# Gill net Selectivity

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## Introduction

Selectivity is an important tool for effective management of fisheries. It is defined as the ability to target and capture fish by species, size or sex or a combination of these during harvesting operation, allowing all incidental by-catch to be released unharmed. By regulating the minimum mesh size of a fishing fleet, the minimum landing size of the target species can be determined. Several researchers stress the importance of selecting the optimum mesh size from the standpoint of conservation of population.

The advantages of selectivity can be listed as :

- Regulate mesh size and minimum landing size
- Allow gear technologists to design gear which permits escapement of unwanted by catch
- Help in return of juveniles back into the system – helps in continued reproduction and growth of the stocks
- Reduction of destructive fishing practices.
- Allow harvest of targeted fish thereby decreasing labour for sorting.

Selectivity is not a single process. The act of catching a fish involves several stages. The fish must encounter the net, be caught and finally be retained. Any one of these stages can be selective.

Selectivity is expressed as a ratio referred to as selectivity coefficient.

$$\frac{\text{Fish caught in the fishing gear}}{\text{Fish population exposed to the gear}} = \text{Selectivity coefficient}$$

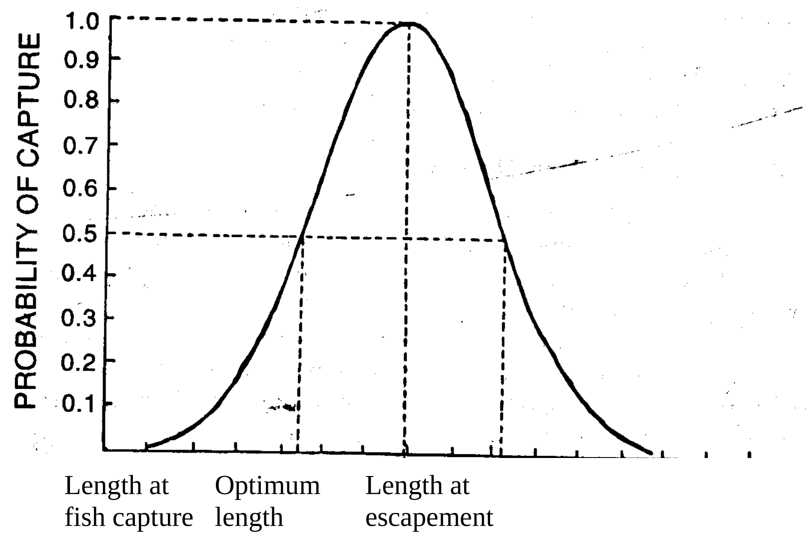
Fish population exposed to the gear can be estimated through the use of a non-selective gear, which catches all the fish that comes in contact. Otherwise various assumptions are made.

Selection length or 'L 50' is a term used to describe the fish length at which a particular gear allows 50 % of the fish to escape and 50% of the fish to be retained. Selection range is the difference in length between the fish that have a retention probability of 25 % and those fishes that have a retention probability of 75 %. Selection factor is an index related to escapement factor expressing the relation between the 50% point (the fish length at which a particular gear allows 50 % of the fish to escape) and the size of the mesh involved.

### *Selectivity Curves*

Selectivity is represented by a curve fitted to points representing the percentage of fish either retained by the gear or escaping from it at each interval against the fish length. Selection curves are often plotted against the ratio of the fish girth / mesh perimeter or fish length / mesh perimeter. Normally two common types of selection curves/ ogives are formed depending on the type of gear and type of selection: normal curve and sigmoid curve.

## *Normal curve*




Passive gears like gill nets generally have normal curves also known as bell shaped or symmetrical curve and can be described by a normal distribution

$$S(L) = \exp\left[-\frac{(L - Lm)^2}{2 \times s^2}\right]$$

where, S(L) = length based gear selectivity
L = length interval mid point
Lm = optimum length for being caught
s = standard deviation normal distribution

