Int. J. Forest, Soil and Erosion, 2015 5 (1): 1-7
ISSN 2251-6387

Review Article

Gillnets and their Efficiency in Fishing Activity

Mohammed Omer Mohammed
Environment and Natural Resources Research Institute, National Centre for Research, Khartoum, Sudan.
E-Mail: mom.7.3.11@gmail.com

Abstract: Global reduction in fish stock and over-fishing particularly in inland water that due to use widely selected fishing gear such as gill nets. Synthetic materials used in manufacturing gillnets have given fishermen great fishing opportunities in practicing fishing which were not available through use traditional gear. There opportunities representing in using gillnets on rough ground that had once been fished by longlines but could not be fished by trawlers, using them successfully in daylight and giving fishermen more freedom to choose the timing and duration of their fishing trips. Therefore, the present paper is briefed information related to gillnet due to its effectiveness on global fisheries.

Key words: Fishing gear, fishing boats, types of fishing boats, Nile fishing boats

Introduction

The introduction of fine synthetic materials, in the construction of fishing gear during the 1960s, marked the beginning of a radical change in the pattern of fishing in the coastal waters. The new materials were cheaper and easier to handle, lasted longer and required less maintenance than natural fibres like cotton and hemp, which had previously been used to make nets. In addition, nets made with synthetic twines generally caught more fish than nets of natural fibre used in comparable situations. Moreover, synthetic twines provides fishing opportunities that were not available to those using traditional gear such as fishing by drifting gillnets in daytime and freedom to choose the timing and duration of their fishing trips (Potter and Pawson, 1991).

The name gillnet indicates that the fish are meshed behind the gill cover. They are panels of netting held vertically in the water column by a series of floats attached to their upper edge (the float-line or cork-line) and weights attached to their lower edge (the foot-rope or lead-line). These nets are either staked or anchored in shallow water or set to drift in open water (Potter and Pawson, 1991; B.C., 1997; FAO, 2000; Ghulam and Ahamed, 2005). These types of gear are therefore distinguished from nets designed to 'enclose' or 'encircle' fish. Nets like trawls and seines can be made with very small meshes, so that no fish become enmeshed, but most types of net are subjected to minimum mesh size regulations which are intended to allow the smaller, usually immature, fish to escape. As a result, fish that are only a little too large to pass through the net tend to become enmeshed, whilst larger fish are contained within the net walls. With enmeshing nets, however, fish can be either too small or too large to be retained by the mesh; thus, for a particular mesh size, gillnets are more 'selective' for fish size than trawls or seines (Potter and Pawson, 1991). Therefore, the aim of the present paper is to provide baseline information related to gillnets stressing on its property and impact on fishing.

Synthetic netting materials

Synthetic fibres, made from at least seven different groups of chemical polymers, are used in the construction of fishing gear. Most modern gillnets used in the world are made from polyamides, commonly called 'nylon' or known by other trade names. 'Netting yarn' is the term used to describe textile materials which are suitable for the manufacture of fishing nets without the need for further processing. Synthetic fibres are produced in various forms, of which two, known as 'multifilament' and 'monofilament', give yarns suitable for various types of enmeshing nets (Klust, 1973; Potter and Pawson, 1991).

In addition to the effects of exposure to sunlight, the physical properties of synthetic nets can also change gradually with use. In particular, abrasion of the nets removes the shine from the material and the accumulation of dirt in the knots and on the roughened surface of the yarn makes the netting more visible in the water (Potter and Pawson, 1991).

