot back out because the mesh is caught behind the gill cover.
- c) Tangling - The fish has not penetrated a mesh but is caught in the net by teeth, maxillaries or other projections.

For any particular mesh size, fish of some optimum size are held most securely; smaller or larger fish are less likely to be caught.

The selectivity, and in particular the catching efficiency of a gill net is also determined by a number of other gear parameters, which affect the catch both individually and interactively. In addition, the success of gillnet fishing is determined by biological environmental and operational factors.

Gill nets are operated as set nets on the bottom, anchored in mid-water, or as drift nets, and they are used for catching a great variety of fish and other organisms (e.g. crustaceans, snails).

## 2. GILLNET PARAMETERS AFFECTING THE CATCHES.

### 2.1. Meshsize

A gill net of a particular mesh size is most efficient for fish of a particular size or length, the mean selection length, and the relative efficiency of the net for different fish sizes is usually presented as a selection curve.

A typical gill net selection curve is bell shaped, falling towards zero on both sides of the maximum but often skewed to the right. Many authors have described selection curves for different species and the mathematical models to determine such curves, based mainly on catch data. This literature is very well reviewed by Hamley (1975).

Based on the experience of the fishermen, gill nets of different meshsizes get tradenames according to species they are best catching.

In some fisheries minimum mesh sizes are prescribed by law to prevent capture of unwanted, small fish (e.g. salmon, halibut).

## 2.2. Type of material, thickness of thread and colour.

All these factors influence the net visibility. Depending on how well the fish can see or feel the net, the materials with lowest visibility also give the best catches.

Elastic and inelastic stretching, strength and flexibility of the twine are also affecting the selectivity and efficiency of the net, and these factors may differ markedly between different types of material.

The most common netting material is polyamid (PA) thread. Four different types are used: Twisted multifilament PA, monofilamen PA, monotwine (3-strand monofilament) PA and multimono PA. Comparative fishing experiments have shown that multitifilament gill nets are less efficient than nets made of the monofilament materials. In the dark period of autumn and winter in Norther Norway this difference is not so pronounced and gill nets made of multifilament PA are still much used, because they are cheaper.

Another material used for gill nets is polypropylene (PP). This is preferred in the Danish "wreck" fishery because of its buoyancy.

The Japanese also use nets of polyester (PES) in the Pacific salmon fisheries. Nets made of polyethylene (PE) have been tried in Bangla Desh (Pajot 1980). They fished well, but were quickly damaged.

Since thinner twines are less visible than thicker ones they fish better, but too thin a twine is easily broken by large fish or by the strain of hauling the net. The thickness of the twine is therefore adapted to the species and size of fish, and to the fishing depth, based on the experimence of the fishermen.

The colour of the net affects the contrast against the background, the sea or the bottom, and the purpose with colouring the nets is to minimize this contrast. In general it appears that with the sea as background dark multifilaments are less visible than light ones. Nets of monofilaments are less visible than multi-mono nets, but both these materials are much less visible than dark multifilament nets (Angelsen og Huse 1979).

### 2.3. Hanging ratio.

The hanging ratio (E) is defined as the numerical value of the desimal fraction of the length of the mounted net divided by the stretched length of the webbing.

The effect of different hanging ratios is clearly demonstrated by Riedel's catches of tilapia (Tilapia mossambicia) (Tab. 1.).

Tab. 1. The effect of the hanging ratio (from Hamley 1975).

Hanging ratio	Avg. no caught		Size range	
	per day	Percent tangled	95% of the catch	
1,0	9,3	0	18 - 23 cm	
0,5	29,5	24	13 - 23 "	
0,33	81,0	80	8 - 22 "	

Experiments in Norway on spawning cod also demonstrate that the catch per net is changing with the hanging ratio.

The best catch per net was obtained with a hanging ratio of about 0.6. The catch per unit of length differed little for hanging ratios of 0.5 to 0.6 but was much reduced for E = 0.7.

