Chapter 10

Purse Seines and their Operation

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10.1 Introduction

Purse seining is one of the most aggressive, efficient and advanced fishing methods. It is aimed mainly at catching dense, mobile schools of pelagic fish and includes all the elements of searching, hunting and capture. The schools of fish are surrounded and impounded by means of large surrounding net. A purse seine is made of a long wall of netting framed with float line and lead line and having purse rings hanging from the lower edge of the gear, through which runs a purse line made from steel wire or rope which allow the pursing of the net (Nedlec, 1982; Brandt, 1984). Thus a bowl like space is created in which the fishes are enclosed and prevented from escaping. Modern purse seines were introduced in commercial fisheries more than a hundred years ago (Skogsberg, 1923). Description of the purse seines and their operation have been given by Ben-Yami (1974; 1987; 1994), Masthawee (1986), Sainsbury (1996), Hameed and Boopendranath (2000) and others. Advances in purse seining were supported by the introduction of high tenacity synthetic twines of high specific gravity, improvements in vessel technology and gear handling equipment such as puretic power block, fish aggregation techniques, acoustic fish detection and remote sensing techniques (Traung, 1955; 1960; 1967; Kristjonsson, 1959; 1964; 1971; Fyson, 1986; Ben-Yami, 1994 and Hameed and Boopendranath, 2000).

10.2 Evolution of purse seines

The purse seines were evolved from beach seines and lampara nets. Beach seines have been used through the ages almost all over the world. They are usually deeper than the depth of the water. The top edge is framed with a float line and lower edge with a lead line. It is set in a semi-circle at some distance from the shore and then hauled ashore onto the beach using long ropes. During hauling, the beach seine filters the enclosed waters from the surface to the bottom. As soon as the wing tips come within the reach of the fishermen they bring the lead line of both wings together in order to gather the fish towards the centre. The bunt part with the catch inside is the last part to be brought ashore. In purse seines, a pursing arrangement is incorporated in order to close the net at the bottom after surrounding a shoal of fish. This facilitated the operation of net in deeper waters.

In some parts of the world, purse seining produces the largest single catches of pelagic fishes. Purse seine fishery for tuna is carried out over a far greater geographical area. Purse seines are also used to catch the demersal fish such as cod by modifying its design to operate close to the bottom. However, the major contributor to the purse seine fisheries of the world is the vast number of smaller vessels landing small pelagic species. A conservative estimate of percentage of the world catch caught by surrounding nets fisheries would be 25 to 30 % of the world catch. (Ben-Yami, 1994).

Sardine and mackerel purse seines are generally 200-300 m long, whereas the tuna purse seines are longer and range in length from 350 to 2500 m and are usually deeper in proportion. Japanese two-boat purse seiners operate large purse seines. The American and other tuna purse seines are of one-boat type for catching skipjack, yellowfin, bluefin and albacore. The dimensions of purse seines are about 585x52 m for Peruvian anchoveta, 900x81 m for Californian purse seines for tuna, 1440x162 m for Norwegian purse seines for tuna and 668x72 m for South African purse seines for pilchard.

10.3 Species targeted by purse seines

Shoaling pelagic species of all sizes ranging from small sardines to large tunas are targeted by purse seines. Major species groups targeted by world purse seine fisheries include European pilchard (*Sardina pilchardus*), sardines (*Sardinella* spp.), menhaden (*Brevoortia* spp.), Japanese pilchard (*Sardinops melanostica*), Chilean pilchard (*Sardinops sagax*), South African pilchard (*Sardinops ocellata*), anchovies, tunas, bonitos, bill fishes, mackerels, salmon, capelin (*Mallotus villosus*) and small quantities of squids and crustaceans are caught in small-scale operations.

10.4 Classification of purse seines

Based on scale of operations, purse seines are grouped into small-scale, medium scale and large scale seines (Fig. 10.1). Based on number of vessels used for operations, there are single boat and two-boat purse seines. Based on depth of operation, purse seines are grouped into surface and sinking purse seines. Based on target species, they are named as anchovy purse seine, sardine purse seine, mackerel-horse mackerel purse seine, tuna purse seine, herring purse seine, capelin purse seine and cod purse seine.