Multifilament yarns

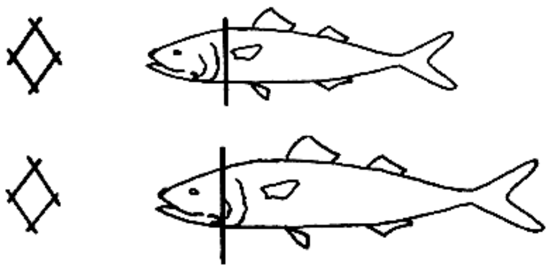
Continuous filaments are very fine fibres, normally less than 0.07mm in diameter and of almost limitless length. 'Multifilament' netting yarns are made from large numbers of these filaments gathered together, with or without twisting. Most commonly, continuous filaments are twisted together to form quite fine 'single yarns', and several of these are in turn twisted together to make the netting yarn. Multifilament nets were the first to be introduced and are often still referred to as 'nylon' by fishermen; while, some loosely twisted multifilament nets are sometimes called 'single-throw'. Multifilament yarns are manufactured mainly from two common synthetic materials: polyamide, polypropylene. Variety of these yarns depends on many characters as: 1) filament thickness or denier, 2) number of filaments in each single yarn, 3) degree of twist of the single yarn, 3) number of single yarns in the netting yarn, 4) degree of twist of the netting yarn and 5) direction of twist of the netting yarn relative to twist of the single yarn (Potter and Pawson, 1991).

Monofilament yarns

Monofilaments are single filaments which are normally more than 0.1mm in diameter. Those thicker than about 0.4mm are strong enough to function alone as netting yarns; nets with a mesh size of less 50 mm (knot to knot) are often made from 0.4 mm yarn; while, 0.6 to 0.8mm yarn is commonly used for larger-meshed nets. Netting yarns are also made by twisting a number of fine monofilaments together; these are usually referred to as 'mono-ply', when larger numbers of thinner filaments are used. They are not normally regarded as 'multifilament' netting yarns, from which they can be distinguished on the basis of filament thickness or the number of filaments making up a yarn. In addition to the range of thickness, monofilaments are made round, oval or flattened in cross section (Potter and Pawson, 1991).

Basic design of gillnets

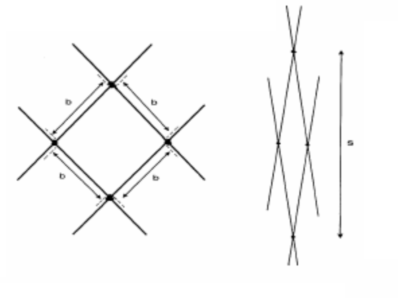
The term gilling is referred to the process of catching fish by gillnet and somewhat misleading as fish are also caught by a number of other processes (Figure 1). The most prominent catching processes noticed in the literature are the following (B.C., 1997; FAO, 2000).



For the smaller fish (top) the girth at the gills (indicated by the bar) matches the mesh-size and this fish is likely to be gilled.
For the larger fish (bottom) the girth at hte head region matches the mesh-size and this fish is therefore potentially snagged.

Source: FAO (2000)

Fig. 1. Relationship between fish size and catching process



Source: Pottera and Pawson (1991)

Fig. 2. Depicts measuring mesh size 'Knot to knot'

The construction of many enmeshing nets simply involves attaching a head-rope with floats along the top of the sheet of netting and a weighted foot-rope along the bottom. The floats may be spaced up to 6m apart along the head-rope, and the sinkers (weights) may be tied to (or incorporated into) the foot-rope, the latter being known as a lead-line (Potter and Pawson, 1991).

A gillnet consists of netting attached between a head-rope and a foot-rope. The net is kept open vertically by the differences in buoyancy between the two ropes. The head-rope is given positive buoyancy by using various floating devices. In shallow waters, floating is typically applied by attachable cork or styrene floats or by using head-ropes where styrene is embedded in the rope. For deep-water fisheries, hollow metal or hard plastic rings are used to provide buoyancy. Weight is most simply applied to the foot-rope by embedding lead into the rope, but may also be applied by using various sinkers, e.g. metal rings (FAO, 2000).

The mesh size can be described by several different measurements (Potter and Pawson, 1991; FAO, 2000) as bellows:

- ❶ 'Knot to knot' (**Figure 2**) and 'bar length' (b) refers to the length of yarn between two adjacent knots (sometimes measured between knot centers).
- ❷ 'Stretched mesh' (s) is the distance between two knots on diagonally opposing sides of a (four-sided) mesh when they are pulled apart, usually with a set force.
- ❸ 'Mesh circumference' and 'round four sides', as the terms imply, give the full distance round each mesh.

Modern gillnets are made of monofilament, multi-monofilament or multifilament nylon. Combining a number of such monofilaments in parallel makes a multi-monofilament. Multifilament consists of thin nylon fibers twisted together (FAO, 2000).

