CHAPTER II

REVIEW OF LITERATURE
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The Set Bag net (SBN) locally called as “Behundi jal”, fishery of West Bengal is one of the most important traditional fisheries and a large population of small-scale fisher folk has been dependent on it for a long time. The set bag net is fixed tapering net, resembling a trawl net, set in the tidal streams of estuary as well as in open sea.

Except the operational techniques, the design, construction and rigging of set bag net are similar to the trawl net design, construction and rigging (Akerman, 1986). The available literatures pertaining to general design aspects, fish behaviour to gears, species and size selectivity and their influences on mesh size and mesh shape as well as catching efficiency related to the tapering and trawl gears are reviewed in this chapter.

2.1. GENERAL DESIGN ASPECTS

Designing fishing gear is the process of preparing technical specifications and drawings for the fishing gear, which meets operational benefits and satisfies gear (Fridman, 1986).
The key to successful development of selective gear designs is the understanding the behaviour of the individual species to various environmental stimuli (Watson, 1989). Buckingham (1972) stated that the factors to be considered while designing a gear include engine power of vessel, length of belly, head line height, mesh size and its shape, netting material used and the overall resistance.

Lonnevik (1989) stated that the hanging ratio of netting affects the overall shape, vertical and horizontal openings, stability, and damage on all netting. Adoption of standard design and modern fabrication methods in anchored bag net results in better catchability. (Kunjipalu. et al., 1993).

Some of characteristics of netting and twine material have significant hydrodynamic, behavioral and mechanical effects on selectivity of gear (Ferro and Neill, 1994). The major factors influencing on the fish catch is its vertical opening of the net (Takayama and Koyam 1959, and Parrish 1959). In a known fishing ground the quantity of fish caught by trawl gear has direct bearing on the volume of water filtered during a certain period of operation and depends on the both horizontal and vertical opening of the net while in operation condition
(Deshpande, 1960). The catch of stake net (bag net) is highly influenced by the lunar cycle, the season and the design. (Hridayanathan and Hameed 1990). The braided polyester netting and the new generation, spectra fiber ropes for trawls given superior strength and abrasion resistance with very low elongation (Stone, 1989).

2.2 FISH BEHAVIOUR WITH RESPECT TO GEARS

Knowledge of fish behaviour and it’s reaction to fishing gear forms the basis for the development of the efficient gears, the energy efficient fishing methods with good selectivity. (Anon 1980). The need to understand the fish reaction to gear for the development of efficient gear has been stressed by Parrish and Blaxter (1963) and Fridman (1969).

Chikimasa (1964) and Garner (1967) stated that pressure build up inside a tapering gear could have a frightening effect on fish. Arimoto et.al., (1989) have observed, with the help of underwater cameras fish reach more near the net mouth and near the throat part of the net. Fridman (1986) noticed that the swimming speed of fish, to large extent, determines the required operation speed and gear size. Dickson (1959) reported the most commonly observed reaction of fish is to swim perpendicular to
moving wire rope. Suueronen (1989) observed that avoidance and escapement of herring (*Clupea harengus*) dependent on the swimming patterns of this fish during trawl operation.

Sreekrishna (1995) reported that mullets and to some extent are known to have the habits of jumping out of water when encountered with obstacles and when disturbed and the flying fish, pomfrets and sardines are known to take shelter around the bundles of vegetation for breeding. Main and Sangster (1983) compared heavy rigged trawl with light rigged trawl and observed the reaction of fish to the trawls. Haddock, saithe and mackerel were found to swim straight to light rigged trawl while they turned away from the path much ahead of heavily rigged trawl. Goeden *et al.* (1990) observed in large low tanks through video that 65% of prawns escaped under net because their escape jumps were not higher than the footrope or because they did not jumps at all.

Main and Sangster (1981) stated that behavioural studies can be best observed by divers than the photographic or video cameras due to their limited vision. Amos (1984b) reported the use of vertical echo sounders and sector scanning to monitor the action acoustically tagged fish. Ona *et al.*, (1989) reported
that high frequency scanning sonar could be used to study the fish behaviour to trawls. Turbidity of water and the visibility have great effect on fish behaviour to the gear and its selectivity (Wardle, 1989).

