EXPLORATORY SURVEY FOR BIOMASS ESTIMATION

T. V. Sathianandan, Grinson George and Somy Kuriakose
Fishery Resources Assessment Division
ICAR-Central Marine Fisheries Research Institute

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Introduction

Bottom trawl surveys are widely used for monitoring demersal stocks when a simple index of abundance is required for scientific and related work. From unfished stocks (or stocks for which no or few data on the fishery are available), preferably the unexploited stocks, biomass and annual yield estimates may also be derived by undertaking bottom trawl surveys. The estimation of total biomass from the catch per unit of effort (or unit area) using a trawl survey, however, involves several crucial assumptions, leaving such estimates rather imprecise. But we can resort to this method when we require an immediate input to be generated and the methodology is less time consuming and easy to carry out.

Various studies have reported that the mean catch (either in weight or in numbers) per unit of effort or per unit of area is an index of the stock abundance (i.e. assumed to be proportional to the abundance). This simple index may be converted into an absolute measure of biomass using the so-called "swept area method" which is followed universally in all trawl survey methods. This method falls under the so-called holistic methods of assessing fish stock abundance.

Various theories were propounded as we trace back the research related to trawl survey stock assessment and the prominent among them are that of the Gulland (1975), Saville (1977), Troadec (1980), Doubleday (1980) and Grosslein and Laurec (1982). These reviews also give guidelines for conduct of trawl surveys (planning, design, data collection, data recording, analysis and reporting), and the steps followed can be referred in Butler et al. (1986), ICOD (1991) and Strømme (1992).For more detailed descriptions of these subjects the reader is referred to, among others, Alverson and Pereyra (1969), Alverson (1971), Mackett (1973), FAO/UNDP (1975), Gulland (1975), Saville (1977), Flowers (1978), Doubleday (1981), Grosslein and Laurec (1982) and Fogarty (1985).

Structure of a Bottom Trawl

The bottom trawl (Fig. 1) is a conical bag netwith a wide opening mouth fitted with weights (sinkers) on the ground-rope and floats on the head-rope. When the vessel is under taking a trawl operation, the net is kept open by two otter boards (wooden or iron structures) which are towed the help of warps attached forward in their centre so they tend to diverge. The towing is done with the mechanical power of an engine in the vessel. The two otter boards are connected to the net by bridles. These may be up to 200 m long and sweep the sea bed over a wide area depending upon the size of the gear used in the operation. They frighten the fish towards the advancing net (a behavioral advantage utilized by the trawl operators) and so increase its effectiveness. The shape, size and mesh of the trawl gear used varies depending on the variety of fish targeted and on the type of the trawling ground. The ground-rope may be fitted with roller gear (bobbins) so that the trawl can be used on stony bottom (rough bottoms) without being damaged. The tail end of the gear from which the captured fish are removed is called the "codend". This is where most of the size selection takes place. In most cases a relatively small mesh size is required in the codend, in order to obtain a representative sample for the entire size range of the species under investigation.

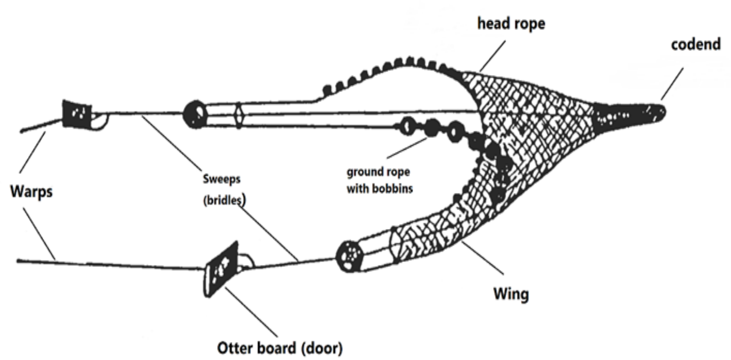


Fig. 1. Structure of bottom trawl

Exploratory Survey for Biomass Estimation

Estimates of biomass and annual yield can be derived from bottom trawl surveys, especially for monitoring demersal fish stocks. But the estimation of total biomass from this based on catch per unit effort estimates involves some crucial assumptions. The mean catch per unit area is an index of the stock abundance. This is on the assumption that it is proportional to the abundance. Using swept area method this index of stock abundance can be converted into an absolute measure of biomass.