The number of fish which are entangled increases with decreasing hanging ratio (Tab. 1), and depending on the fish movement and speed the net should be constructed more like a proper gill net for spawning cod, and as entangling net for tilapia.

The nets used in the "wreckfishing" in the North Sea have a hanging ratio E = 0.3 - 0.35 because the fish are not moving so much and entangling is more common.

#### 2.4. Buoyancy

Buoyancy evenly distributed along the headline seems to give better catching efficiency than floats attached at few points. The reason is probably that the nets stand better on the seabottom with less tension which may reduce the catching area of the nets.

In general lightly floated nets fish best, but they are also more easily flattened by currents.

The amount of buoyancy also effects the catching efficiency of the net. 65 to 100 grammes buoyancy per meter headline in cod nets were found to be the best (Angelsen et. al 1979).

### 3. ENVIRONMENTAL FACTORS

These are not very well described in reports on gill net fishing. Some factors are obvious, real bad weather prevents fishing altogether, strong currents reduce the hauling speed and may also stop hauling nets. It also often dictates the fleets to be set along the current in order to prevent damaging the gear when hauling, and this may not give the highest catch rate.

In shallow waters gill nets seem to fish better in the night than during day (Pristas and Trent 1977). In the St. Andrew Bay, when the water temperature dropped 2°C or more the gill net catches increase because of increased activity and migration of fish (May, Trent and Pristas 1976). In the demersal gill net fishery in the North Sea the fish are found and caught mostly on hard stony- or coral bottom. This has also a negative effect on the catch, in some areas up to 40% of the gill net catches were destroyed (eaten up) by amphipodes and similar bottom animals.

From other fisheries it is known that the moon phase affects the fish migration and thereby the catches. Similar observations in the gill net fisheries are not well documented, but may well be of importance.

#### 4. GEAR HANDLING, FUEL CONSUMPTION

The handling of gill nets on board the vessels evidently varies with type of fishery and the size of vessels used, as well as from country to country.

In the mechanized Scandinavian gill net fisheries the deck arrangement is principally the same on all gill netters without regard to the size. They are each quipped with a railroller and a net hauling gurdy, and most have also a netchute in which the fish are removed from the nets.

The fleet of nets is hauled through the chute and stacked in the net-bin, normally located at the stern.

The hauling operation is the most work intensive part in gill net fishing and the main bottleneck is taking the fish out of the nets. In recent years numerous innovations have been tested to reduce manual labour and new and better net-handling equipment has been developed. This may lead to an increase in the net hauling capacity and better the catching efficiency of the vessels:

The fuel consumption for an Islandic gill netter (35 m long, 800 hp) has been measured by Augustson and Ragnarsson. (1981). The fuel consumption per ton of catch was 101 liter/tonn, of which 52% was used during steaming.

The fuel consumption during the shooting operation was very small and during hauling the fuel consumption, and the time spent, depended on the number of fish in each fleet.

Data on fuel consumption in different types of fishing has been reported by Endal (1980) who found that the fuel ratio (kg fuel/kg fish) for "coastal fishing" was 1/10 of that for middle water bottom trawling and 1/2 of the figure for near water longlining.

In "coastal fishing", gill netting is the most important gear and the fuel ratio, 0,1 kg fuel per kg fish caught demonstrates that gill netting is low in fuel consumption compared with other types of fishing. Fuel consumption may nevertheless be reduced in this type of

gill net fishing by optimizing operational tactics to minimize steaming time, and particularly by improved propulsion systems .

#### 5. FISH REACTION TO THE NET.

Direct free field observations of fish reaction to gill nets are very difficult. In a tank experiment with salmon for the purpose of studying gill net damages to the fish some main features were observed when the salmon hit the net.