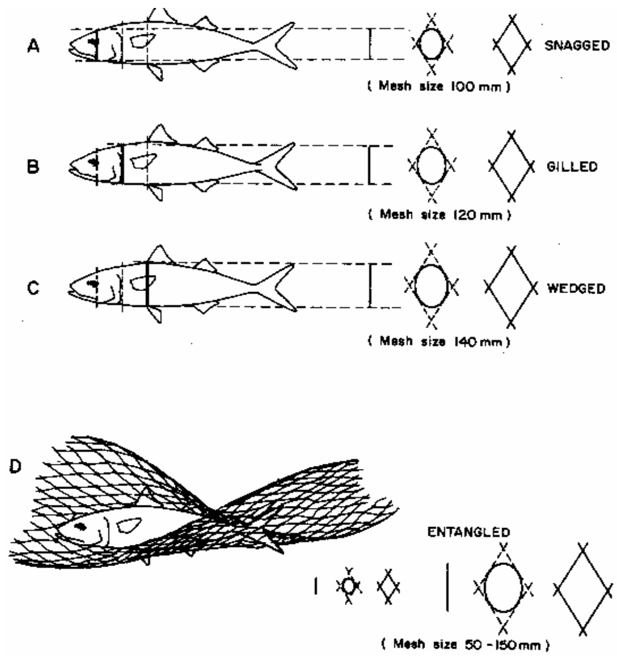
and can be analysed mathematically. Width of the curve represents the selection range and the height corresponds to optimum size of fish caught by the gear. In symmetrical curve, the ability to catch fish decreases equally on both sides.

## *Sigmoid curve*

In sigmoid curve also termed as asymmetrical curve or \`S' shaped curve the gear prevents escapement of larger ones but allow smaller ones to escape in relation to size ie. it catches increasingly more fish as the size increases. Selectivity of non-selective gear like trawl is generally represented by sigmoid curve.

# Selectivity in gill nets

Awareness of gill net selectivity existed as early as in 1882 but its scientific study started with Baranov (1914). Later, selectivity of gillnets received much attention in various parts of the world. A rule of thumb states that few fish are caught in a gill net whose length differs from the optimum by more than 20%. Baranov interpreted gill net capture as a mechanical process that depends only on the relative geometry of the mesh and the fish. Catching process in gill nets can be either by wedging, gilling or entangling.




For the first two, the selection curves are bell shaped and can be described by normal distribution. Capture by gilling, wedging and tangling are dependent on the shape of the particular species of fish encountered. Hence, gill nets are size and species selective. Gillnets are size and species selective. Tangling may be less dependent on mesh size and more dependent on other factors. This type of selection cannot be described by a normal curve. The combined selectivity curve for gilling, wedging and tangling would became a unimodel curve skewed to the right hand side. When fish capture is concentrated at two or more positions on the body, the selection curve may have two or more modes. The left slope of selection curve represents smaller fish wedged in the meshes; the right slope represents larger fish mainly tangled by head parts. Gillnet selection curves are broader and more skewed to the right when many fishes are tangled and may approach the normal curve when most fish are wedged. The mode of capture depends on form of body, material and hanging coefficient. Multimodel selectivity curves may be expected whenever capture is concentrated at body discontinues discontinuities such as maxillares or spines.

The size selectivity could be estimated by different ways. Mean selection length, selection factor and selection ranges are to be estimated using statistical techniques. Since, these factors vary according to the material used for webbing; such experiments are to be conducted periodically to update the information. Biological data in growth and maturity of the fish stocks are necessary to fix the required mesh size for each species. The size of fish at which maximum growth rate is registered and the size at first maturity are two factors are to be considered for fixing suitable mesh size in order to maintain the fishery in a steady state. If the mean selection length is just above these two lengths, then both recruitment and maximum growth potential of fish are taken care of, and fishing does not affect the stocks in any way.

## Factors influencing the selectivity of gill nets

Gill net selectivity is influenced by several factors; mesh size being the most important. Visibility of net material, stretchability of meshes, net construction, method of fishing, shape of the fish and pattern of behaviour of the fish are other factors determining gill net selectivity.

