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An Introduction to Commercial Fishing Gear and Methods Used in Scotland

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Note to the Third Edition

Since this pamphlet was first published there have been fundamental changes in the status of fishing methods brought about by international recognition of territorial claims by coastal states in the administration of sea fisheries; political, economic and social change and an ongoing requirement to limit exploitation of diminished fish stocks. The loss of traditional distant and middle water fishing grounds marked the beginning of a decline which all but eliminated the Scottish deep sea trawler fleet.

These events increased the pressure on home water stocks to meet market demands and under the EU Common Fisheries Policy annual quotas were imposed on most species in the interests of conservation. Drifters and ring-netters were superseded by more efficient purse-seiners and mid-water pair trawlers, which in turn have been largely replaced by powerful single boat pelagic vessels. Many former herring boats turned to whitefish or shellfish species such as *Nephrops* or scallops and both demersal trawlers and Scottish seiners now regularly pair up for two-boat fishing. Twin rig trawling (i.e. one vessel towing two nets simultaneously) is widely used in the capture of *Nephrops* and whitefish.

In addition to these developments in fishing methods technological advances in vessel design and equipment have greatly improved catching power, safety and working conditions for fishermen. Features such as deck shelters, hydraulic winches, power blocks, net drums, rope reels and automated fish handling systems are now routinely used. New larger vessels capable of fishing deep water species to the west and north of Scotland have replaced many of the traditionally built vessels which formerly worked the shallower waters of the continental shelf for both pelagic and demersal fish.

Over the past few years the number and complexity of regulations governing the construction and use of fishing gear has increased considerably. As these regulations are continually being added to and amended, no references have been made to them in the text, with the exception of gears for migrating game fish. Information on current legislation covering all fishing methods described in this pamphlet can be obtained from: the Scottish Fisheries Protection Agency (SFPA), Pentland House, 47 Robbs Loan, Edinburgh, or from local Fishery Offices situated in the main fishing ports.

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Introduction

In early times man hunted fish to supply food for his family and himself, fishing from the sea shore or river bank, using spears, crude hooks and lines and simple traps. When he took to the water in the first rough dugouts, his field of operations was substantially extended. As the pattern of community living developed and preservation techniques such as drying and curing became established fish became not only food for the catcher but also a staple commodity of trade. Competition and technological advances slowly brought about improvements in fishing gear and new methods of capture appropriate to the target species sought were evolved by trial and error down through the centuries.

Today there is a wide range of towed fishing gear for catching fish on the seabed, just off the bottom and in mid-water suitable for all sizes of vessel working singly or in pairs. There are various types of seines used for surrounding large shoals of fish in open water or small shoals near the coast, static nets that catch fish by enmeshing them, traps for lobsters, crabs, salmon and sea trout, lines set to catch fish on baited hooks and dredges for scallops and queens.

For those who for professional reasons need to know something about fishing gear and methods used today, or those who simply would like to know about the gear and methods used to catch the fish they eat, this booklet is offered as an introduction.

The main types of fishing gear used by Scottish fishermen and the species for which they are used are listed in the next section. References to the published literature are omitted from the text, and instead a 'Reading List' is appended on page 42.

Fishing Methods for Commercially Important Species - Summary

Demersal Species (Whitefish such as Cod, Haddock, Whiting, Flatfish, etc.)

Bottom Trawling (Single-boat)

Bottom Trawling (Pair)

Seine Netting

Pair Seining

Beam Trawling

Long lining

Set-nets

Pelagic Species (Herring, Mackerel, Sprat)

Purse Seining

Mid-water Trawling (Pair)

Mid-water Trawling (Single-boat)

Shellfish (*Nephrops*, Shrimps, Scallops, Queens, Lobsters, Crabs, etc.)

Bottom Trawling (Single-boat)

Scallop Dredging

Potting and Creeling

Migrating Game Fish (Salmon, Sea trout)

Bag-Nets, Stake-Nets

Beach-Seining

Haaf-Nets

Trawling

Trawling is the operation of towing a net to catch fish, and the basic requirements for operating the trawl-net are sufficient power to tow the net, a means of holding the mouth of the net open while towing, a system of wires to connect the net and gear to the source of towing power and the ability to cast and haul the net.

Vessels provide the necessary towing power, from small inshore boats up to large deep-sea trawlers, with the size of gear scaled to match available horsepower. They may be designed to tow the fishing gear either from the side or from the stern and also provide accommodation for the crew, transportation to and from the fishing grounds and a working platform for fishing operations. Winches installed on deck move and store the trawling wires or warps. Auxiliary winches, power blocks and net drums or used to handle the gear while hauling and shooting.

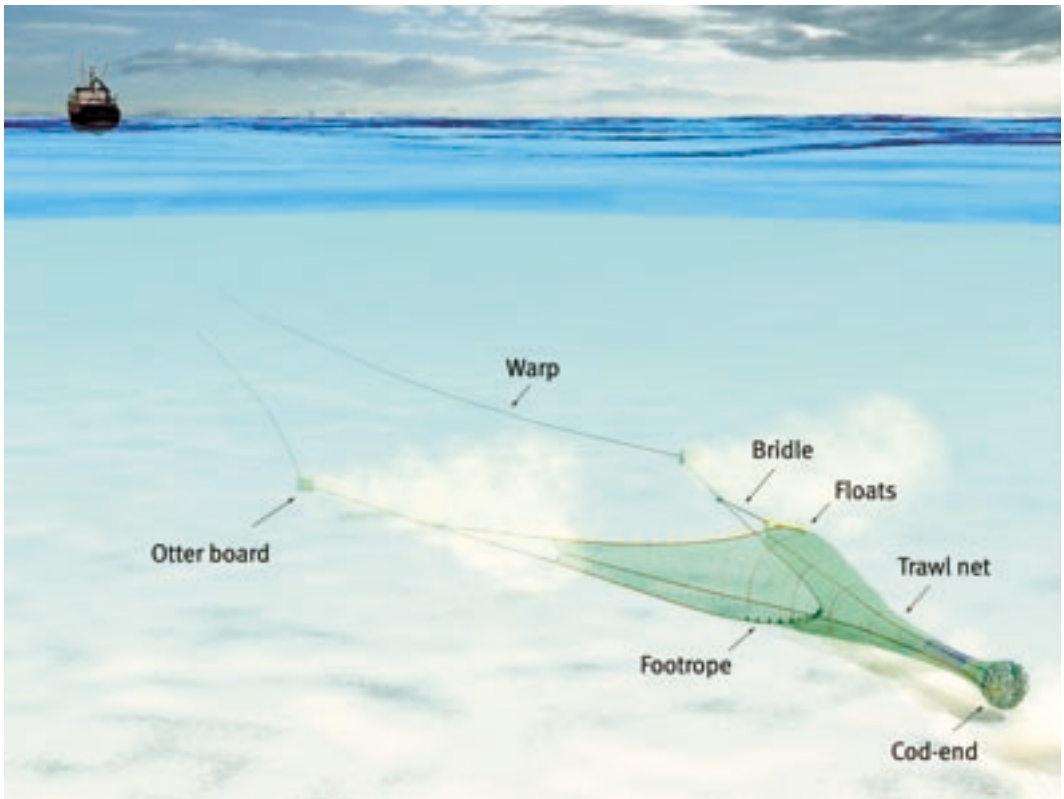


Figure 1. The Principal Features of Demersal Otter Trawl Gear

Trawls may be towed over the seabed, or at any depth in mid-water, according to the target species sought, by one or two vessels. In single-boat trawling otter boards are used to spread the connecting wires and hence hold the net open horizontally (Fig. 1). In two-boat or pair trawling the wires that connect each vessel to the net are held open horizontally by the vessels keeping station some distance apart when towing.

Floats, usually spherical and made of strong plastic or aluminium alloy to withstand implosion at maximum fishing depth, are attached to the upper edge of the net mouth (headline) to provide vertical lift while weight is distributed along the lower edge (footrope) to hold it down.

All trawl-nets, large and small, for both bottom and mid-water trawling, are basically funnel shaped, with their sides extended forward to form wings which guide fish into the mouth of the net. The net may consist of two panels, top and bottom, or four panels, top, bottom and sides. Bottom trawls have a top canopy, called the square, extending forward from the funnel to prevent fish from rising up and escaping over the top of the net. Each panel is made up of sections of netting, suitably tailored to give the required shape and trim to the net when it is fishing.