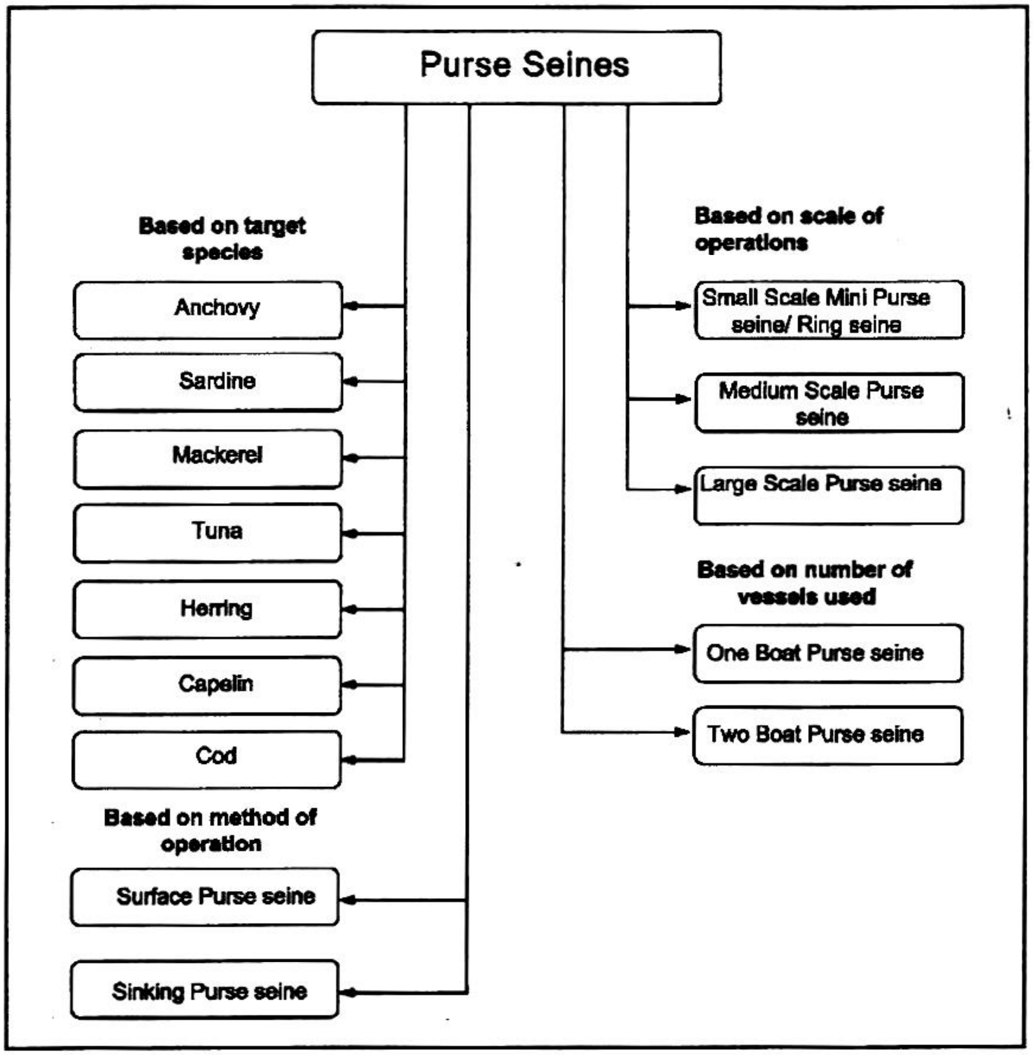

Fig. 10.1 Classification of purse seines

10.5 Structure of purse seine

The structure of purse seines vary widely depending on the method of operation, gear handling, depth of operation, target species and vessel characteristics. Brief description of a typical purse seine net is given below:

Bunt: The region in the purse seine net where the catch is accumulated before brailing is called the bunt. It is made up of heavier netting as it has to withstand excess strain of the catch. The bunt is placed in the centre or at the end of the wall of the netting depending on the type of operation. The bunt should be at least as long and deep as the length of the boat.

Main body: It extends from one end to the other end of the net except the bunt region. It is the largest part of the net and facilitates surrounding of the fish shoal during operations. It is made by joining together large sections of netting of appropriate mesh sizes to catch the target fish. The material used should have high specific gravity to increase the sinking speed during setting. Knotless netting are lighter and are widely used for purse seines. The disadvantage of knotless netting is that it is difficult to repair when damaged.

Selvedges: Selvedges are strips of strong netting and are used for strengthening the main webbing and to protect it from damage during operations. It is provided in the upper, lower and side edges of the main body of the net. It consists of a few rows of large meshes of thicker twine. The upper selvedge is attached to the float line or the head rope and the lower selvedge to the lead line or foot rope. It is also attached to the side ropes or gavel lines. Lead line is usually longer than float line by 10 %.

Floats: Best floats for purse seines are plastic. Shape of floats can be cylindrical or spindle. Total buoyancy of float is maintained at 1.5 to 3.5 times the total under water weight of the purse seine net and its appurtenances. Higher buoyancy is provided in the bunt area in order to counteract the sinking force due to weight of heavier netting in this area and the weight of fish while concentrating the catch. Usual extra buoyancy of floats is 2 to 4 times the weight of foot rope with sinkers. Usually double float lines, one rope with right hand twist and the other with a left hand twist is rigged, which prevents it from twisting. Braided rope is very good for float line because once stretched it does not kink twist (turn around itself) or twist.

Sinkers: Spindle shaped sinkers are attached to the lead line to attain 1-3 $kg.m^{-1}$ for small purse seines and up to 8 $kg.m^{-1}$ for large tuna purse seines.