Glass et al., (1993) were observed that the fish reacts more in small mesh narrowing funnel netting keep clear off the large mesh netting panels.

2.3. SIZE SELECTIVITY

Selectivity can be considered as the factors that causes the size composition of the catch to be different from that of the population or that causes fishing mortality to vary with size of the fish (Pope et al., 1975). The size and shape of codend meshes are main factors, which determine its selectivity (Pope 1966). Mesh size and gear operation pattern are the factors, which affect size selectivity (Karlsen, 1985). Reeves et al., (1992) and Galbraith et al. (1994) noticed that the mesh size and codend diameter had a greater influence on selectivity. The chief area of size selection of P. borealis was the codend; negligible loss occurred through wing and belly (Nilssen and Larsen, 1986a).
As early 1910 fishing experiment was to study the relative escapement of fish from codends (Todd 1911). The use of large mesh sizes to reduce juvenile catch was recommended by the International Council for the Exploration of the sea (ICES) for the fisheries of Northern Europe (Great Britain Parliament 1933). FAO recommended that to catch fish of certain size, the selection of mesh size should be such that it retains half of the fish of critical size (FAO, 1968). Panicker and Sivan (1965) suggested an increase in codend mesh size to capture larger shrimps and to reduce depletion of bottom fauna. Alagaraja et al., (1986) noticed that instance of heavy landings of undersized prawns along the coast of Kerala due to the use of small mesh trawls.

International Council for Exploration of Sea (ICES) has recommended an increase in the mesh size from 105 mm to 120 mm for the cod (Gadus morhua) fishery in the Baltic Sea (Lowry et. al., 1994). The larger mesh size (40 mm) in codend of dolnet (Bag net) has an adverse effect on the catch of secondary species like non-penaeid prawns and total catch (Kunjipalu et al., 1993). George et. al.,(1974) suggested suitable mesh size for the codend of the stake nets. Valdemassen (1989) showed that size selectivity of shrimp (Sandalus borealis) has little affects
due to increased mesh sizes in codend. Armstrong et al., (1990) observed the fewer small fishes to be retained in codends increased of large mesh size. Lehman et al., (1993) reported significant reduction of small shrimp in 60 mm mesh codend than codend with mesh size of 45 mm. Kunjipalu et al., (1993) found that the mesh size of the Bombay duck catch was consistently better in experimental bagnet with 30 mm and 40 mm codend meshes.

Swan (1989) stated that, the very large meshes (up to 25.6m) in trawls are seen to be effective in herring fish and very large catches may be taken when fishes are light in weight, i.e., buoyant with high oil content. Lhomme (1978) compared the results of prawn catches of trawls of different mesh sizes in the body of the net and found that average size of shrimp caught in 80 mm size was greater than 60 mm size.

The larger size shrimp would be caught only if a much larger mesh size were adopted and the immediate effects would be loss which could not be economically endure (Lindner, 1966). After an under water observation of haddock trawling, Serebrove (1989) concluded that increasing mesh size cannot be an effective method of protecting young fish, since the
hydrodynamic conditions of catch formation traumatize a considerable part of the fish of any size. Fujishi (1974) discussed the difficulties in developing a criterion for mesh size of gears engaged in multi species fishery. Hoidal et al., (1982) presented a model using "Von Bertalanffy and Beverlon and Holt equation" to estimate effective mesh sizes and suggested that this model can be used to estimate the stock.

Fridman (1986) defined the selection factor as the ratio of fish length to mesh lumen length at which 50% of the fish escape and 50% do not. Goni (1985) found out that, increase in mesh size has increased the selection factor in selectivity experiments for European hake and rose shrimp. The selection factors of 0.85 and 0.84 were estimated for the two species of sepiidae (Pereira 1993). The selection factor for the 34 mm mesh codend for species of Cypris was in the range of 2.80 to 3.75 (Livadas, 1989).