A net may be rigged with varying degrees of slack, which is primarily regulated by the hanging ratio. The hanging ratio measures how tightly the net is stretched along the head and foot rope. The hanging ratio may theoretically vary between the value 0 (all meshes mounted at the same point on the ropes, so the net has no length dimension) and a value of 1.0 (the netting is fully stretched out, so the net has no height dimension, see Fig. 2.1). In commercial fisheries hanging ratios are normally found between 0.25 and 0.65 (Baranov, 1948).

Gill nets property

Color of netting

Gillnets are marketed in a variety of colors and shades and individual fishermen often show strong preferences for certain colors. Despite of the individual variations, a general trend is often observed. In the Danish fisheries, for instance, orange colored nets dominate in the Baltic Sea; whereas, grey or green nets are preferred for the North Sea fisheries (Angelsen, Haugen and Floen, 1979).

There are some hypothesizes related to efficiency of colored gillnets in fishing. One of them considers that the most efficient color of nets should be that of the dorsal region of the fish as this color conceals the fish in its particular environment. This should argue for darker nets being most efficient (Baranov, 1948). Later studies (e.g. Jester 1973, Tweddle and Bordington 1988) have not confirmed Baranov's camouflage hypothesis as white nets often perform better than dark ones. In both these studies, clear species differences were observed such that the ‘best’ colors differed from species to species. It has been noted that the efficiencies of different colors also show seasonal differences (Potter and Pawson, 1991).

The visibility of monofilament nets from a physical perspective has been discussed and shown interesting patterns regarding the importance of object orientation in water as well as the differences in reflection in air and water (Plate 1). Further inferring has been made is the visibility of nets depends on both the water color and the color of the seabed (Wardle, Mojsiewiecz and Glass, 1991). Light intensity has been used thresholds as an indicator of the fishing power of different colored nets by comparing mackerel (*Scomber scombrus*) behavior towards different colored twine. Considerable differences in color detection thresholds were observed for both a thin monofilament thread and a thicker multifilament thread (B.C., 1997).

Source: Mohammed (2006)

Plate 1. Depicts effect of flood season on gilnet yarn color

Dimensions of netting

It is a well-known fact to fishermen and net manufacturers that nets constructed of thinner twine catch considerably more fish than nets made of coarser materials. Fishermen usually attribute the higher fishing power of finer nets to these nets being 'softer' (FAO, 2000). The available experimental information suggests that the effect of twine thickness is found for all materials, i.e. multifilament (Predel, 1963), monofilament (Hovgård, 1996b; Jensen, 1995a) and multi-monofilament (Millar and Holst, 1996).

The choice of dimensions of netting material implies a trade-off between fishing power and net durability as nets made of fine, materials are more easily damaged. In commercial fisheries, durability and ease of handling are often the main arguments to use relatively coarse netting materials (FAO, 2000).

Types of netting

Fishermen have clear notions of the importance of the material type where considerations are given to both catch performance and physical attributes. Multifilament nets are considered to be the least efficient; while, at the same time being the strongest. Multi-monofilament nets are generally considered to be the most efficient as the use of thin parallel threads make the net more 'soft' than the monofilament or multifilament nets. A stated draw-back of multifilament nets is the higher tendency for entangling various unwanted by-catches, e.g. crabs or starfish, which may considerably slow down the cleaning process. The different qualities of the netting materials often led to clear patterns in their use. In Denmark, for instance, multifilament nets are typically used in the trammel nets targeting flatfish, multi-monofilament are the predominantly used materials when targeting cod, whereas hake fisheries most often use monofilament nets (FAO, 2000).

Most scientific comparisons have been between monofilament and multifilament nets. The results of these comparisons are not clear. Some studies, find multifilament superior to monofilament nets whereas, other studies indicate the opposite (Predel, 1963; Washington, 1973; Hylen and Jacobsen, 1979). Studies including several species indicate that the differences may be species-dependent. But it has been observed that equal total catches between monofilament and multifilament nets, whereas the clear differences are seen between species (Jester, 1973). Monofilament nets have been found more efficient for pikeperch fish (*Stizostedion lucioperca*), but multifilament more efficient for bream (*Abramis brama*) fish (Machiels et. al. 1994).