The objectives of bottom trawl survey are:

- Estimation of the total biomass and catch rates.
- Estimation of biomass of selected species.
- Collection of biological data such as length frequency data for estimation of growth and mortality parameters.
- Collection of environmental data.

The bottom trawl is a conical net bag with wide mouth fitted with weights on the ground rope and floats on the head rope. The net is kept open by tow otter boards which are wooden or iron structures towed by the warps attached forward of their centre so that they tend to diverge. These may be very long and sweep the sea bed over a wide area. They frighten the fish towards the advancing net and increases its effectiveness. The shape of the net varies depending on the kinds of fish targeted and the types of bottom. The ground rope is fitted with roller gear so that the trawl can be used on stony bottom without any damage. The tail end of the gear from which the captured fish are removed is called the codend where most of the size selection takes place. In order to obtain a representative sample of all the size ranges of the species the mesh size should be relatively small at the codend.

For estimation of stock sizes a completely randomized design or a stratified random sampling design is preferred and in most cases stratified sampling design is preferred. Strata are constructed in accordance with the density distribution of the fish so that areas with high/ medium/low densities are separated. For stratification some prior information is required which is obtained in a first survey following simple random sampling design and the variability obtained is used for stratification. The distribution of hauls within strata should be random taking into account the practical difficulties. The number of hauls possible in a given period can be calculated as:

Number of hauls per day = T / (t2+t3+t4)

where T is the number of hours available per day, t2 is the duration of one haul, t3 is the time used for shooting and hauling the trawl and t4 is the average time taken to cover distance between stations. It is important to standardize the length of the haul throughout the survey, since the catchability of species and sizes often depends on the duration of haul. Following are the important points to be remembered while recording data from a trawl survey:

- The objective of the survey determines the data items to be recorded, e.g. biomass estimation, length frequency analysis, mortality estimation.
- Data items include specification of gear, haul duration, position at start and end of haul, wire length, wing spread, bottom type, depth, etc.
- Catch record should include total weight, species composition, length frequencies for selected species.
- Data should be well organized to facilitate processing.
- There should be a log summarizing the whole cruise.
- There should be fishing log that provides information on vessel's position, time of start, end of haul gear rigging, etc. Summary information on catch should also be recorded in the fishing log.
- Detailed information on catch in terms of length, weight, sex, maturity stage, etc. for each specimen should be recorded along with length frequency distributions.

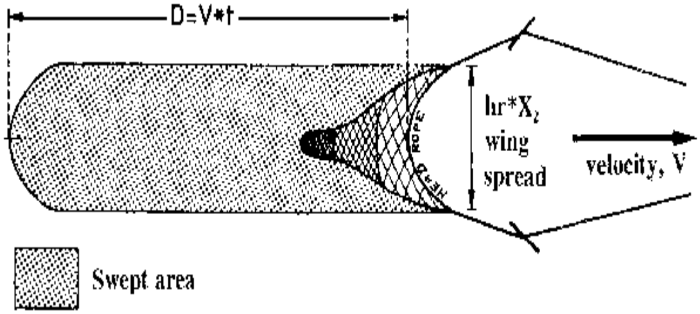
Swept Area Method

From Fig. 13.5.1, Trawl sweeps a well defined path, the area of which is the length of the path times the width of the trawl which $D = v \times t$ is called the swept area. It is estimated as:

$a = D \times h \times X_2$

Where, 'v' is the velocity of the trawl over the ground when trawling, 'h' is the length of the head-rope, 't' is the time spent for trawling and X_2 is the fraction of the head-rope length, 'h', which is equal to the width of the path swept by the trawl and the wing spread is $h \times X_2$. Different values of X_2 in use are 0.4 to 0.6 for Southeast Asian bottom trawls, 0.5 as a compromise suggested by Pauly and 0.6 in the Caribbean suggested by Klima. Catch per unit area estimated by dividing the catch by the swept area is used for the estimation of biomass. When exact positions of the start and end of the haul are available, the distance covered in nautical miles is estimated as:

$$D = 60 * \sqrt{(Lat1 - Lat2)^2 + (Lon1 - Lon2)^2 * Cos^2(0.5(Lat1 - Lat2))}$$



where Lat1, Lat2 are the latitude at start and end of haul in degrees, Lon1,Lon2 are longitude at start and end of the haul in degrees. When the velocity of the vessel and its course together with direction and speed of the current are available, then the distance covered per hour is calculated as:

$$D = \sqrt{VS^2 + CS^2 + 2VS * CS * Cos(dirV - dirC)}$$

where VS is the velocity of the vessel in knots (nautical miles per hour), CS is the velocity of current in knots, *dirV* is the course of vessel in degrees and *dirC* is the direction of current in degrees.

If cw is the catch in weight of a haul and 't' the time spent in hauling (in hours), the cw/t is the catch in weight per hour. If 'a' is the swept area then a/t is the swept area per hour. Then the catch per unit of area is obtained as:

$$CPUA = \frac{cw/t}{a/t} = \frac{cw}{a}\ kg/nm^2$$

If X_1 is the fraction of the biomass in the effective path swept by trawl, which is actually retained in the gear and cw / a is the mean catch per unit area of all hauls, then an estimate of the average biomass per unit area is:

$$\bar{b} = \frac{\left(\overline{cw/a}\right)}{X1}\ kg/nm^2$$

Let Anm^2 be the total area under investigation, then the estimate of total biomass for this area is obtained as:

$$B = \frac{\left(\overline{cw}/a\right)^{A}}{X1}\ kg$$

An example of biomass estimate from commercial trawl data off Saurashtra coast in western India is given here. A trawler (overall length: 17.5 m) conducted fishery survey during 1985-1989. During the 5-year period, the survey was conducted in eighty-eight 10′ squares between the latitude zones 20°N and 70°E (off Veraval) and 23°N 68°E (off Jakhau) at depth range of 12 to 70 m. The area of each 10′ square in the survey area was considered as 326.6 km^2.

The total area considered (A) for the survey was estimated as (326.6 * 88) 28,740.8 km^2. The area swept (a) by the gear during one hour of trawling was calculated considering the trawling speed (v) as 2.5 knots/h (= 4.3 km/h), the headrope length (h) of the trawlnet as 24 m, and X2 as 0.5. The area swept was calculated as 0.052 km^2/h for the entire period of the survey.

The biomass was calculated by pooling the catch from each 10′ square during the 5-year period. The total catch was 205.2 t and the CPUE was 43.9 kg/h.

Biomass = (43.9 * 28740.8)/(0.052 * 0.5) = 48528 t

Density = Biomass/Area considered

= 48528 / 28740.8 = 1.688 t/km^2.

Precision of the estimate of biomass in the swept area method can be achieved by increasing the number of hauls. Another way of increasing precision is to apply stratified sampling by considering depth and bottom type. Suitable stratification may improve precision for the same number of hauls.

However, estimation of biomass and density from the CPUE involves several crucial assumptions, such as (i) the CPUE is proportional to the biomass abundance, and (ii) the proportion of detainment in gear, etc. It has been observed that for some stocks, the observed CPUE is only related to stock size, and in such cases, there may be no CPUE data that are satisfactory. For example, the CPUE from purseseine fisheries for shoaling pelagics may lead to erroneous estimates. For pelagic trawling, avoidance can be very great. Moreover, survey by any gear provides an estimate of only the target stocks of that gear and not the totalbiomass of the considered area. Due to this reason, the biomass is usually underestimated by the swept area method. This method has its main application to gears hauling non-selectively along the seabed.

For a meaningful estimate, surveys have to be conducted for several weeks every year, for which the estimation cost could be high.

Suggested Reading

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