Walsh et al., (1989) found that, selection factors were higher for American plaice (*Hippoglossoides platessoides*) in diamond mesh codend. The 50% retention lengths for *Penaeus semisulcatus* were 1.96 cm and 2.27 cm for 30 mm and 40 mm codend of high opening bottom trawl respectively (Siddeck
1986). Under water observation conducted by Stewart and Robertson (1985a) showed that covered codend causes obstruction of fish escape. Vooren (1985) compared the selection factors and escapement with respect to different mesh sizes for three different species namely castanha (*Umbrina canosa*), Pescada (*Cynoscion strialus*) and Pescadinha (*Macroden anaylodon*) by means of regression analysis.

Polet and Redant (1994) noticed that the 90 mm mesh size codend is less selective for Nephrops and Whitings. Hickey *et al.*, (1993a) found that 155 mm diamond mesh codend produces better selection for Atlantic cod (*Gadus marhua*). The simple way to improve size selectivity in existing trawl is to shorten the lace rope in the codend that catches fewer small fishes (Jacobson 1991). A codend of 135 mm meshes with lastrigde ropes has a selectivity comparable to a 150 mm conventional codend [Isaksen and Valdemarson, 1990. Armstrong *et al.*, (1989) noticed that the length of the extension piece and codend diameter also influence codend selectivity.

Matsushita Yoshiki *et al.*, (1996) have suggested that the overlapped meshes decrease the mesh area, resulting in the low efficiency of mesh selection.
2.3.1. Influence of square mesh on size selectivity

Mesh shape also influences the gear design parameters in the same way as mesh sizes. Several scientists have worked on trawls with different mesh shapes and studied their influence on selectivity. Fish size selectivity is related not only to the mesh size of codend but also to the shape of the mesh as determined by rigging of the codend webbing (Robertson 1982, Robertson and Stewart, 1988, Casey and Warnes 1987).

Robertson (1983) compared fish escape rates of square mesh and diamond mesh codends and concluded that square mesh codends had higher escape rates of juveniles because of larger mesh opening and caused less damage to fish. Isaksen and Larsen (1988) found that square mesh codends gave improved selectivity for cod and haddock and considerable reduction of undersized fish.

Cooper and Hickey (1987) observed the reduction of haddock and cod by about 25% in square mesh codend while comparing to that of diamond mesh codend and observed higher value of 50% retention length ($L_{50}$) of the fish. Averill and Carr (1987) indicated that square mesh sections in trawl not only
improves the catch rates but also reduce the discard rates. Larsen et. al., (1988) compared the proportion of undersized cod caught by 95mm square mesh codend with that of diamond mesh codend. Diamond mesh seems to catch 48% more of undersized fish in terms of number and 10.4% by weight.

Robertson (1986a) discussed the design and construction of square mesh codends. Robertson (1986b) in another experiment concluded that because of low selection ranges of square mesh codend. Robertson and Stewart (1988) found that $L_{50}$ values for square mesh codends were larger than for diamond mesh codend of same mesh size for whitings. Thorsteinsson (1989) noticed that the drastic reduction of 0 group of fish and catch of undersized shrimps to a great extent in square mesh netting. Suuronen (1990) compared the size selectivity of 36 mm square mesh codend with that of diamond mesh codend of same mesh size and concluded that square mesh codend will have a sharper selectivity and will retain fewer juveniles of herring (*Clupia harengus*).

Square mesh netting provides an adequate escape route for all undersized fishes before they are trapped in the codend (Sterling 1991). Whitings have better escapement from the net.
with the square panel than from the conventional diamond net (Briggs, 1991 and Moth-Poulse, 1994). The conventional codend retained all sizes of fish and 135 mm and 110 mm knotless square mesh codends had a tendency to free small fish of walleys Pollack (*Theragra chalcogramma*) (Matsushita et. al., 1993). The mean selection lengths with respect to *Sarida tumbil* and *Dussumieria acuta* were greater in 30 mm square mesh codend than in diamond mesh codend (Kunjipalu et al., 1994).