A comparison study has been done on fishing nets used in British cod fisheries and found that the multifilament net has a better catch than multi-monofilament and monofilament nets. The catch differences could be attributed to the way fish are enmeshed, whereby the multifilament and the multi-monofilament nets caught considerably more entangled fish (Stewart, 1987).

Lack of good understanding of the exact importance of material coarseness within the various materials complicates comparisons between materials. When comparing an inferior version of one material to a superior version of another material the catch differences will not only reflect the material. In an experimental fishery in the Bay of Biscay, using trammel nets targeting sole (*Solea solea*), multi-monofilament nets were generally found to be more efficient than multifilament nets (EU, 1997).

Hanging ratio

Hanging coefficient (E), equals the length of the pressed as a decimal but it may also be shown as a percentage or a fraction (e.g. E=0.67 is equivalent to E = 67% or E = 2/3). The hanging coefficient determines the length and depth of the final net and the shape of the meshes in the water (Potter and Pawson, 1991). Commercial nets typically have a hanging ratio between 0.25 and 0.65. In the European marine fisheries the lower hanging ratios are applied in flatfish fisheries, whereas nets for catching round fish typically have hanging ratios between 0.4 and 0.5 (FAO, 2000).

Hanging ratios have been shown that it may affect the selectivity of the nets. It has been noted that a decrease in hanging ratio resulted in an increasing number of mainly smaller *Tilapia mosambica* becoming entangled in the net (Riedel, 1963). Similarly, a decrease in selectivity for blue ling has been found when the hanging ratio decreased from 0.6 to 0.4 due to more small specimens being caught in the loosely hanging nets (Engås, 1983).

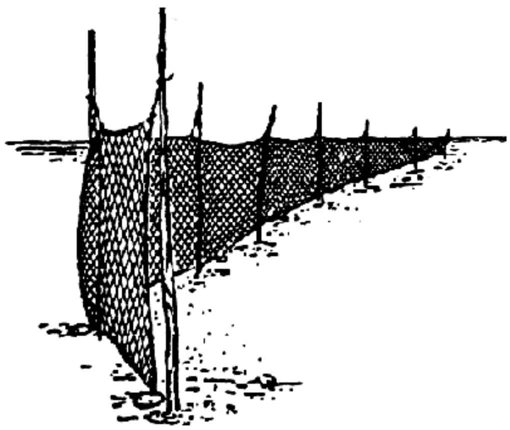
In 1965, it has been found that the numbers of large perch increased when the hanging ratio decreased, whereas no change could be observed in the length frequencies for roach (*Rutilus rutilus*) when changing the hanging ratio. it has been interpreted the species difference as being due to the fact that the perch were a spiny fish that were entangled more easily when the hanging ratio was decreased (Mohr, 1965). This interpretation, which has been widely cited, has recently been questioned by (Machiels et. al. 1994) who found a change in selection for the 'smooth' bream (*Abramis brama*), but not for the 'spiny' pikeperch (*Stizostedion lucioperca*). Several studies reported a general higher catch for the more loosely hung nets (Angelsen, Haugen and Floen, 1979; Machiels et. al. 1994; Samaranayaka, Engås and Jørgensen, 1997). Experimental fisheries carried out by the Danish Fisheries Research Institute suggest, that the catches of the dab (*Limanda limanda*) were highest in loosely hung nets whereas little difference was seen for cod (*Gadus morhua*) fish (FAO, 2000).

Types of gill nets

Gillnets are many types according to their design and purpose. They can catch fish by entangling, enmeshing and gilling in the netting and the fish that is caught by these ways called gilled, entangled or enmeshed fish. Gillnets may be either single (gillnets) or triple (trammel nets). Several types of nets may be combined in one gear. These nets can be used either alone or, as is more usual, in large numbers placed in line ('fleets' of nets). According to their design, ballasting and buoyancy, these nets may be used to fish on the surface, in mid-water or on the bottom (Yusof, 2007).