Demersal Otter Trawling

Taking together both whitefish and *Nephrops* fleets the otter trawl is by far the most widely used of the Scottish towed gears. This was not always the case however as up until the end of last century beam trawlers, sailing craft which harnessed the vagaries of wind and tide, were the only vessels capable of trawling. The beam trawl (qv) is a compact net held open by a fixed frame, at that time constructed with a wooden beam mounted between two iron heads, or runners, one each side of the gear. With the introduction of steam propulsion to fishing vessels a constant towing speed could be maintained and this allowed shearing devices known as otter boards to replace the rigid frame by hydrodynamically spreading the net in a horizontal direction. This development liberated trawl design from the constraints imposed by beam length and was quickly adopted by many fishing nations. There is some debate as to whether the idea originated in Ireland or England but it was in France that the next major advance was made.

The Vigneron Dahl system, which was patented in the early 1920s, introduced the concept of rope bridles between otter boards and net. This substantially increased the area of seabed swept by the gear at very little cost interms of additional towing power and dramatically improved productivity. Up until that time trawl wings had been shackled to the otter boards with short lengths of rope (legs). The VD rig, as it came to be known, used a Danleno (probably derived from a corruption of the French word *guindineau*), a short pole or spreader to which each wing end was attached. As trawl design developed this was seen to restrict the vertical opening of the net so headline and footrope were extended by adding rope legs between Danleno and wing end. The resulting arrangement (Fig. 2) remained the basic rig of the deep sea trawler fleets of NW Europe and beyond for the best part of the twentieth century.

Figure 2. Traditional Arrangement of Wires and Hardware for Single Boat Bottom Trawling

As vessel power increased and fishing gear became larger and more robust the original wooden Danleno spreader evolved into the heavy duty assembly shown in Figure 3. The steel bobbin helps to rid the gear of any rocks or stones which may be picked up and run down the bridles towards the net where they could inflict damage. The butterfly is self-adjusting and compensates for small fluctuations of tension in the legs. An alternative Danleno that incorporates a lighter hemispherical scuttle bobbin is shown in Figure 4.

Figure 3. Typical Deep Sea Danleno Assembly

Figure 4. Scuttle Danleno

Figure 5 shows the principal net sections of a schematic two-panel bottom trawl-net. In most whitefish trawls the mesh sizes decrease, section by section, towards the cod-end. Statutory regulations set the minimum sizes of meshes which may legally be used according to the type of fishing and species sought. These regulations are aimed at the long-term conservation of fish stocks by enabling undersized fish to escape through the meshes and thus avoid capture. Most Scottish demersal trawl-nets are made from twisted or braided polyethylene twine, often distinctively coloured bright orange or green. Figure 6 demonstrates how the netting sections and framing ropes are put together to make a complete trawl-net. Top wings and square are mounted to the headline and lower wings and belly to the fishing lines. Upper and lower panels are laced together to form a seam, or lastridge along each side of the trawl-net, which may be reinforced with a lastridge line as indicated.

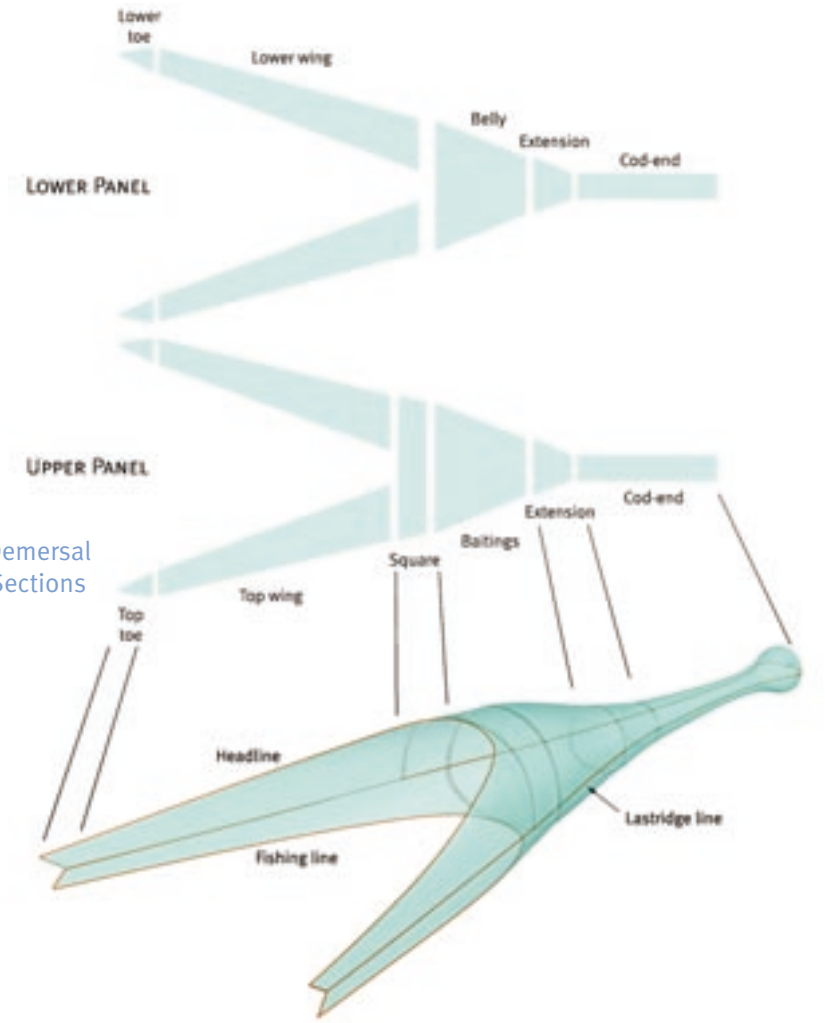
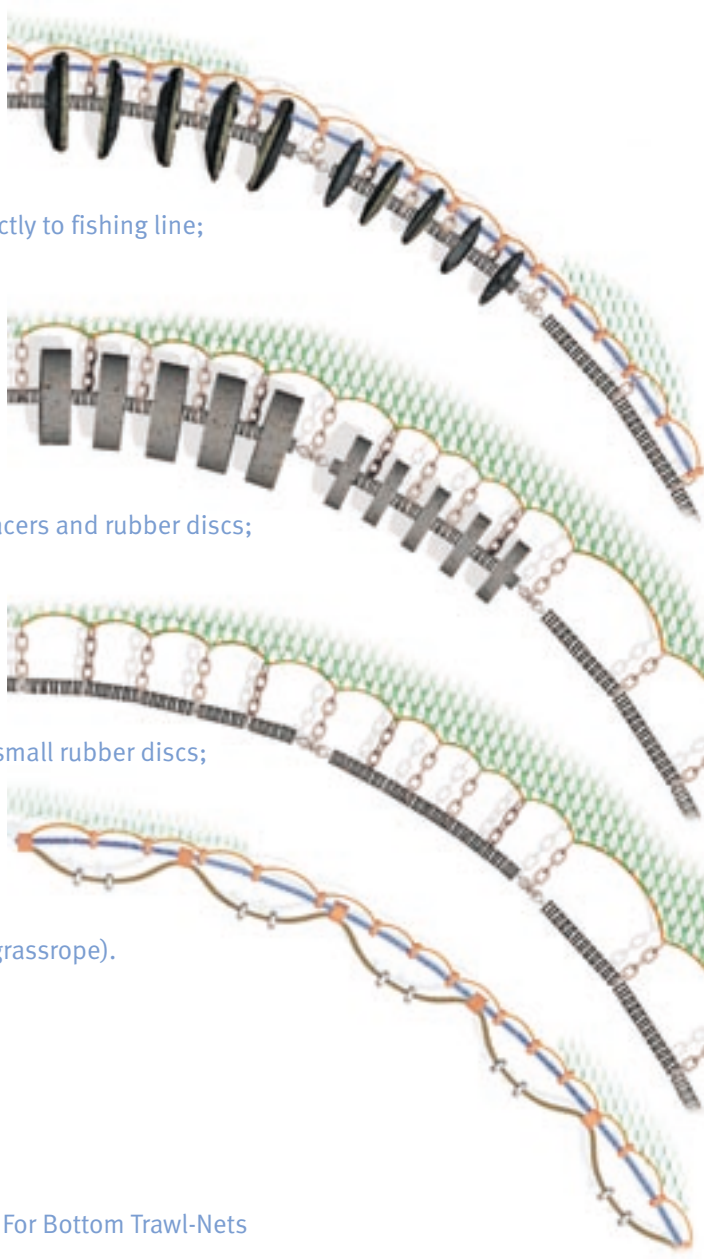


Figure 5. Principal Demersal Trawl-Net Sections

Figure 6. Netting Sections assembled on Framing Ropes

The fishing lines of bottom trawls are attached to a groundrope, which holds the bottom of the net mouth in ground contact whilst providing some protection for the netting against snagging by holding the fishing lines clear of the seabed. The groundrope is made of sections of wire or chain shackled together. Depending on the bottom conditions where the gear is to be fished, it is either simply rounded with heavy fibre rope or furnished with rubber discs cut from old car tyres, larger rockhopper discs from truck tyres or moulded rubber wheel rollers (bobbins) and spacers (Figures 7a-c). On light trawls (and seines) worked on clean bottom, the footrope may consist only of a fibre rope weighted with lead rings (Fig. 7d).



a) rockhoppers attached directly to fishing line;

b) rubber wheel bobbins, spacers and rubber discs;

c) rope-rounded footrope or small rubber discs;

d) lead weighted fibre rope (grassrope).