Bridles and tow line: Bridles are ropes attached to float line and lead line on either side and are connected to a tow line of sufficient length to facilitate setting and hauling operations.

Lines and ropes: Braided ropes are preferable to twisted one, to avoid kinks. New ropes are pre-stretched before hanging the netting. This can be done by putting the rope under load and using swivels to rake out extra twist. In the case of multiple head lines and float lines, ropes with opposite twist directions are used so that the twisting forces of each rope counteract one another.

Float lines: Floats are threaded to the float lines to which the netting is hung directly. Single rope float line is disadvantageous due to distortion of the meshes of the selvedge which occurs around the floats if the hanging is tight and with loose hanging the distortion is less, but spaces are created between the float line and the netting where small fish may escape or large fish or porpoises may get jammed during hauling. Both the distorted net edge and the loose hanging create weak spots along the float line which may give way when under load. It is advisable to have float lines made up of two or more ropes. While rigging the net, it is more convenient to hang the netting from the hanging line and then to seize it together with another rope carrying the floats.

Lead lines: Lead lines as a rule are made of ropes of the same size as that of the float lines. Single rope lead lines are used more often than that of single rope float lines. It could be mainly due to the size of the sinkers which are smaller than the size of the floats and hanging netting directly on the lead line does not cause problems. Chain lead lines and lead lines without sinkers are also used.

Gavels and other vertical ropes: Gavels (breast lines) are made of ropes similar to the lead lines or float lines. Their length depends on the net.

Purse lines: Fibre ropes and steel wire ropes are used for purse lines. Fibre ropes are used when the pursing is manual. Most seiners have purse lines at least 10 – 20 % longer than the total length of their seines. If the purse lines are very long then swivels are used to connect one or two purse lines to prevent twisting and kinking. Purse lines are subjected to considerable frictional wear in the purse rings and abrasion on the winch barrel and in the purse blocks. Steel wire, polyamide and PES are considered good for purse lines. It must be about 100 to 150 times longer than the joint length of the lead line and the gavels. Purse lines are made of synthetic rope for small and light purse seines or of steel wire ropes of 9-16 mm dia for heavier purse seines.

Hanging coefficient: The most common horizontal hanging coefficient on float line is 0.7 and for body and bunt is 0.65. In the case of lead lines, it is 0.75 for body and 0.7 for bunt.

Tow lines: It is usually made of rope or steel wire and is the last part of the seine that is paid out from the purse seiner. The end of the tow line remains attached to the seiner and it can be used to allow a greater circumference of set to be made by using the tow line as an extension of the net.

Tow ropes: It is about two-third of the float line length. The tow rope or lazy line is paid away at the same time as the bunt.

Purse rings: Snap-type or closed steel or brass rings are used. The size of purse rings depends on the size and weight of the net. These in turn depend on the size of the boat. For small and light purse seines, purse rings of 100 to 150 mm dia made of 10 mm dia steel rods and weighing 1 to 1.5 kg each can be used. For bigger nets, 120 to 180 mm dia rings made of 12 mm dia steel rods weighing 2-3 kg each can be used. Number of purse rings may vary from 20 to 60.

10.6 Design of purse seine

Factors such as size of the vessel, biological characteristics of the target species (such as shoal size, swimming speed, swimming layer, behaviour of the target fish during approach of the craft and during surrounding and pursing of the gear) and characteristics of the fishing area are considered during the design process (Ben-Yami, 1974; 1987; 1994). The length, depth and shape of the net depend on the target species. Selection of materials, mesh size and twine thickness for the bunt and the body netting, hanging coefficient, determination of weight and floats required for the net are other design parameters for purse seines. The design of a mini purse seine operated in the traditional motorised sector of India is given in Fig. 10.2 and a modern purse seine operated in mechanised sector is given in Fig. 10.3.

10.6.1 Dimensions

The length and depth of the seine are determined by the size of the vessel, the species, behaviour of the fish and fishing conditions. It is easiest for operation when the depth is between 10 and 15% of the length (Ben-Yami, 1994). However, the depth goes up to 30-50% of the length in certain cases such as inshore purse seines for sardines, anchovies and pilchard where the shoal depth is generally high. Long and relatively shallow seine is appropriate for fast swimming fishes like skipjack. The depth of the purse seine is more commonly one-tenth of the float line, but may vary from one-fourth to one-third for deep swimming and quick diving shoals.