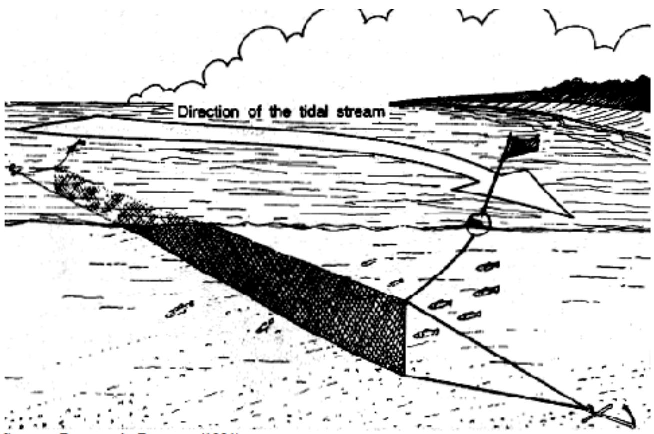
Fixed nets

Fixed nets (Figures 3; 4) are one types of the passive gear constructed from one layer of netting. They consist of a heavily weighted footrope and head-rope with floats. Each end of the net is attached to an anchor or a whole net is tied to stakes (Potter and Pawson, 1991; B.C., 1997; Yusof, 2007).



Source: Yusof (2007) and FAO (http://www.fao.org/fishery/geartype/247/ed)

Fig. 3. Depicts a fixed gillnet setting on stakes in a fishery



Source: Pottera dn Pawson (1991)

Fig. 4. Depicts fixed gill net setting in a fishery by anchors

Fishing by fixed gill nets is probably one of the most commonly used methods for catching fish. It is easily set with the use of a boat. One end of the net is either tied off on shore or anchored with a marked buoy. The boat is then reversed and the net is let out over the bow (Potter and Pawson, 1991; B.C., 1997).

To avoid tangles it is best to carefully load the net into a tub or bag trying to keep cork and lead-line separated (Plate 2). This will allow the net to be set with a minimum of tangles and snags. When all of the net has been let out, pull the net taut by holding onto the bridle ropes and reversing the boat. When the net is taut, set the second anchor and mark it with a buoy. If sinking nets are being used, ensure that there is sufficient buoy line to let the marker reach the surface when the net is deployed (B.C., 1997; Bashir, 2007).

Source: Bashir (2007)

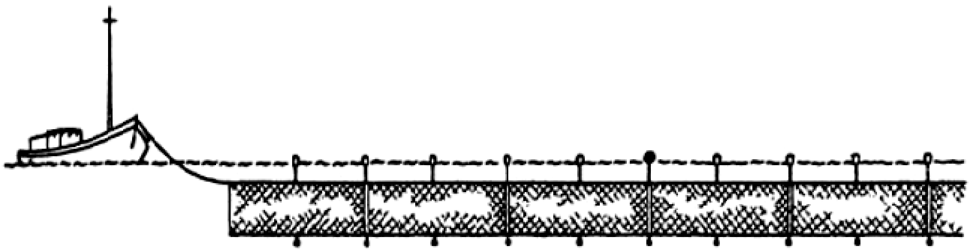
Plate 2. Position of fixed nets in a Canoe for setting in a fishery

Fixed net can be set in a variety of ways depending on the sea/river and the purpose of the set. Floating nets will catch fish in the upper 2-4 m of the river/sea. Floating net in the littoral zone perpendicular to shore will focus on species migrating through the littoral zones. Sinking nets/staking nets will catch benthic species. They are done in slightly offshore and parallel to shore may concentrate on species migrating on and offshore (when the tide ebbs these nets may eventually allow the fish (not entangled or gilled) to pass freely underneath their bottom line (B.C., 1997; Yusof, 2007).

Generally, fixed nets are set at dusk, left to fish overnight and are retrieved the following morning to process the catch. However, areas with cover, such as snags or underwater debris, are good places to catch fish but there is a high risk of tangling or snagging the net and great care should be used when setting the net (B.C., 1997).