- a) Fish that hit the net without being gilled wrench strongly with head or tail at the same time as they move backwards or alongside the net. Therefore, if the net hangs loosely, there is a great chance of the fish getting entangled.
- b) Fish that are gilled in a mesh swim strongly forwards and try to pull the net with them. If they do not slide through, they soon turn and swim in the oposite direction getting still more entangled (Angelsen and Holm, 1978).

Observations of fish marked with acoustic tags in the vicinity of net walls have clearly shown that many fish possess a remarkable ability to avoid the nets and escape capture.

Evidently, vision is of major importance, but some species may also be able to detect dangerous obstckles by other senses.

Since the fish must swim into the net to become captured, the more active fish are more likely to encounter the net and get caught. In the cases of cod and halibut, when fished on the spawning grounds, it is the more active males that easiest get caught. Similarly, salmon are caught as they move towards the rivers, and herring when they become active in the surface waters at night. Fish may be chased into the net either by predators or human action, or conversely they may encounter the net when chasing their prey. Adverse physical conditions, such as low temperatures, reduce the activity of the fish, and hence the catches are less.

## 6. GILL NET DAMAGES TO RELEASED FISH, GHOST FISHING.

The fate of fish that get in touch with gill nets and thereafter escape is mostly unknown.

Observations made by UTV (Olsen, K. 1981) showed a number of dead herring laying on the sea bottom in the vicinity of cod gill nets. An estimated additional 40-50% of the catch landed appeared to be killed and lost. Probably other forms of net damage such as loss of scales might lead to further deaths at a later time.

From the salmon drift net fishery both in the Pacific and the Norwegian coast there are observations about fish falling out of the nets, estimated at 1,8% of all Pacific salmon landed (French and Dunn 1973) and 0,8% in experimental fishing for Atlantic salmon (Jensen 1977). In some of the Norwegian rivers up to 90% of the salmon caught had gill net marks on their body, and there is a serious fear about their ability to survive.

Gill nets are frequently lost due to adverse weather and current conditions, damages to buoy lines etc. Retrieval experiments both in Canada, Iceland and Norway show that such lost nets may continue to fish for long periods of time. How serious this "Ghost fishing" problem may be is not yet quantitatively established, but it could well be a significant source of mortality in certain localities. (Way 1977, Angelsen 1981).

## 7. GILL NET CATCHES COMPARED WITH THOSE OF OTHER GEARS.

What kind of gear to be used for capturing different fish depends among other things on the effectiveness of the gears and regulations by the government.

A recent experiment in the North Sea to compare the effectiveness of gill nets and longlines, gave no cod caught on longlines which gill nets gave an average of 3-4 cod per net. The gears were set in the same area and in the same direction with a distance of about 0.3-0.4 nautical miles. The reason for this difference in catching efficiency is not yet clear.



In the Lofoten spawning cod fishery the catch composition of longlines, gill nets and purse seines were compared by Rollefsen (1953). The conclusion was that the smaller size groups have a very pronounced tendency to be caught on longlines, while on the other hand the larger size groups are under represented in line catches compared to those of the purse seine. The purse seine demonstrated also the existence of a group of fish which had previously been naturally protected against longlines and nets by their larger size and by their behaviour.

Mesh selection by gill net may affect the catch per unit of effort compared with other fishing gears. An example from the herring fishery is given by Østvedt (1964) and from the Pacific salmon fishery by French (1968).

In some years the herring catch per unit effort for gill nets was higher than for purse seine, other years lower. The reason for this is explained with the availability of recruit spawners. In years with high amount of recruit spawners the relative catch per unit of effort for purse seine was better than for gill nets, mostly because of the mesh selection, but also caused by the behaviour of the fish. The bigger herring readily seek deeper water during the fishing operation and thus escape the drift nets more often than the smaller ones. The same happens in the Pacific salmon fishery. The big salmon escape. The longline, however, select larger salmon mainly because of the difference in the feeding habits, while the gill net catches probably best seem to represent the size composition of salmon in the Pacific.

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