Figure 7. Typical Groundropes For Bottom Trawl-Nets

For high headline trawl-nets used for catching roundfish species that can be found several metres off the bottom, the rig may be modified to include a middle leg, with or without Danleno, or twin or triple bridle rigs may directly connect otter boards and net. Some alternative wire systems for bottom trawling are shown in Figure 8. Generally combination or steel wire ropes are used but when fishing hard ground part or all of the wire in contact with the seabed may be replaced by abrasion resistant drag alloy chain.

a) single bridle rig;

b) twin bridle rig;

c) three bridle rig;

Figure 8. Bridle Systems for Demersal Trawling

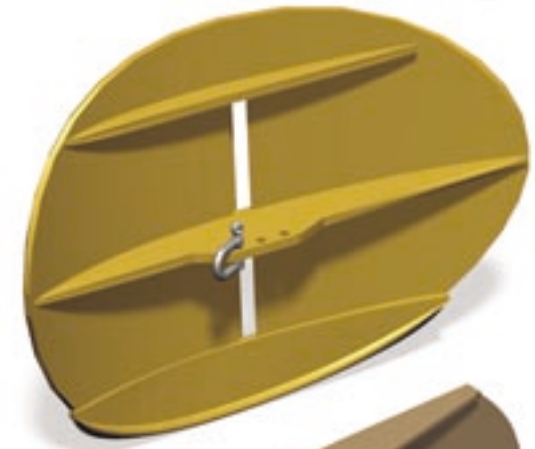
Some types of otter boards used to spread the gear are shown in Figure 9. The traditional wood and steel flat otter boards are now seldom used for deep sea trawling but are still preferred by smaller, low horsepower vessels content to tow at slower speeds than those achieved by bigger vessels.

Depending on their size, they may be of simple one-piece construction or more ruggedly made up of oak or elm timbers bound and strapped by steel bars with protective plates fastened to the front and back of the lower planks and a heavy steel keel bolted or welded to the bottom edge. Two triangular brackets are hinged vertically on the front of the otter board, the apexes of which when brought together provide an out-posted connecting point for the warp.

On the back of the otter board are fastened two 'U' bolts or rings, spaced one above the other, to which the backstrops are shackled. The positions of the connecting points for the warp and backstrops are chosen such that the otter board adopts the best attitude for optimum spreading efficiency when the gear is towed.

a) wood and steel flat otter board

b) steel V-board



c) steel oval cambered
(e.g. Polyvalent)

d) steel rectangular cambered
(e.g. Bison)

e) Suberkrub board

Figure 9. Types of Otter Boards

V-boards are found mainly on inshore whitefish and *Nephrops* trawlers. While not especially hydrodynamically efficient they are very easy to use and require little maintenance. The V-form is particularly effective on soft bottom conditions such as mud where other types of board tend to dig in. The cambered types, being a more efficient design, have much greater spreading power but cost more to manufacture and require some maintenance. The all-steel, high-aspect ratio Suberkrub boards are specifically designed for single-boat pelagic trawling (*q.v.*).

Figures 1, 2 and 8 show the various arrangements of wires and hardware used in single-boat demersal trawling, which when shackled together connect the net to the ship. The lengths of the wires are so chosen that all the forces transmitted in them at normal towing speeds will hold the gear at the best fishing configuration for the type of net and species sought, i.e. the otterboards separated sufficiently to spread the net horizontally without sacrificing headline height, the bridles at the best angle for herding fish into the path of the net, and the angle between top and bottom legs such that the top leg does not over-constrain the vertical lift of the headline. The total length of wire between otter board and net can be as much as 200 m and warp lengths employed vary between two and five times the fishing depth, with the ratio increasing as the water deepens. In moderate water depths (i.e. 80-180 metres) a ratio of around 3:1 is normally used.

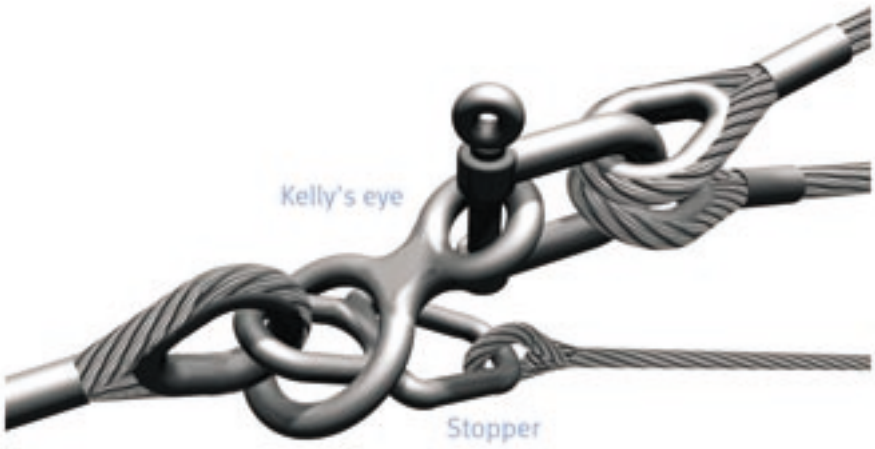
Demersal industrial species, i.e. non-food fish such as sandeel and Norway pout, are also largely taken by single-boat bottom trawling. With the decline in traditional roundfish stocks such as cod and haddock many vessels have turned to the exploitation of high value species like monkfish and megrim using 'scraper' trawls. These nets are designed to maximise groundfish catches by increasing area swept, i.e. they have very long wings and do not require a high headline.

Shooting and Hauling Otter Trawl Gear

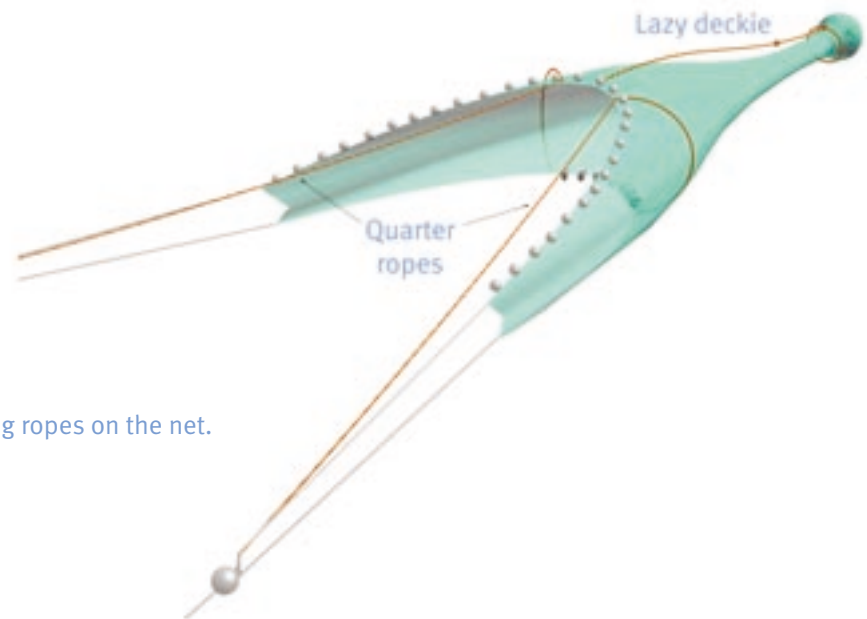
The amount of wire used each side of trawl gear varies from about 150 m on small vessels up to over 2,000 m on large trawlers that fish in deep water. In order to lead these wires (warps) from the winch to the towing points the wires are guided round pulleys. The towing points hang from gallows positioned fore and aft at the ship's side or at each stern quarter. On many vessels the run of the wires between winch and towing points may change direction several times depending on deck layout. The ropes that are attached to the gear to facilitate shooting and hauling are shown in Figure 10 and in order to more easily understand their operation it is convenient to start with the towing condition and explain how the gear is hauled.

Figure 10a shows the wires associated with an otterboard when viewed from the back and Figure 10b shows the junction of the backstrops and the bridle in detail. While the gear is being towed the drag of the net transmitted through the bridle holds the stopper jammed into the kelly's eye; the pennant, or independent piece, the leading edge of which has been tied to a convenient position on the front of the otter board, hangs slack. When the gear is being hauled and the otter boards come up to the gallows, they are each made fast with chain through the brackets (chained up), allowing the weight to be taken off the warps.

a) the wires at the back of the otter board;



b) the junction of backstrops and bridles;



c) the hauling ropes on the net.