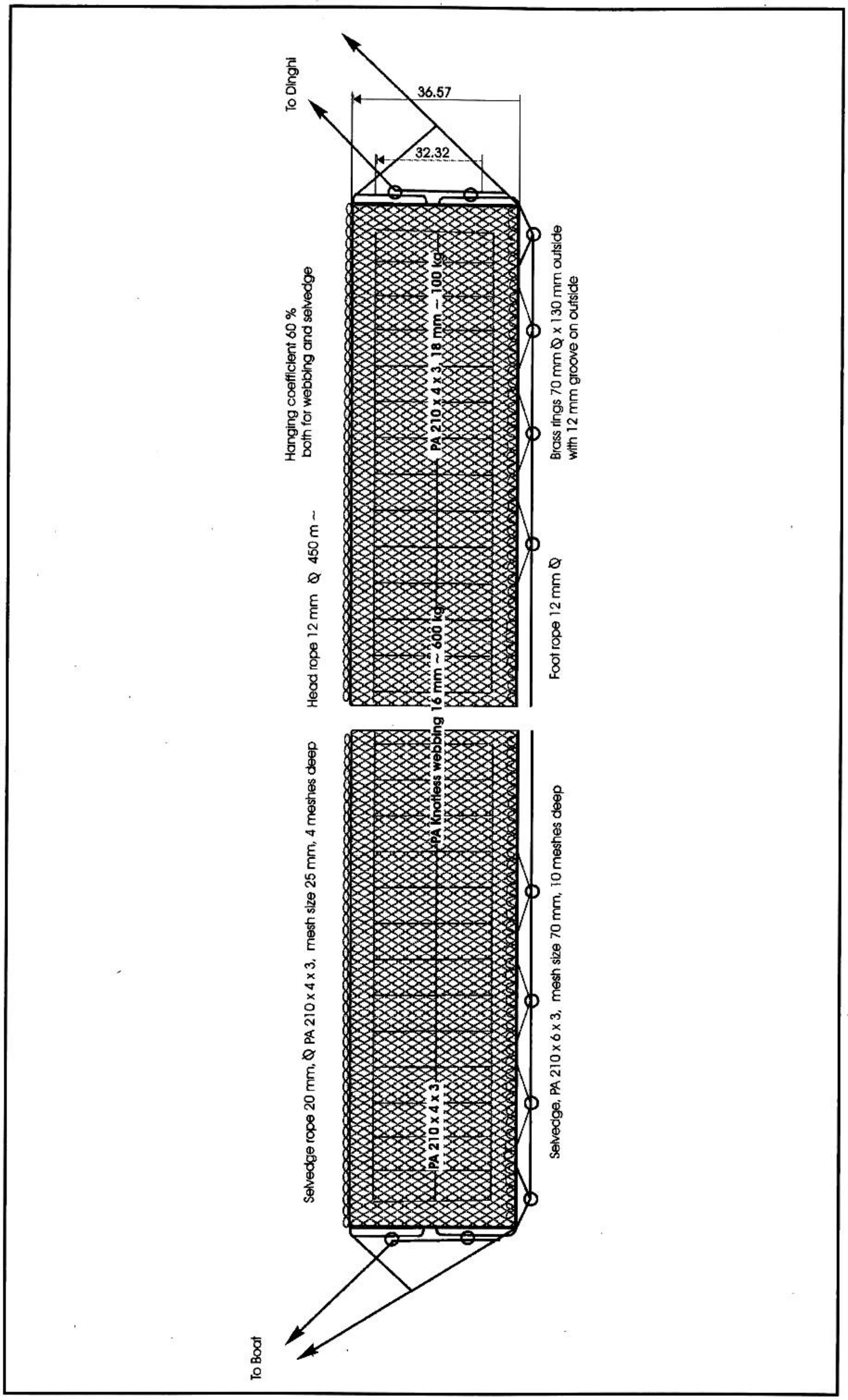

Fig. 10.2 Design of mini purse seine operated in traditional motorised sector of India