Drift nets

Drift nets (Figure 5) are mobile gillnets of one sheet of getting joining to head-rope with more floats and foot-rope with lightly sinkers. Each end attached to anchors with flag as a mark. These net are similar to fixed nets in construction, but drift nets are distinguished by many floats on head-rope and a very light foot-rope (Potter and Pawson, 1991; Yusof, 2007).



Source: FAO (http://www.fao.org/fishery/geartype/220/en)

Fig. 5. Depicts the use of drifting gillnets in fishing activity

In application, drift nets are allowed to move freely with the water currents, and therefore have more floats on the head-rope and a very lightly weighted foot-rope, so they hand down loosely from the surface. The head-rope is often suspended some distance below the surface on rope strops attached to buoys. Such nets can be fished close to the sea bed, where this is clear of obstructions (Potter and Pawson, 1991; Yusof, 2007).

Encircling nets

Encircling gillnets (Figure 6) are one type of gill nets used by forming a circular shape to surround fish with making knocking on the water surface and then to collect the fish. They are like the standard form of gillnet. It has more floats on the head-rope, but is not like that of the drift nets (Yusof, 2007).

Behaviour of fish in nets

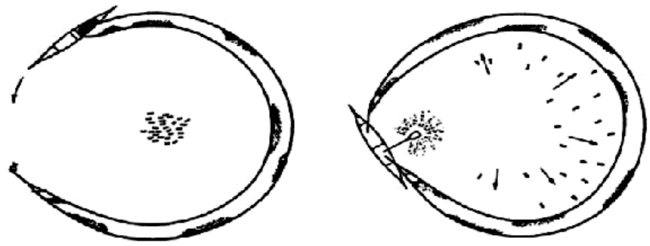
Fish are usually caught in gillnets, either by trying to swim through a mesh and becoming wedged 'gilled', or by becoming snagged or tangled in the netting. In tank experiments, it has been observed that the behavior of Salomon when they became caught in a gillnet. The fish initially struggle quite powerfully, usually for less than 30 seconds, although in a few cases they swam vigorously for 2 or 3 minutes [1]. Investigations of fish energetic have been suggested that at normal sea temperatures, a Salmon could only swim vigorously for one or two minutes before becoming totally 'exhausted' through the accumulation of lactic acid in the muscles (Zhou, 1982).

It has been noted that differences in the behavior of Salmon that were enmeshed and those that were snagged or tangled. Gilled-fish tended to swim strongly forwards, pulling the net with them. If they were still held, they would then turn and swim in the opposite direction. Thus, if the net were hung fairly loosely, the fish would swim back into it and become caught in more than one mesh. Salmon that hit the net and became snagged without being gilled tended to wrench strongly with their head or tail, at the same time moving backwards or alongside the net. Once again, a loosely hung net offered more chance of the fish becoming entangled (Angelsen and Holm, 1978).

Probability of capture or escape

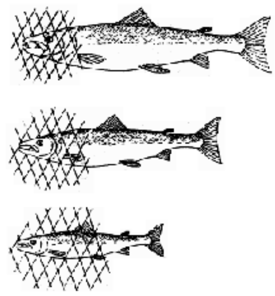
The probability of a fish being caught after it comes into contact with a gillnet is largely dependent upon its size. Gillnets are therefore said to be 'size selective'. A fish with a maximum girth less than the mesh circumference will be able to swim straight through, while a fish so large that it can barely get its head into a mesh is unlikely to become firmly wedged and may escape. Tangle nets are designed so that some large fish may still be held even if they cannot be properly enmeshed and, in traps and seines, such fish should still be retained within the enclosed area of netting. A gilled-fish may also escape if it can apply sufficient force to the net break a mesh or make a knot slip. Large Salmon can sometimes distort and break meshes of drift nets, even where the breaking strain of the netting yarn is 15-20 kg, and will frequently burst right through small-meshed nets which are made of fine yarns (Potter and Pawson, 1991).

Fish of all sizes may be held by the net if they are caught or entangled on jaws, teeth, spines or other projections (Figure 7). Tangle nets are specifically designed to operate in this way, and are also often made from multifilament netting which is softer and is generally thought to be more likely to snag the fish than the harder (Potter and Pawson, 1991).