Figure 10. Auxiliary Items for Shooting and Hauling Otter Trawl Gear

On side trawlers, the fore end of each pennant is then untied, the warp disconnected from the otter board and the two wires shackled together. Hauling then recommences and the length of each bridle passes through its kelly's eye until the Danlenos arrive at each gallows. Attached to each Danleno is a quarter rope (Fig. 10c) which runs through a becket on the headline, then round the outside of the net and is fastened at its other end to the groundrope. When both Danlenos are secured at the ship, the quarter ropes are hauled to bring headline and footrope together up to the ship's side. With the weight held by the quarter ropes made fast other lifting tackle is brought into operation to lift the groundrope inboard. The cod-end is then hauled to the ship's side, lifted aboard and emptied; shooting of the gear is carried out in the reverse order. If a large bag of fish has been caught it may be necessary to split the catch and make two or more lifts with the aid of the lazy deckie and halving becket (Fig. 10). As the lazy deckie is hauled the becket tightens and the cod-end is strangled, closing it off from the rest of the catch. When the cod-end has been emptied and the codline retied, it is lowered over the side to fill with more fish for the next lift, and so on until all the catch is on board.

With the present widespread adoption of shelterdecks most Scottish trawlers now shoot and haul trawl gear over the stern. Similar procedures to those already described are carried out while stern trawling but the kelly's eye and stopper are usually replaced by 'G' and 'O' links to enable the backstrops to be completely disconnected from the running wires after the otter boards are chained up at each quarter. If a net drum is used, the pennants can be shackled up to pony wires and the bridles, wire legs, wings and groundgear hove straight on to the drum. The remainder of the net is hauled by means of a power block, which is also employed to divide catches using the above method of double bagging.

Twin Rig Trawling

The essential elements of twin rig trawl gear are set out in Figure 11. This gear is generally used for target species tight on the bottom, such as angler, flatfish and *Nephrops*. By towing two nets side by side the effective swept area, and hence catch, is increased. As with the single demersal trawl above, otter boards (a) provide the horizontal spreading forces and floats and groundropes the vertical forces. The obvious difference in rigging is the third wire or central warp (b), which runs from the vessel to the clump (c), a heavy weight which can consist of short lengths of chain cable shackled together or a custom made device (Fig. 12) designed to roll rather than be dragged along the bottom. Warp length/water depth ratios are similar to those used with the single demersal trawl and bridles/sweeps (d) can be steel wire, combination wire, chain or a mixture of all three. Normal towing speed used is around 2.5 knots.

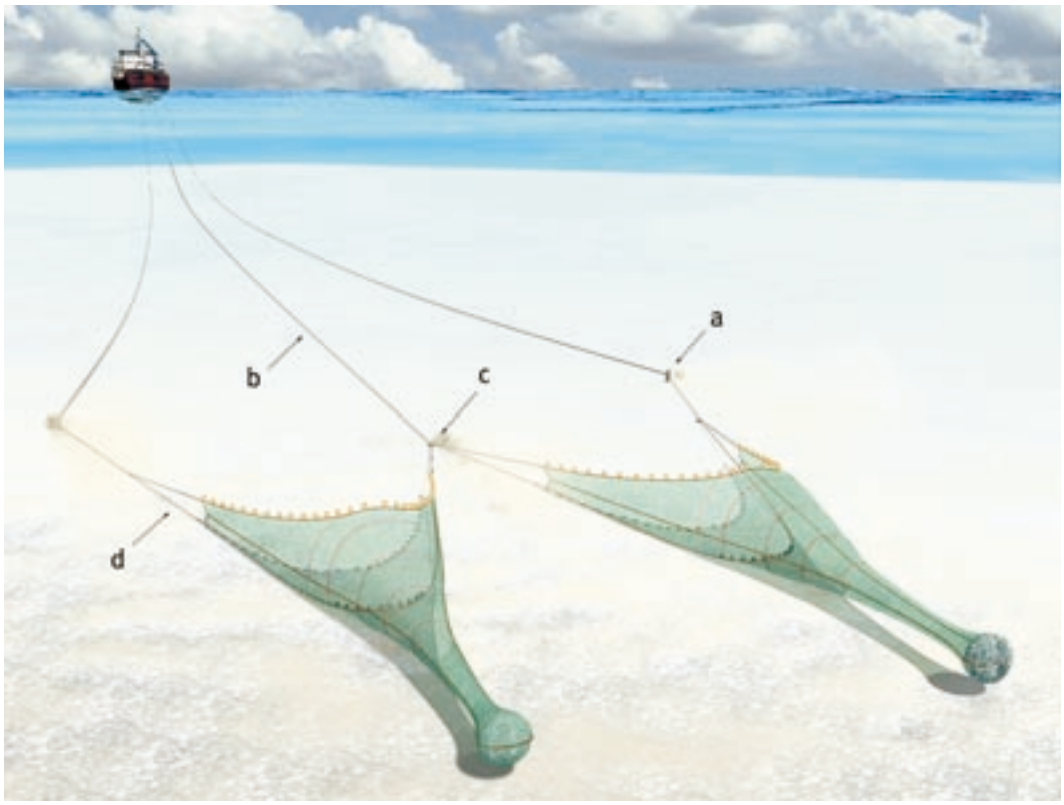


Figure 11. Twin-rig bottom trawling

Figure 12.

Figure 13.

Demersal Pair Trawling

Nets used for pair trawling are of similar design and netting material but tend to be much larger and heavier than comparable single-boat gears. As otter boards are not required to provide horizontal spreading forces vessels of relatively modest horsepower can tow a considerably larger gear between them. A rockhopper footrope (Fig. 7b) is frequently used to protect the net from bottom damage and the gear is usually shot and hauled over the stern using a net drum. A heavy length of wire and/or chain (200 m-400 m) is included in the rig between warp and bridles to ensure good bottom contact. After one vessel shoots its net the bridles are passed across to the partner with the aid of a messenger and connected to the heavy sweep wire. Both boats pay out wire as they steam ahead to take up towing positions (Fig. 13). Scottish pair trawlers generally tow between 0.15 and 0.25 nautical miles apart, taking into account water depth and bottom conditions. At the end of the haul both boats come together again and the previously transferred bridle is passed back to allow the first vessel to complete hauling operations.

Beam Trawling

Beam trawls are used to harvest whitefish, mainly flatfish such as sole, plaice or megrim together with angler and other species found hard down on the seabed. Each net is fished from an outrigger boom, one on each side of the vessel (Figure 14), and towed from here on a single warp (a) shackled to a three chain bridle (b) attached directly to the beam (c) which holds open the mouth of the trawl. The beam, 9-12 m in length, is constructed from heavy steel tube and supported on each side by rugged steel trawlheads (d) which slide over the sea bottom. Ahead of each groundrope several tons of tickler chains (e) or chain mats (f) are used to disturb fish,

causing them to rise up and be taken by the trawl following immediately behind. Towing speeds are generally higher than otter trawling, reaching 6 or 7 knots on clean ground with ticklers, whereas on rough ground stone mats are towed at around 4 knots. Beamers usually operate on the continental shelf (200 m) with warp length/water depth ratios of between 2.5:1 to 3:1. Some larger vessels use a double wire system (z) to facilitate the hauling procedure.