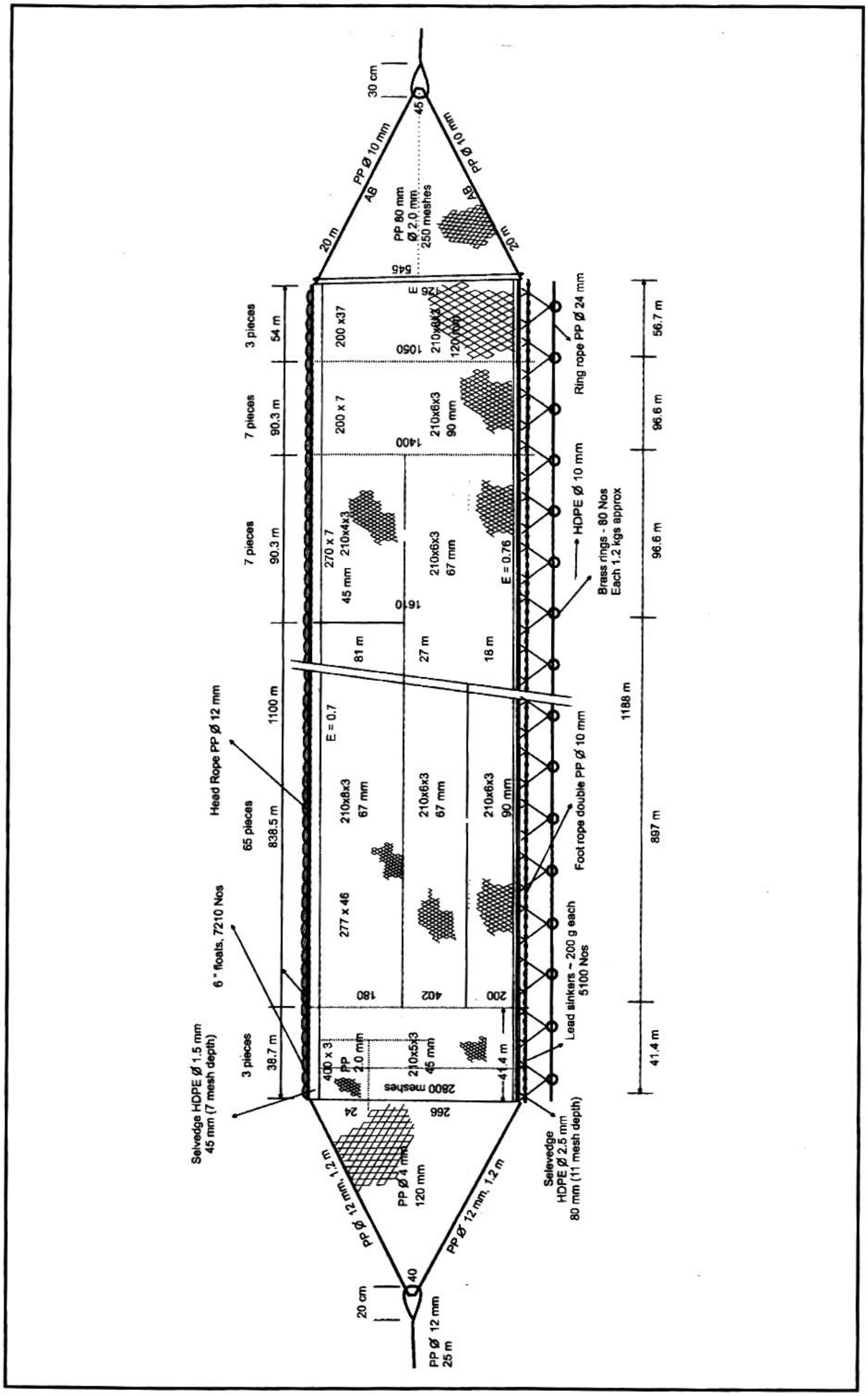

Fig. 10.3 Design of a large mesh purse seine operated from seiners of 18 m L_{OA}

The overall size of purse seine is best expressed as length of the float line. A purse seine in water is not a truly vertical wall of webbing but the net is hung so that it is roughly cup-shaped when laid out in a circle. This is accomplished by making the lead line shorter than the float line by 5 to 12% (Ben-Yami, 1994).

10.6.2 Mesh size

The mesh size and twine size are directly related to the size of fish and the quantity of fish caught. Choice of too small mesh size increases the cost and results in slow sinking. Too large a mesh size results in loss of catch as well as gilling. The mesh size of purse seines must be small enough not to gill the fish in any part of the seine. A common practice is to select a relatively smaller mesh size in the bunt, compared to the body meshes. Choice of mesh size is a function of the target species and is estimated by the following formula (Fridman, 1986):

Mesh opening in the bunt (mm) = 2/3.L/K

where L = length (mm) of target fish; K=5 for fish that are long and narrow; 3.5 for average shaped fish; 2.5 for flat, deep bodied or wide fish.

10.6.3 Twine size

The main criterion for determining the twine thickness for netting in a purse seine is to provide sufficient strength for pursing and hauling when the load due to the fish is maximum. The wing ends and the lower and upper selvedges of the seine are subjected to the greatest stresses. Therefore twines of greater thickness are used in these parts. Minimal loads are imposed on the central section of the seine.

10.6.4 Floats and sinkers

Sinking speed is found to be proportional to the square root of the apparent lead line weight. Excessive weights results in damage, strain on hauling equipments and handling problems. The normal requirement is 0.5 top 2.0 kg.m^{-1} of foot rope. The buoyancy requirement is 2-4 times of the weight of the foot rope. The weight of the ballast (in air) normally ranges between one-third and two-third of the weight of the netting in air. The weight in air of the ballast in the foot rope is generally between 1 and 3 kg.m^{-1} and up to 8 kg.m^{-1} in large tuna seines (Prado, 1990). The rigging of floats on a purse seine must take into account not only the buoyancy needed to balance the total weight of the gear in water, but also should have additional buoyancy. This additional buoyancy should be of the order of 30% for calm waters and up to 50-60 % in areas of strong currents, to compensate for rough sea conditions and other factors related to handling of the gear. Buoyancy should be greater in the area of the bunt and mid-way along the seine, where pulling forces are greater during pursing (Prado, 1990). In general, the buoyancy of the floats should be equal to about 1.5 to 2 times the weight of the ballast along the bottom of the seine (Prado, 1990). Lead line of the purse seine is usually longer than the float line up to 10 %. However, in some designs, the two lines are equal in length.