Amos (1984a) suggested that square mesh in throat would be useful in allowing small and unwanted fish to escape from the trawl. Hillis et al., (1991) inserted square mesh panels on the front part of the codend and observed that the substantial reduction in both undersized and commercial sized whitings. Briggs (1992) observed in the Irish sea Nephrops fishery that, the square mesh codend in Nephrops trawl yielded very good escapement of whitings than the conventional all diamond net and thus could be used as conservation tool in whiting fishery. Ulmestrand and Lareson (1991) tested with 70 mm square mesh window in the top panel of a Nephrops Trawl and noticed the significance difference in the size of whiting (*Micromesistius poutassou*). Robertson and Shanks (1994) observed the significant increase in the escape of juveniles of haddock and
whiting in Nephrops trawls with 80 mm square mesh window on top panel and 70 mm square mesh codend and extension. Kunjipalu and Varghese (1989) have suggested that square mesh codend in demersal trawls could be used as a tool for conservation and management of fishery resources.

Wray (1990b) concluded that, hexagonal meshes have better let through characteristics of undersized fish than diamond meshes in the body of trawl. Suuronen et. al, (1991a) observed that the 50% retention length for the hexagonal mesh codend was considerably smaller for herring.

2.4. SPECIES SELECTIVITY

Isaken et. al., (1992) said that a new concept of separator panel, and grid installation was developed in Norway in order to have species selectivity by avoiding the by-catch of fish in a shrimp trawl. Design of trawl with separator panel terminating into two codends for dual purpose of fish conservation and effective separation of catch was discussed by Wray (1990a). He also reported that effective separation of fishes could be attained based on their behaviour, while the fish conservation could be effected by using large mesh in one of the codends or through escape catches. Main and Sangster (1982) noticed the
separation of finfish from shellfish in trawl having a horizontal separator panel. William (1983) found that successful separation of prawns from red fish in Canadian separator trawl by allowing the juveniles of red fish to escape. Chuck and Seidel (1984) found that the fish deflector has the ability to reduce the by catch of jellyfish and finfish.

Anon (1985) has reported effective separation of prawns and whitings by using horizontal separating panel in trawl. Main and Sangster (1985) rerigged the conventional fish or shrimp trawl with a horizontal separating panel dividing the codend into two compartments and were able to minimize the undersized gadoid by-catch. Main and Sangster (1986) made underwater observations and indicated that the entry height of fishes into the trawl mouth differs from species to species and it is possible to have species separation by adjusting the height of separator panel. They also concluded that the smaller fishes could be released by keeping top codend open or providing with large mesh. Friis and Yngvessen (1987) reported on the design and operation of a separation trawl used in Denmark. Hillis et al., (1988 and 1989) investigated vertical separation of whitings and Nephrops by two separator trawls, and found Nephrops in lower codend. Ashok and Sheshappa (1989) in their study on
separator trawl experiment have observed total separation of crustaceans into the lower codend of trawl.

Moth-Poulsen (1994) has developed a trawl with separator panel into two compartments and found that upper compartment had gainful of whitings. Among the horizontal separator panels, the square mesh panel and grid in trawls, the horizontal separation panel had less separation effect (Wileman et. al., 1994).

Nasution et. al., (1982) have reported the trawl equipped with “By-catch Excluder Device” (BED) caught 63.92% less by-catch than the standard trawl. Sujastani (1984) reported that “By-catch Excluder Device” in shrimp trawls reduced the catch of unwanted fishes and can be helpful for conservation of fishery resources. Monintja and Sudjastani (1985) revealed that the implementation of BED on the standard commercial trawl shrimps had a by-catch reduction of 42.5%. Finfish excluder device installed in the codend of a shrimp trawl is reported to be very efficient in decreasing the by-catch of finfish (Anon 1990).

Olsen (1990) reported that the ‘shrimp grid’ developed at Norway is very effective in reducing by-catch. Valdemarsen
(1990) could reduce juvenile by-catch of haddock in shrimp trawl by providing the codend with grid made of parallel bars. Wray (1990c) reported about the successful operation of Norwegian grid device “Troll X” which could release juveniles and undersized fish from trawl. Hickey et al., (1993b) have developed a shrimp trawl rigged with excluder device with different Nardmore Grates having 22 mm, 25 mm and 28 mm bar spacing and 43 mm square mesh codend and by-catch reduction of 60-90% depending on species.