Source: Yusof (2007) and FAO (http://www.fao.org/fishery/geartype/221/en

Fig. 6. Depicts operation process of encircling net in fishing activity



(a) Large fish wedged around head (probably also snagged).
(b) Medium sized fish wedged around body behind gills.
(c) Small fish wedged at maximum girth in front of dorsal fin.

Source: Potter and Pawson (1991)

Fig. 7. Depicts positions of holdign fish in gill nets

Selectivity

Importance of selectivity

Selectivity can be defined as any factor that limits the catch to a specific range of the fish population. The quality and quantity of the catch are dependent on such conditions as gear specifications, morphology and operation, time of fishing, seasonal variation in fish behavior, fish size, etc. Comparing catches from various gear types would illustrate the selectivity of fishing net. Selection can be expressed relative to the fish population in the area fished and is then termed *absolute selection* (B.C., 1997; FAO, 2000).

Methods of estimation gill net selectivity

The most direct method for estimating selectivity is to tag or mark a large number of fish and determine the proportion caught by the fishing gear in each size category. This is readily accomplished in small lakes; however, in large lakes and the ocean it is rare that enough tagged fish are released in a single tagging experiment to enable selectivity to be well determined (Ghulam and Ahamed, 2005; Ransom and John, 1997).

It is better here to refer to the two alternative approaches to estimating selectivity. First, if the commercial catches are known by age and by year, then age-structured models such as virtual population analysis can be used to estimate selectivity of the commercial fishing gear. Statistical catch-at-age models can be formulated in a variety of ways; many formulations depend upon the selectivity of the independent survey or commercial catch rate series being known, at least for older ages. This may cause a fundamental indeterminacy in many formulations because the estimated selectivity of the gear that is being used, it depends upon assumptions about the fishery (Myers and Cadigan, 1995a & 1995b).

A second approach is to compare the catch rates of different sizes of fish in two or more gear types. This is known as indirect estimation of selectivity [16]. However, the functional form of selectivity from such a comparative approach have been shown that it cannot be determined from comparative catch data alone using two types of gear, e.g., two hook types (Millar, 1995). Furthermore, indirect methods of estimating selectivity have been shown that it cannot distinguish between models in which fishing power is constant with mesh size and models in which fishing power is assumed to be proportional to mesh size (Millar and Holst, 1996).

Reference

Angelsen, K. K. and Holm, M. (1978). Rapport an garnforsok med laks. Fish og Fiskestell, (8): 15-27 (Cited by Pottor and 1991).

Angelsen, K., Haugen, K. and Floen, S. (1979). The catching efficiency of cod gillnets with different hanging ratio and different float-line buoyancy. ICES CM 1979/B:19 (Mimeo).

B.C. (1997). Fish collection methods and standards. Version 4.0, Resources Inventory Committee. http://www.for.gov.bc.ca/ric

Baranov, F. I. (1948). Theory and assessment of fishing gear. Chap. 7. Theory of fishing with gillnets. Pishchepromizdat, Moscow, 45p. (Translated from Russian by the Ontario Department of Lands and Forests. Maplc. Ont (Cited by FAO, 2000).

Bashir, F. A. R. (2007). Biology aspect of commercially important fish species an ichthyic mass of Jebel Aulia. M.Sc. (Fishery) thesis. University of Juba, Khartoum, Sudan (cited by Mohammed, 2009).

Engås, A. (1983). The importance of various gear parameters in the gillnet fishery for blueling (Molva dypterygia). M.Sc. Thesis, University of Bergen.

EU (1997). Selectivity of gillnets in the North Sea, English Channel and Bay of Biscay. AIR2-93–1122+ Appendices. 61 pp.

FAO (2000). Manual on estimation of selectivity for gillnet and longlines gears in abundance surveys. FAO Fisheries Technical Papers 397, Rome, 84 p.

Ghulam, K. M. and Ahamed, K. K.U. (2005). Diversity of selective and non-selective fishing gear and their impact on inland fisheries in Bangladesh. NAGA, WorldFish Center Newsletter, 28 (1 & 2): 33-36.

Hovgård, H. (1996b). Effect of twine diameter on fishing power of experimental gillnets used in Greenland waters. Can. J. Fish. Aquat. Sci. 53: 1014–1017.