10.6.5 Hanging ratio

Hanging ratio (E) is usually greater on the lead line than on the float line. Hanging ratios generally range from 0.50 to 0.90, depending on the type of the net. The hanging ratio may also vary along the float line or lead line and is usually lower in the bunt.

10.6.6 Towline and purse line

The towline is normally about 25% of the length of the purse seine and the purse line is about 1.5 times the length of the float line and may range from 1.1 to 1.75 times the length of the float line. The purse line must have good resistance to abrasion and good breaking strength. As a general guideline the breaking strength of the purse line is greater than 3 times the combined weight of the netting, lead line, leads and purse rings (Prado, 1990).

10.6.7 Hung depth

As an approximation, hung depth is roughly 50% of the stretched depth of the seine at its extremities and 60% near the center of the net (Prado, 1990).

10.6.8 Sinking speed

Sinking speed of different designs of purse seine may range from 2.4 to 16.0 $m.min^{-1}$, and on an average 9.0 $m.min^{-1}$(Prado, 1990).

10.6.9 Selection of materials

The choice of material for the construction of purse seines is based on requirements of high breaking strength, elastic properties, specific gravity and other properties of netting which facilitate high sinking rate and low resistance to water currents. Synthetic materials such as terylene, polyester and polyamide are preferred due to their high breaking strength and specific gravity. Knotless netting is preferred to knotted netting due to the comparatively low twine surface area of knotless netting. Recently hexagonal mesh netting has been introduced due to the advantages of comparatively low hydrodynamic resistance and saving in the total material required for the net. Only the bunt and selvedge are constructed using knotted netting for the required strength in these parts of the net. A recent trend is to make combination twines of polyamide and polyvinyl chloride so as to combine the strength of the former and the high specific gravity of the latter material.

10.7 Fishing Operations

Purse seining operations involves location of fishing grounds, scouting, setting, pursing and hauling. Searching for fish aggregation, then identifying wherever possible the fish species and evaluating school sizes and its catchability, prior to surrounding are important aspects of purse seine operation. In artisanal or semi-industrial fisheries, the purse seine handling equipment may include a purse seine winch or a capstan, a purse line reel, a brailer and a power block and in some fisheries, a net drum. In industrial purse seine fishery, the basic equipments include, in general, a hydraulic power block or Triplex roller, a powerful purse line winch, a number of derricks, including a brailer or a fish pump, a skiff and sometimes, a helicopter. The purse seine can be used by a large range of vessel sizes, ranging from open boats and canoes up to large ocean going vessels. The purse seines can be operated by one or two boats. Most common ones are those operated by a single boat, with or without an auxiliary skiff.

10.7.1 Location of fishing grounds

Location of fishing grounds is necessary to reduce expensive searching time and fuel costs. Satellite imagery, aerial spotting and general hydrographical information are very helpful in locating fishing grounds. Information on position and extent of fish concentrations, average size of shoal and depth and general movement of schools are very vital for increased efficiency of purse seine operations.

10.7.2 Fish schooling patterns

Different species and sizes of the fishes have different schooling characteristics and this makes it possible to identify different school types from the air and sometimes at night due to bioluminescence. Experienced fishermen are able to identify the species and roughly estimate the size of the schools. The commonly encountered types of schools are the following (Puthran and Pillai, 1974):

Breezing school: Fish swimming very close to the surface of the water, usually in a single direction, creating ripples which resemble those created by a light breeze.

Boiling school: Fish feeding intensively and often in conjunction with marine birds, crowding upon the prey and creating an impression of the top of the boiling pot.

Jumpers: Schools moving with some fish jumping out of water.

Black spots: Surface schools appearing as black or dark spots.

Spinners: Fish swimming very close to the surface which shine from time to time, probably by deflecting light from their bodies as they twist and turn in pursuit of prey.

Fire balls: Surface schools which can be spotted during night time owing to the bioluminescence they generate in water.

10.7.3 Scouting for fish

Visual spotting is the most common method in which an observer spots the schools from an elevated point in the seiner such as the crow's nest placed on the main mast. Scouting is also done using powerful binoculars which are generally mounted on the bridge. A constant look out is maintained for fish schools. Hydroacoustic instruments such as sonars are important tools to locate fish aggregations.

10.7.4 Setting operation

The seine is arranged properly before the commencement of the voyage so as to enable the crew to release the net smoothly, during the setting operation. The head rope with floats is generally stacked at the port side stern, keeping the skiff end at the top with the skiff line and the haul line at the bottom. The main factors considered during the setting operation are the type of bottom, distance from shore, state of the sea, direction and speed of wind and current. Strong under currents having a direction and velocity different from the surface current may deform and entangle the net.

At just the right moment, the tow boat is dropped over the stern with the end of the seine tied to it. Running in reverse, the towboat holds the end while the seiner quickly circles the fish paying the seine overboard as she goes, coming around to pick up the end from the tow boat again (Fig. 10.4).