### *Mesh size*

Mesh size has been the greatest influence on selection process in gill nets. Owing to the decisive role played by mesh size in gill nets, selection occurs at both ends of the selection range as smaller fishes pass through the meshes without being caught and larger fishes will not be able to penetrate the meshes. The use of suitable mesh size in the gill net fishery is important as it creates a possibility of protecting the fish, which has not reached the minimum legal or commercial length. There is an optimum size at which a fish is most likely to be held, unable to escape. Fishes below and above this optimum size, but within the capture range are less likely to be captured. Gilling is a function of the head girth and wedging, a function of maximum girth of the fish as the smallest fish caught has a maximum girth and the largest fish caught has a head girth equal to the perimeter of the mesh.

### *Netting*

Other than mesh size, the most important characteristics of a gill net that affect selectivity are its visibility, stretchability of meshes, construction (mono or multi) and thickness and colour of the material. The elasticity and flexibility affect selectivity. Meshes of a more elastic twine can be stretched to a larger size by a struggling fish and generally an increased elasticity results in the capture of a larger average size of fish and a wide selection range. As the twine is made thinner, stretchability and flexibility increases.

### *Gear design*

Gear construction, hanging coefficient and rigging affect net behaviour in the water which in turn affect both the selectivity and the efficiency of fishing. Loosely hung nets allow more fish to become entangled. The headline and footropes and their relative magnitudes are important in ensuring that the net shape and fishing power are maintained irrespective of tide and current conditions.

### *Operational factors*

Selectivity can be affected by the way a net is fished. Location, depth of fishing and orientation of fishing gear affect the efficiency and hence the selectivity of the gear.

## Methods of measuring the selectivity

Gill net selectivity fits the broad definition of selectivity i.e. the ratio of the number of fish caught by the experimental net to the number of fish exposed to the gear for a given species and size of fish. The number of fish caught by the gear is readily known. But the number of fish expressed to the gear is not always so easily obtained. Various methods are used to determine gill net selectivity.

## *Direct estimates*

Compare size distribution of gill net catches with a known population i.e. the size distribution of the fish population. It can be grouped into two: fishing a known population and comparison with gear of known selectivity.

### *Fishing a known population*

If the size distribution of the sample population is known (by catching tagged fish) the proportion of fish caught in each size class can be used to estimate selectivity toward each size class.

$$\text{Selectivity} = \frac{\text{No. of fish caught}}{\text{No. of fish exposed to the gear (no. of fish in the population x fishing effort)}}$$

Since no assumptions are needed about the nature of the selectivity curve this method is very reliable but very expensive and difficult to put into practice. Mostly used to check on the validity of the assumptions utilized in other methods.

### *Comparison with a gear of known selectivity*

If the size distribution of the fish population is known, from fishing with a gear of known selectivity, selectivity can be estimated by comparing the catch of the experimental gear with the population estimate from the net of known selectivity (usually a non-selective gear such as trawl). It is based on the assumption that the catch of the non-selective gear catches all the fish encountered and fully reflects the size and species of the population.

## *Indirect estimates*

Compare size distribution of catches in gill nets of different mesh sizes, relying on suitable assumptions. Indirect estimates can be classified into two groups: using Type B curves as intermediaries and fitting a predetermined distribution

## *Using Type B curves as intermediaries*

The Type B selectivity curve (selectivity of different mesh sizes to one size class of fish) is plotted first and from them Type A curve (selectivity of one mesh size to different sizes of fish) is estimated. Type B curve is estimated by comparing the catch of one size class of fish from nets of several mesh sizes. The assumption is that all mesh sizes when fished with same effort are equally likely to be encountered by fish and thus the catches are proportional to the selectivity. Plotting the catches against the mesh sizes will generate a Type B curve for a given size class. This can be done for the other major size classes and all the curves so generated can be arranged to form a 3 dimensional display with selectivity presented as a function of both mesh size and fish length and the Type A curve is obtained by simple solutions. Baranov (1948) gave a method of estimating modes of selectivity curves of from the comparison of catches of by two mesh sizes. The length frequency distribution of catch obtained in two gill nets, of different mesh bar $a_1$ and $a_2$, fished simultaneously may be prepared and the frequency curve corresponding to these can be drawn on a single graph.

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

$$k = \frac{2a_1a_2}{lo(a1+a2)}$$

This method is the most popular because it utilizes easily available data.