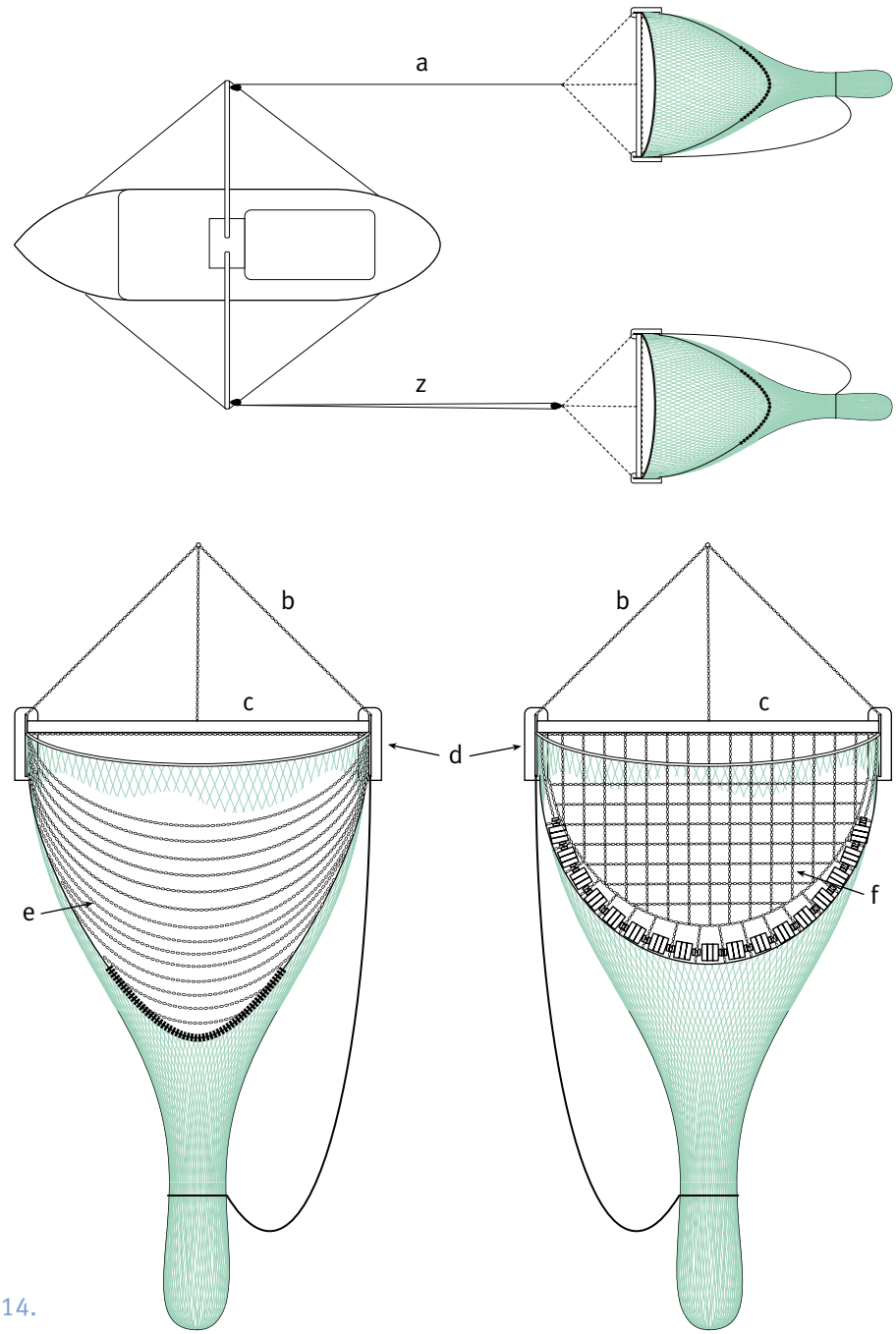


Figure 14.

Shellfish Trawling

Otter trawls for shellfish species such as Norway lobster (*Nephrops norvegicus*) or pink shrimp (*Pandalus borealis*) differ very little from whitefish gear apart from being generally more lightly rigged and subject to a smaller regulation minimum mesh size. Steel V-boards (Fig. 9b) are almost universally used and rubber disc footropes or grassropes (Fig. 7c, d) are usually adequate for the soft mud or sandy bottoms encountered. Trawls for queen scallops, on the other hand, use much heavier twines than are found on comparable whitefish nets, with bellies and cod-ends heavily protected by cow-hide chafers or similar due to the abrasion which occurs between catch and sea bottom.

Twin rig trawling (Fig. 11, p.17) is also widely practised in some *Nephrops* fisheries. In the Solway Firth fishery for brown shrimp (*Crangon crangon*) beam trawls are used exclusively. A small fleet of local vessels, all under 200 horsepower, deploy beams up to 6 m in length. Queen scallops are sometimes also taken by small beam trawls.

Pelagic Pair Trawling (Mid-water Trawling)

Mid-water or pelagic trawls are towed at the appropriate level in the water column to intercept shoaling fish such as herring or sprats. The location of the shoals is determined by sonar or vertical sounder echoes picked up by the vessels hunting in pairs. One boat then shoots its net and the partner vessel comes alongside to pick up upper and lower bridles. When both warps are shackled up appropriate lengths of wire are paid out and the vessels steam towards the target shoals (Fig. 15). The depth of net relative to the surface is indicated by an underwater instrument mounted on the net headline. Known as a net monitor or net sounder this instrument

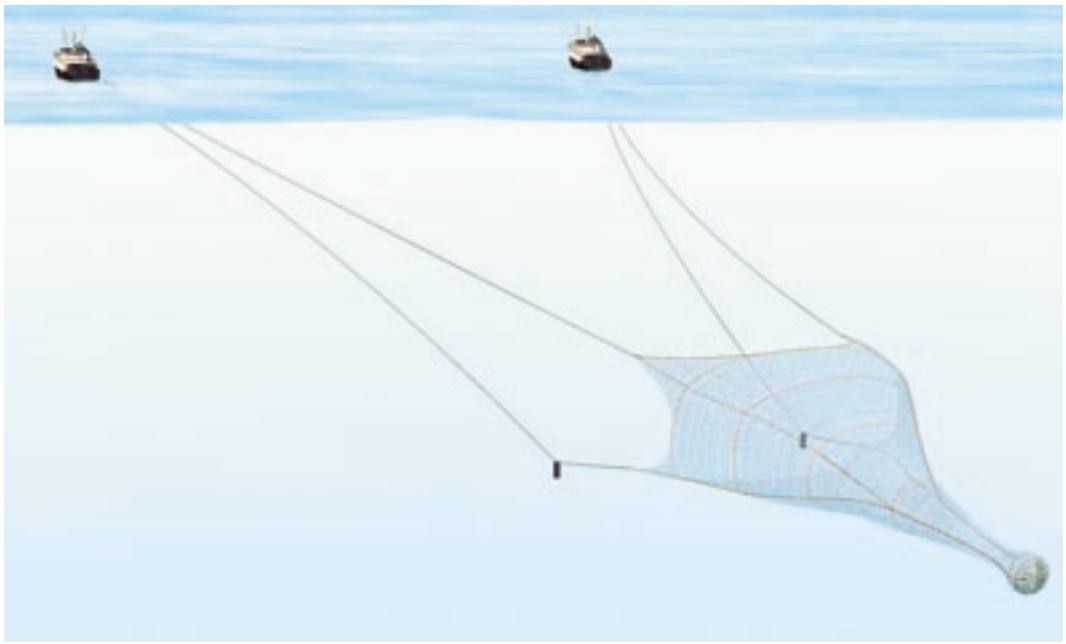


Figure 15. Two-Boat Mid-water Trawling

can be connected to the towing vessel by cable or can transmit acoustic signals to a receiver, either hull mounted or towed by one or both of the boats. Gear depth is controlled by changing the length of towing wires and/or altering towing speed. As with bottom pair trawls the absence of otter boards allows two vessels of modest horsepower to tow a relatively large trawl-net.

Pelagic trawls are invariably constructed from polyamide (nylon) twine. This material has the advantages of both strength and elasticity to absorb the huge stresses imposed by large catches when fishing in bad weather. Advances in twine technology mean stronger, thinner twine can be used, thus reducing hydrodynamic drag and allowing the construction of ever larger nets. Meshes in the wings and foreparts of mid-water trawls can be massive (‹10 m) so nets are generally shot and hauled from net drums to reduce the risk of fouling the gear. Mesh sizes decrease, section by section, towards the cod-end which may have a 16 mm mesh size when fishing for sprat. Unlike demersal trawls, pelagic trawls do not have an overhang, or square, and are invariably of four-panel construction (Fig. 16). As little or no bottom contact need occur (the heavy weights on each lower bridle will touch down first and thus keep the rest of the gear off-bottom) groundropes are not required but chain can be added as ballast to the footrope to ensure the gear opens satisfactorily while shooting.