The operation of the purse seiner to catch fish, from the beginning of the shooting of the net up to the end of the hauling of the seine is called a "set". Usually, the purse seine is set and the circle is closed within 4 to 8 minutes. The maximum pursing speed depending on the power and rpm of the winch may reach up to 2 $m.s^{-1}$. As the cable reels over the drum, the purse rings with bridles come up one after another closing the bottom of the net and when all the rings are up, they are hoisted and the net is completely closed. Until the purse seine is not closed, the fish can still dive below the net or the purse seine vessel and escape. During the pursing, especially when there is current, in order to prevent the purse seiner from drifting over the net, the skiff is attached to the starboard side of the vessel and pulls it away from the net. In the Eastern Central Pacific area, a special operation, known as the 'backdown operation' is practiced at this time in order to release dolphins which are trapped in the purse seine. The pursing may take around 15 to 20 minutes for large purse seines.

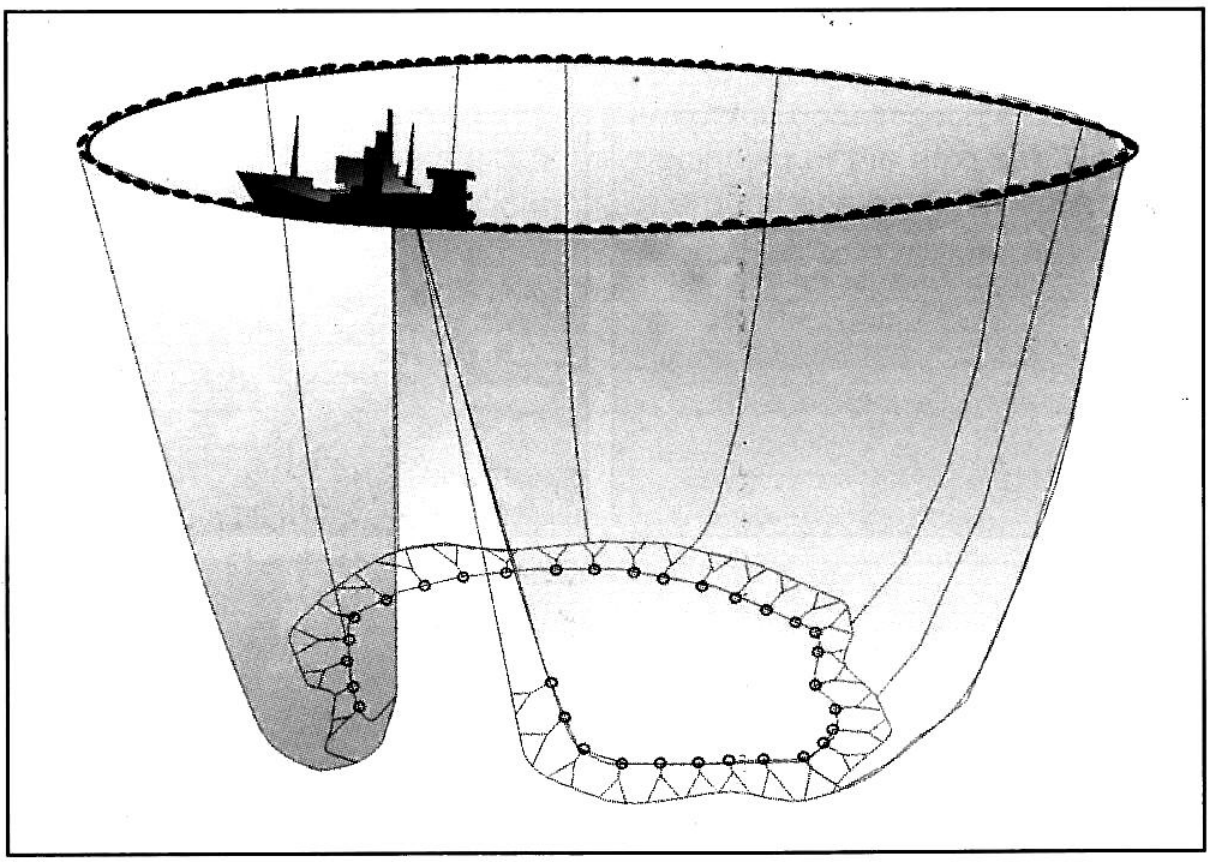

Fig. 10.4 A diagrammatic representation of purse seining operation

A fair knowledge of direction and speed of wind and current are the prerequisites of successful purse seining. As the layout of the net is in the proper direction and if the current is feeble and the wind strong, paying of the net should begin in such a way that if the boat is drifting towards the net it should be taken away from the net. Normally the starting point of the set should be such that, at the end of the shooting, the working side of the seiner faces the wind so that the wind pushes the vessel away from the net. In case when both the current and the wind are strong, it is not advisable to operate the gear (Ben-Yami,1994). The vessel speed is reduced due to the resistance of the seine descending from the deck. It is estimated that a seiner looses about 20% of her free running speed while setting a seine on a straight course (Ben-Yami,1994). The seiner looses additional speed owing to the curvature of the set as a function of the radius of the set to the vessel length. Normally the net is set at the maximum possible speed. However excessive setting speed may delay the sinking of the lead line.