## *Fitting a pre-determined distribution*

Using a priori model of the selectivity curves, Type A curve is estimated algebraically from catch data without plotting intermediate type B curves. Only normal curves can be estimated to the correct accuracy using this method. By comparing the catches from two or more gill nets, each of which has a slightly different mesh size but fished with the same effort. Holt (1963) introduced a method, which has since been the most popular way of fitting gill net selectivity curves. Holt compared the catches $C_1j$ and $C_2j$ in two slightly different mesh sizes $m_1$ $m_2$ assuming that (i) the selection curves for both mesh sizes are normal, (ii) have the same variance and (iii) The modes $l_1$ and $l_2$ of the selectivity curves are proportional to the mesh sizes. Two nets are used to fish in the same areas at the same time. Observation are number of fish caught and length group. Natural logarithms of ratio of catches in numbers for two nets with slightly different mesh sizes having overlapping selection gives are linearly related to fish lengths.

For gilling and wedging the selection curves are bell shaped and can be described by the normal distribution. Thus

$$S (L) = \exp [- (L – Lm)^2/2s^2]$$

Where S (L) is the length based gear selectivity, L is length interval midpoint, Lm is the optimum length for being caught and s is the standard deviation of the normal distribution.

The procedure involves calculation of the proportions between the number of fish of a particular length retained in gill nets of different mesh sizes:

$$\frac{\text{Cb = no. of fish of length l in a net with larger mesh size (m2)}}{\text{Ca = no. of fish of same length l in a net with smaller mesh size (m1)}}$$

Calculation of log ratios for successive fish lengths

$$Y = \ln (Cb/Ca)$$

Regression analysis of the log ratios against the interval midpoint and expressed as

$$Y = \ln (Cb/Ca) = a + bL$$

Where Y is the natural logarithm of ratio of catches, L is the mid point of the length class, and a and b are constants.

The selection factor (SF) is calculated as

$$SF= (-2a)/ [b (m_1 + m_2)]$$

where $m_1$ and $m_2$ are the mesh size of two gill nets with slightly different mesh size

The optimum selection lengths ($L_1$ and $L_2$) in the two gillnets are calculated from the following equations:

$$L_1 = SF \times m_{1;} \quad \text{and} \quad L_2 = SF \times m_2$$

The standard deviation (S) of each probability function is calculated as follows:

$$S = (L_2 - L_1)^{0.5} / b$$

Using the values for L1, L2 and S, the probability (P1) of capture for a given length L in a gill net having a mesh size m1 can be calculated

$$P_1 = \exp [-(L - L_1)^2 / (2S^2)]$$

Similarly the probability of capture ($P_2$) for the mesh size $m_2$ was calculated as

$$P_2 = \exp [-(L - L_1)^2 / (2S^2)]$$

The curves are drawn using probability of capture against each length class. When more than two mesh sizes are fished together estimates are obtained from each pair of successive mesh sizes.

## *Estimating gill net selection by inference form girth measurements*

Model lengths are estimated from girth measurements. Assumption is that to be gilled or wedged, a fish must be able to pass through the mesh beyond its gill covers but only as far as its maximum girth will allow. The comparison of fish body and stretching of mesh as the fish struggles to escape also have to be considered.

By measuring head girth and maximum girth for a given mesh size and species of fish, selectivity can be modelled. Peak of the selectivity curve can be estimated roughly according to the principle that the girths of the most efficiently caught fish are proportional to the mesh size.

Maximum girth = k x mesh perimeter,

where the modal girth / mesh perimeter ratio `k' is a constant. It is estimated that that the value of k is near 1.25 with a range of 1.08 – 1.35.

Modal lengths of fish caught are estimated from the girths. The modal length is that length at which the maximum girth is 1.25 times the mesh perimeter. Alternatively it is that length at which the mesh perimeter equals the average of the head an maximum girth. If it is assumed that girth is proportional to length selection factor can be estimated from girth measurements.

## *Mortality Estimates*

Any method of estimating fishing mortality can also estimate selectivity if the calculations are done separately for each size class of fish. Like direct estimates, mortality estimates can estimate heights as well as shape of selectivity curves. They require no assumptions about the nature of the selectivity curves, but rely on assuming that catchability remains constant during the sampling. The disadvantages are the difficulty of obtaining adequate samples and satisfying the assumption of constant catchability.

# References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