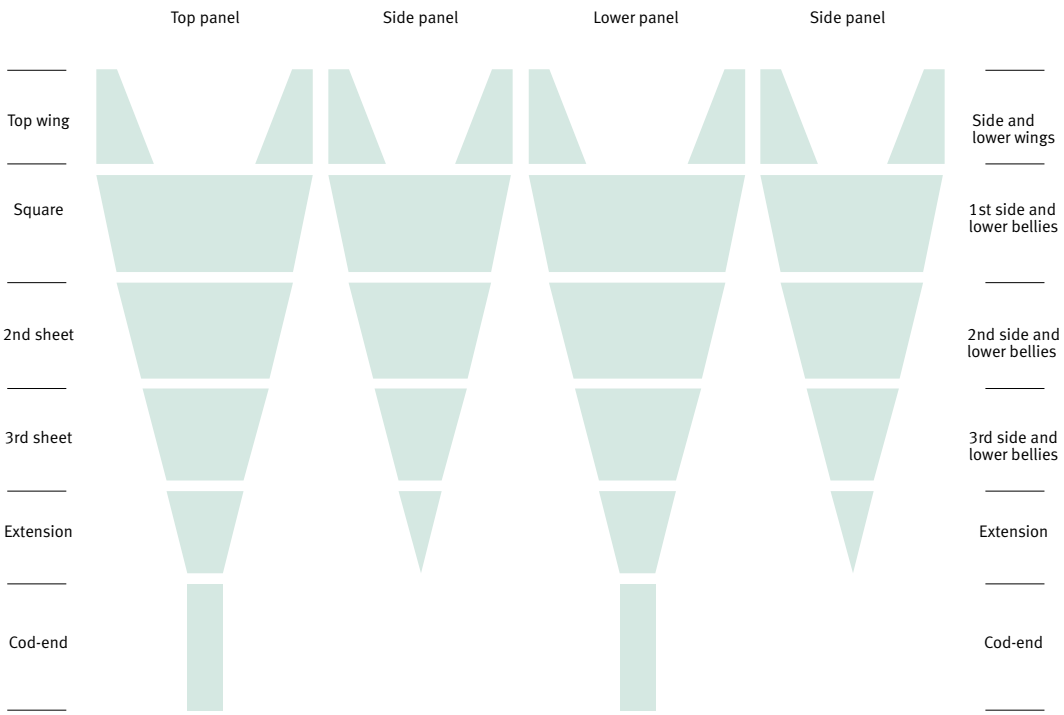


Figure 16. Principal Pelagic Trawl-Net Sections

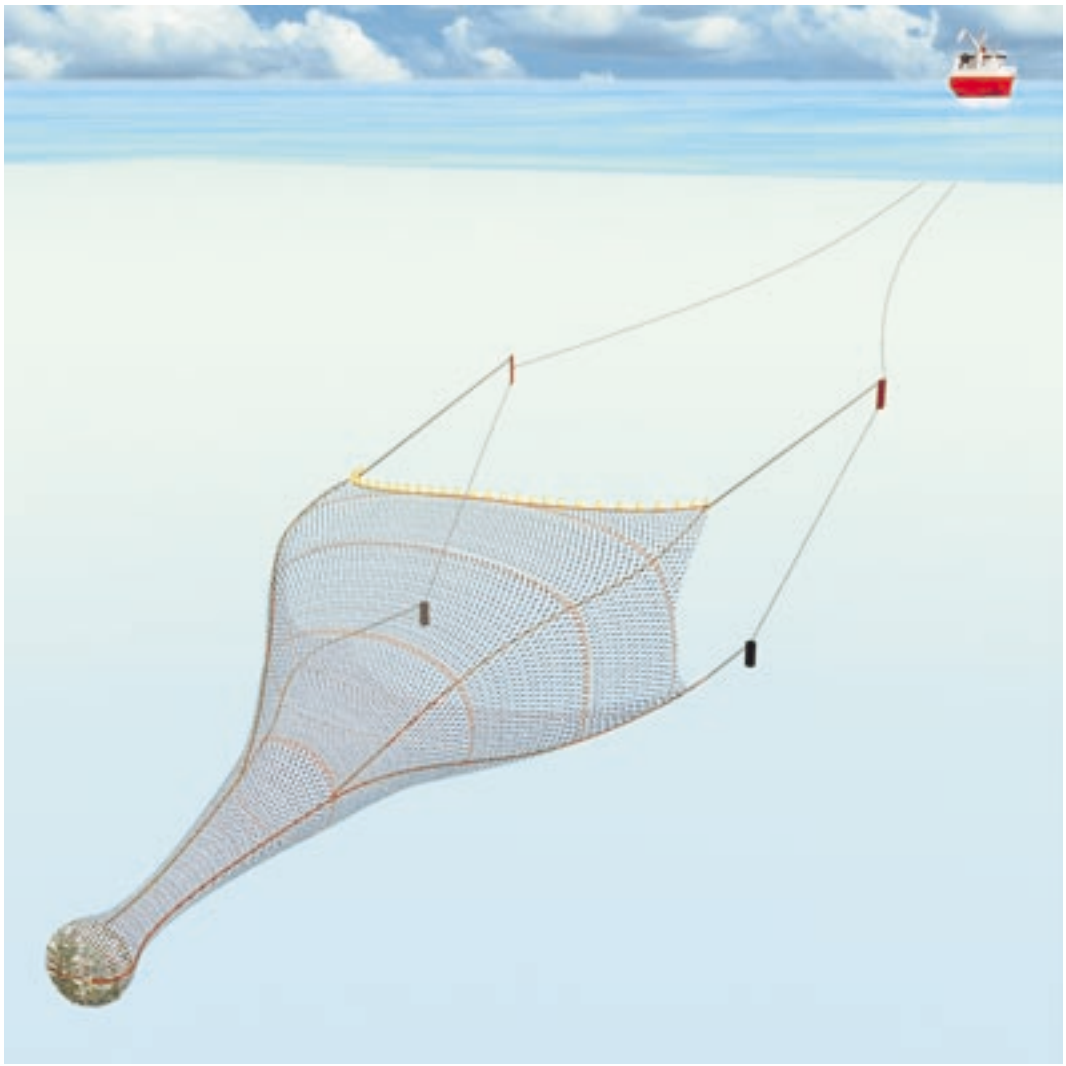


Figure 17. One-Boat Mid-water Trawling

Pelagic Single-boat Trawling

Considerable horsepower is required to tow these huge nets designed to catch mackerel and herring, similar in practically every detail to the two-boat gear (Fig. 16), at an effective fishing speed. The trawl is spread horizontally by cambered section otter boards (Fig. 9e) and, as with pair trawls, heavy weights on each lower bridle ensure a substantial vertical gape (Fig. 17), which is continuously monitored by netsounder. Net depth is changed by altering either warp length or towing speed. These hydrodynamically efficient otter boards provide not only high horizontal spreading forces but also improve lift when towing speed is increased to raise the net when aiming for a shoal of fish. Industrial (i.e. non-food) pelagic species such as blue whiting and scad are mainly taken by this method.

Seine-Netting

Modern demersal seining, or bottom fishing with rope warps and wing trawls, is reputed to have first been carried out by a Danish fisherman, Jens Laursen Vaever, in 1848. This method of seining, known as anchor seining, is still carried on in Denmark today. The ropes and net are set out from an anchored dhan (marker buoy) by the vessel which returns and makes fast to the dhan anchor cable. The gear is then hauled with the vessel being held stationary by the anchor. In the early 1920s Scottish fishermen developed a different method of seining which dispensed with the need for an anchored dhan, but which utilised the thrust of the vessel's propeller to balance the drag of the gear as it was slowly winched aboard. Over the years Scottish seining, or fly-dragging, as the method came to be known, has firmly established itself as one of the most important methods of capture used by the whitefish fleet.

Scottish Seining (Fly-dragging)

This fishing method depends on the long lengths of rope used, up to three kilometres per side, herding fish into the path of the net as the gear is hauled. The gear is set roughly in the shape of an isosceles triangle with the dhan, which marks the end of rope first shot and to which the vessel returns to complete the set, as the apex and the net as the centre of the base. Having picked up the dhan the vessel then starts to steam slowly ahead while heaving in both ropes, gradually advancing winch speed as the gear closes to keep the net moving forward at a steadily increasing rate.

For many years seine nets were constructed of two equal panels with lastridges running along the centre lines of the top and bottom of the net. This design, with each side being the mirror image of the other, resulted in a net which was complicated to construct and repair, had no overhang or fishing square and only modest headline height. In Scotland today, conventional wing trawls, i.e. nets with upper/lower panels, fishing squares and lateral lastridges are universally used. These light trawls are made up from the same twisted polyethylene twines used by the demersal trawl fleet and a grassrope (Fig. 7d) is the footrope normally used. For rougher ground, however, this may be replaced by a rubber disc or light hopper groundrope (Fig. 7b,c). Up to 15 coils (each 220 m long) of polypropylene ropes, lead cored to ensure quick sinking and good bottom contact, can be deployed on each side of the net. Sweeps, usually manufactured from polypropylene/steel combination wire, are generally between fifty and seventy metres in length.

Seine net vessels range from 12-30 m and in the past were fitted with much lower powered engines than trawlers of comparable size because of the difference in fishing techniques. New vessels however, are invariably built as dual purpose seiner/trawlers with engines developing 500 horsepower or above. Most boats now have shelterdecks under which the long rope warps are stored on rope reels. An articulated power block is used to haul both sweeps and net.