A small-scale mechnaised tuna purse seiner operating in Indian waters and views of setting of the seine, brailing and landed catch are given Fig. 10.5. A ring seiner operating sardine and mackerel ring seines in the coastal fisheries of southwest coast of India is shown in Fig. 10.6.

Fig. 10.5 A small-scale mechanised purse seiner, based at Cochin, India and views of setting, brailing and landed catch

Fig. 10.6 A typical ring seiner

10.7.5 Hauling operation

Side by side with pursing, hauling also starts from the wing end either manually or using power block. Purse seine is hauled manually in small-scale operations and by using hydraulic power in medium and large scale operations. The net is stacked on the stern of the boat in such a way that it will come smoothly off the stern at the beginning of the next set. Hauling operation will, if there is no incident, take around one hour. When most of the purse seine has been retrieved, the fishes have been gathered within a restricted area along the portside of the vessel. Then the fish are harvested from the purse seine using a large scoop net called the brailer. The duration of this operation will depend upon the quantity of fish in the net.

10.7.6 Gear fouling

Fouling of gear is caused by coiling of the wing with the purse cable, which to a great extent is due to pursing prior to the fixing of foot and head rope of bag end. When the skiff end foot rope is free during pursing, the purse wire as it rolls over the winch, may drag the free foot rope and entangle with it resulting in incomplete pursing. Yet another type of gear fouling can occur if proper care of the direction of the wind and current is not taken. In this case, the boat will be over the net and while pursing, the cable will come in contact with the netting below the boat resulting in fouling (Ben-Yami, 1994).

10.7.7 Preventing fish escapement during purse seining

Preventing the escape of fish from a purse seine as it is being pursed has been tackled in many ways (Ben-Yami, 1994). The most common, and simplest method is by making noises in the water is by banging on the hull of the seiner and skiff. Some fishermen also use explosives. Special dyes are also used which form an opaque curtain in the sea through which the fish will not pass. Fish scaring lamps are used during night. Tom weights are used over the side of the seiner by means of a rope running through a separate sheave at the purse davit to reduce the gap between the wings during hauling operations. A submersible hydraulic winch is also used in some of the sophisticated vessels. Sometimes fishes tend to escape between the float line and the netting if the hanging is not done tightly. Fish jumping over the float line is also common and could lead to major losses of the catch. To prevent this, the float lines are tied together and also suspended by booms and lifting it over the gunwale. This operation can also be done by auxiliary skiffs.

10.7.8 Purse seining with light attraction

Lights are used to concentrate fish in some fisheries, prior to purse seining (Ben-Yami, 1976). Light attraction can be useful for successful purse seining when one or more of the following conditions occur: (i) fish do not create schools to justify purse seining operations, (ii) fish swim too fast, (iii) fish prefer to stay in shallow and rocky areas and (iv) fish swim to deep. Light attraction is unsuccessful when visibility in water is poor and current moonlight is strong. Chumming is often used to slow down fast swimming fish. It enables the aggregation of dispersed and loosely associated fish (Ben-Yami, 1988; 1994).

10.7.9 Purse seining with FAD and floatsam

The attraction of fish to floating objects has been observed and utilized by the fishermen in many parts of the world to aggregate fish. Artificial fish aggregating devices (FADs) are deployed to aggregate pelagic fishes like tuna. FADs are equipped with selective call radio buoys to facilitate their detection by radio direction finders. When sufficient fish aggregation is detected, the purse seine is operated to harvest the aggregated fish. There are three main methods of making a set around the FAD. In the first method the FAD is hauled in along with float, cable and anchor towards the end of pursing on the deck of the seiner. The second method consists in pushing the FAD float under the lead line just before the end of pursing. In the third method, the FAD is rigged with two floats, one at the end of the anchor cable and the other connected to the FAD. The FAD can drift or can be slowly towed away from the anchor buoy and the set can be made around the drifting part of the FAD. The FAD remains safely inside the net throughout the operation and is not hauled onboard until the seine has been fully pursed. FADs in association with lights are also used to keep the school of fish in the proximity of the FAD during the pursing operation. A scout boat with echosounder is associated with the FAD to detect harvestable fish concentrations near the FAD and to communicate with the seiner.

10.7.10 Ecological impacts

During purse seining, there is no impact on the bottom habitat except in shallow water operations where the lower edge of the gear may contact the sea bottom. The main negative impact is the incidental capture of dolphins in certain fishing areas. Special techniques have been developed to reduce by catch of dolphins (Ben-Yami, 1994). The Medina panel and 'back down' procedure, allow the encircled dolphins to escape alive. In light-assisted and FAD-assisted purse seining, incidental catch of non-targeted species and juveniles also may occur.

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