Hylen, A. and Jacobsen, T. (1979). A fishing experiment with multifilament, monofilament and monotwine gillnets in Lofoten during the spawning season of Arcto-Norwegian cod in 1974. Fisk. Dir. Skr. Ser. Hav. Unders. 16:531–550.

Jensen, J. W. (1995a). A direct estimate of gillnet selectivity for brown trout. J. Fish Biol., 46: 857–861.

Jester, D. B. (1973). Variations in catchability of fishes with color of gillnets. Trans. Amer. Fish. Soc., 102:109–115.

Klust, G. (1973). Netting materials for fishing gear. FAO Fishing Manuals. Fishing News (Books) Ltd, West By fleet, Surrey, 173pp.

Machiels, M. A. M., Klinge, M., Lanters, R., and van Densen, W. L. T. (1994). Effect of snood length and hanging ratio on efficiency and selectivity of bottom-set gillnets for pikeperch, Stizostedion lucioperca, and bream, Abramis brama. Fish. Res., 19:231–239.

Millar, R. B. (1995). The functional form of hook and gillnet selection curves cannot be determined from comparative catch data alone. Can. J. Fish. Aquat. Sci., 52: 883-889.

Millar, R. B. and Holst, R. (1996). Estimation of gillnet and hook selectivity using log-linear models. ICES J. Mar. Sci.

Mohammed, M. O. (2006). Effects of gillnets and fishing gear on fisheries of Jabel Awlia and Al-Kalakla on the White Nile, Khartoum state. M. Sc. (Aquatic Animals) thesis. Sudan Academy of Sciences, Khartoum, Sudan (cited by Mohammed, 2009).

Mohammed, M. O. (2009). Fishing technology. Sudan Currency Printing Press, Khartoum, 184pp.

Mohr, H. (1965). Auswirkung der einstellung von kiemennetzen auf die fangigkeit von barsch and plotze. Arch. Fishereiwiss., 16: 108–115.

Myers, R. A. and Cadigan, N. G. (1995a.) Was an increase in natural mortality responsible for the collapse of northern cod? Can. J. Fish. Aquat. Sci., 52: 1274-1285.

Myers, R. A., and Cadigan, N. G. (1995b). Statistical models for catch at-age data with correlated errors. Can. J. Fish. Aquat. Sci., 52: 1265-1273.

Potter, E. C. E. and Pawson, M., G. (1991). Gill netting. Lab. Leafl., MAFF Direct. Fish. Res., Lowestoft, (69); 34pp.

Predel, G. (1963). Kiemennetze als fanggeräte fur die kleine marane (Coregonus abula). Dtsch. Fisch. Ztg., 10: 123–128. (Cited by FAO, 2000)

Ransom A. M. and John M. H. (1997). Direct estimates of gear selectivity from multiple tagging experiments. Can. J. Fish. Aquat. Sci., 54: 1-9.

Riedel, D. (1963). Contribution to the experimental determination of the selection parameter of gillnets. Arch. Fischereiwiss., 14: 85–97.

Samaranayaka, A., Engås, A. and Jørgensen, T. (1997). Effects of hanging ratio and fishing depth on the catch rates of drifting tuna gillnets in Sri Lankan waters. Fish. Res., 29: 1–12.

Stewart, P. A. M. (1987). The selectivity of slackly hung gillnets constructed from three different types of twine. J. Cons. Int. Explor. Mer., 43: 189–193.

Wardle, C. S., Cui, G., Mojsiewiecz, W. R. and Glass, C. W. (1991). The effect of colour on the appearance of monofilament nylon under water. Fish. Res., 10: 243–253.

Washington, P. (1973). Comparison of salmon catches in mono- and multi-filament gillnets. Mar. Fish. Rev., 35: 13–17.

Yusof, S. H. (2007). Classification of fishing gears. Malaysian Technical Cooperation Programme, PKTM5/ 2007.

Zhou, Y. (1982). The swimming behaviour of fish in towed gears: are-examination of the principles. Scott. Fish. Work. Pap., Dept. Agric. Fish. Scott., (4): 1-55.