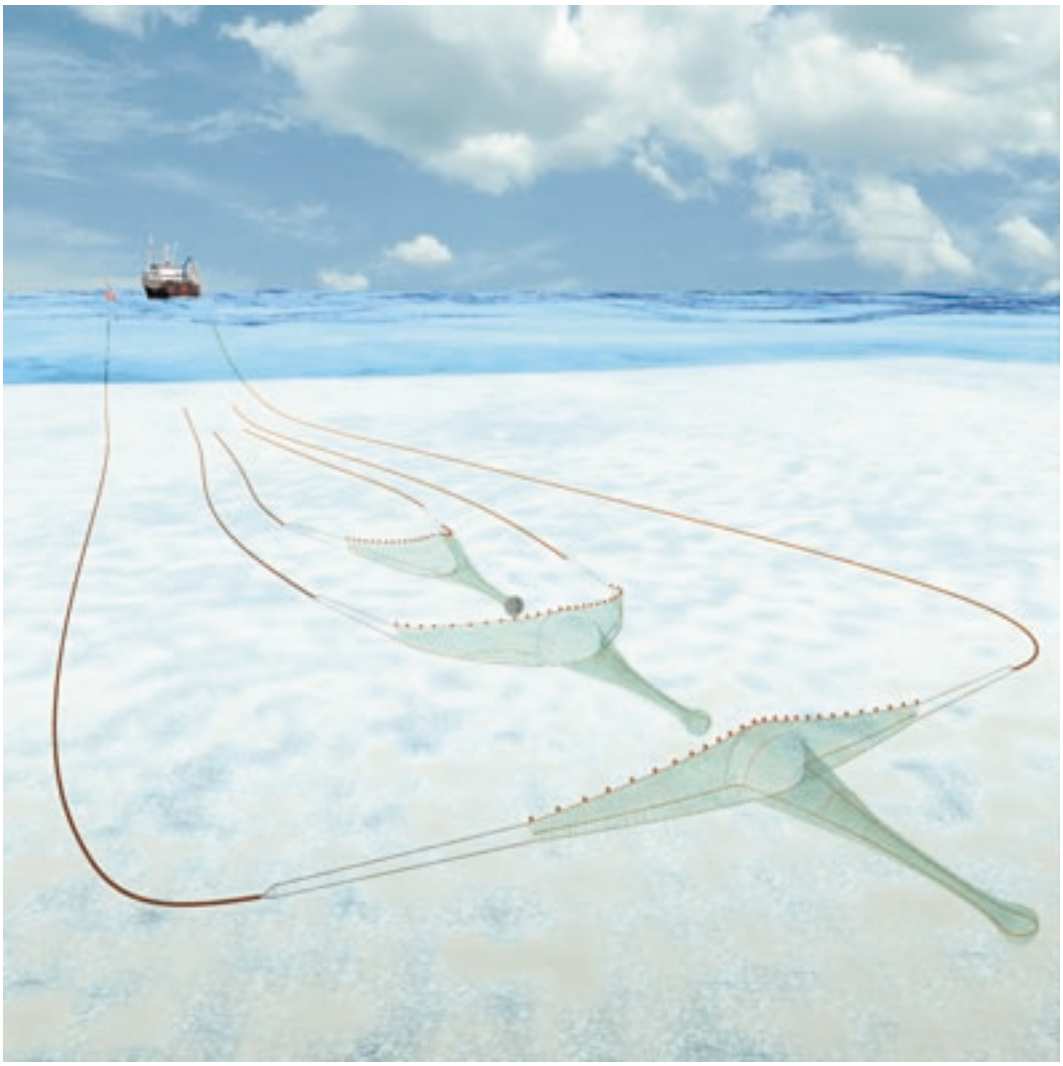


Figure 18. Shooting the Scottish Seine-net

Fishing the Seine-Net

When fish have been located, the vessel takes up position some distance away, depending on ground, sea conditions and the extent of the fish concentration. A dhan, marked with flag and radar reflector, is attached to the free end of the first rope and dropped over the side. The vessel then steams to one side of where the fish have been located, paying out rope as it steams. When it has passed the fish the boat alters course, still paying out ropes, and steams across to shoot the net behind the fish (relative to the dhan). When the net and bridles have been shot in a straight line (Fig. 18) the vessel starts to pay out the second length of rope, shooting several coils before altering course again to head back to the dhan. By the time the gear is set, the dhan picked up and the end of the first rope retrieved, nearly all the length of rope each side is lying on the seabed.

With the vessel maintaining just sufficient way to be going ahead, both ropes are hauled simultaneously, slowly at first, the ropes herding fish towards the path of the net as they close. As hauling proceeds the net slowly picks up speed and begins to move in the direction of tow. Gradually winch hauling speed is increased and the net begins to chivvy fish just in front of it while the ropes continue to herd more fish inwards. When the ropes are seen to be nearly closed they are fast hauled and the net overtakes the remaining fish in its path. Fast hauling continues until the Danlenos are brought to the ship's stern. After the cod-end is emptied the gear is 'laid on' or made ready for the next shot, taking into account whether the vessel will ring to port or starboard.

Pair Seining

Traditionally, pair seining involved a second vessel picking up the dhan and both vessels towing the gear in the manner of a demersal pair trawl before hauling as described above. This procedure substantially increases the area of seabed swept by the gear and can improve catches when fish concentrations are small and widely dispersed. However, on dual purpose vessels pair seines are now commonly rigged, shot and hauled exactly as pair trawls, with wire towing warps and sweeps in front of 880 m of polypropylene seine net combination rope per side (Fig. 19). Vessels maintain station up to 0.5 nautical miles apart while towing.

Figure 19.

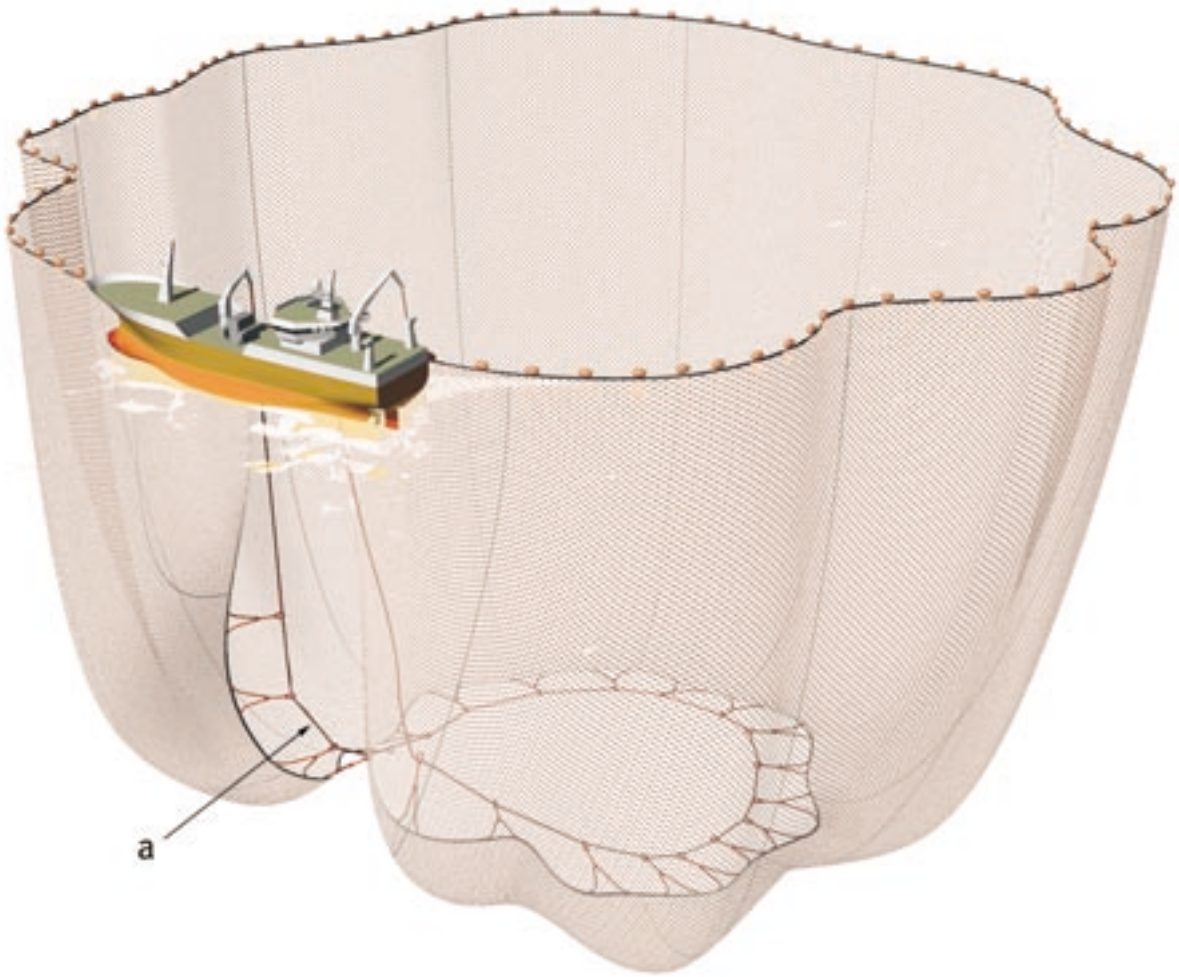


Figure 20.