Marlen et al., (1994) made observation of large pelagic trawls through 'RCTV', and found that codend cover can have significant effect on the escapement behaviour of fish. Rulifson et al., (1992) showed the effectiveness of by-catch reduction devices (BRDS) in South Atlantic Coastal waters when compared to the unmodified nets. Matsuoka et al., (1991) carried a series of experimental prawn trawling tests with a simple Trawl Efficiency Devices (TED) and observed slightly reduction in the catch of prawn. Brewer et al., (1995) tested a trawl with by-catch reduction device called “Fish-Eye” and a square mesh window and observed higher prawn yield with reduced by-catch.
2.5. CATCHING EFFICIENCY

Catching efficiency of the gear is influenced by its design, mesh size, and mesh shape and other operational techniques. However, mesh size and mesh shape can be chosen so as to bring about a compromise between the conservation measures and catching efficiency.

2.5.1. Influence of mesh size and mesh shape

Large meshes in gear have a good guiding effect, but when fishing close to bottom. Big meshes do not appear to have the same guiding effect (Anon 1980). Lan (1989) reported from his experiment conducted in east China that, large meshed trawl had a higher mouth opening and higher catch than the conventional trawl. Pinhorn (1970) has opined that, even through there will be immediate losses in the use of large mesh size, it will lead to potential benefit in the subsequent years.

Lower average catch was obtained in large mesh during a comparative experiment (Claesson 1986). Nilssen and Larsen (1986b) compared catching efficiency of 20 mm codend mesh with and without fine meshed cover for lobster fishing. The net with fine meshed cover retained about 27 times more catch of lobster than the other one.
Naidu et al., (1987) have reported the effect of the variation in the mesh size on the catching efficiency of trawl. Chen et al., (1987) compared the percentage retention of shrimps in different mesh size codends by covered codend experiment. Fujishi (1985) also reported increased catch rate from a six-panel high opening bottom trawl with large meshes in the frontal body.


Siddeck (1989) reported that, the new fish-cum-shrimp trawl with large mesh size performed better by bringing a
slightly larger amount of shrimp and a greater quantity of fish. Vijayan et. al.,(1990) observed 31.5% higher catch of shrimp and 37% more revenue using the improved gear in traditional motorized craft. Suuronen et. al.,(1991) observed that, in pelagic herring trawling, large numbers of juvenile herring were caught with 32 mm diamond mesh codend. Nayak (1991) investigated the effect of large meshes in the body of the newly developed four seam bottom trawl (NLMT) and found that, the average catch was about 37% higher in NLMT than that of HOBT. Vijayan et. al.,(1992) has got 29.6% increased fish catch in rectangular trawl with larger meshes in forward parts.

Lehmann et. al.,(1993) compared the catch results in 60 mm and 45 mm mesh sized codends and found that, 60 mm size codend yielded 40-50% reduction of small shrimp and 15-30 % reduction of large shrimps. Lowery et. al., (1994) found that, the catch of cod was reduced by approximately 40% in 120 mm mesh sized codend and total catch value was reduced by approximately 35%, when compared to the reference net having 105 mm in the codend.

Mouth-Poulsen (1994) in his study on the selectivity of whiting trawl observed the whiting gaining access to upper
codend while the cod in the bottom codend. An average separation of 50% of the whiting in the top codend was accompanied by only 19% of the haddock and the catch of number of unmarketable fish as a means of decreasing by-catch was reduced from 53.4% to 16.7% without reducing the catch of the main target species and small shrimps in Seto Sea of Japan (Tokai et al., 1994).

Fonteyne et al., (1992) suggested that, application of square mesh may reduce the catch of small round fish. Broadhurst et al., (1994) reported while comparing the catch of the gear with conventional codend that, the catch of the trawl with codend made entirely of square meshes shown a 52% reduction in the mean weight of prawns caught and a 95% reduction in the number of nulloway caught.