Purse-Seining

Purse seiners capture large aggregations of pelagic fish that shoal in mid-water or near the surface by surrounding these concentrations with a deep curtain of netting which is supported at the surface by floats (Fig. 20). Small lead weights on the underside of the curtain ensure that the leadline quickly sinks and the net is then pursed under the shoal by heaving on a wire or purseline (a) which runs through steel rings attached to the lower edge of the net. When the gear is closed and fish can no longer escape, the netting is hauled lengthwise using a mechanised power block until the fish are packed tightly in the bunt, or last remaining section of the net to be hauled. The fish are then pumped or brailed aboard the vessel. A large purse seine can be as long as 1 kilometre and 200 metres deep. Purse seiners generally try to avoid bottom contact as the small mesh nylon netting is easily damaged.

Figure 21.

Potting and Creeling

Creels and pots are small traps (Figure 21) baited with fresh or salted fish which are set down on the seabed to catch crabs, lobsters and *Nephrops*. They may be fished singly but most commercial fishermen use them in strings as shown in Figure 22.

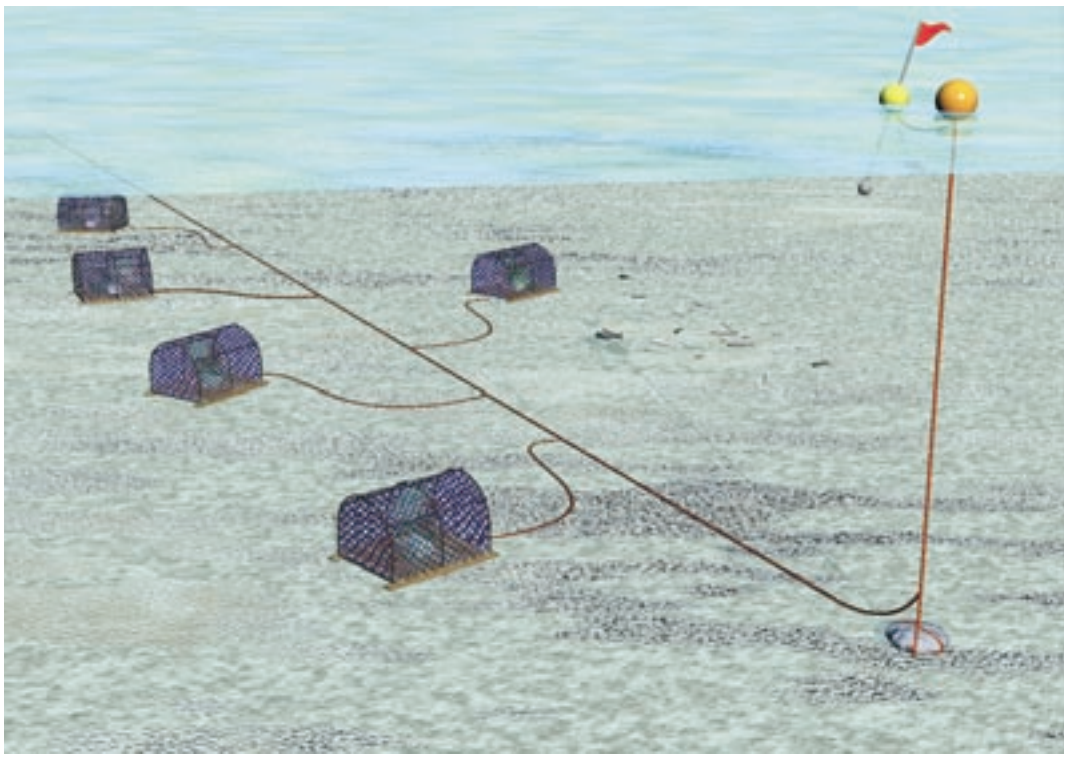


Figure 22.

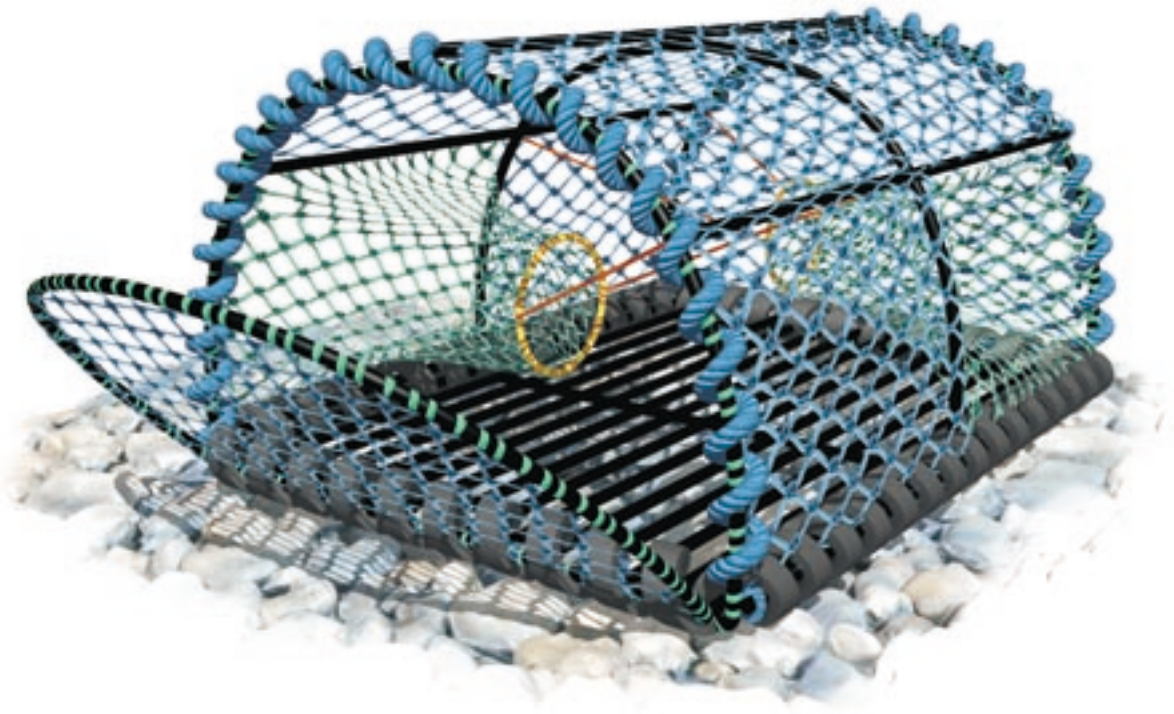


Figure 23.

Creels

Almost all creels now used are constructed from 8 or 10 mm steel rods dipped in plastic for corrosive protection. Most creels are usually made in the traditional 'D' shape (Fig. 23) but some box shape creels are still used. The bases of the creels for crab and lobster are made from longitudinal parallel steel bars whereas the light creels used for *Nephrops* usually have a netting base. The entrances of the creels may be either 'hard' or 'soft' eye. With the 'hard' eye, the apex of the entrance funnel is held open by attaching a plastic ring to the netting, held in place by twine strops. The 'soft' eye has an entrance entirely made from netting, the upper section of the funnel being deeper the lower, which allows a flap of netting to cover the entrance. This acts as a non-return valve. The two types of eye are used for different shellfish. The hard eye allows easier access but also easier escape chances for *Nephrops* and velvet crab, and creels are usually hauled each day. The soft eye is more commonly used for lobster and brown crab. To facilitate the removal of the shellfish and re-baiting, a hinged door is attached at one side, held closed by a length of rubber and hook arrangement. A bait strop for holding the bait away from the walls of the creel is affixed from the top bar to the base. For protection on the seabed, particularly on lobster creels, rope or strips of old car tyre are reeved around the base and up the sides to prevent damage to the steel frame and netting.

Pots

Pots or inkwells (Fig. 24) commonly used in the English Channel by the Cornish and Devon crab fleets are rapidly becoming the most important method used for catching brown crab in Scottish waters, in terms of number of pots used by each vessel and the tonnage removed. The construction of these pots has changed from using natural materials such as cane to plastic piping frames with a netting cover with plastic 'bucket' entrance with a heavy plastic matrix base. The stanchions, base and top area are protected with either rope or old car tyre. A bait band formed by a rubber cross section of car inner tube is placed around the outside wall of the entry bucket, where portions of bait are held in place away from the outside walls of the pot.

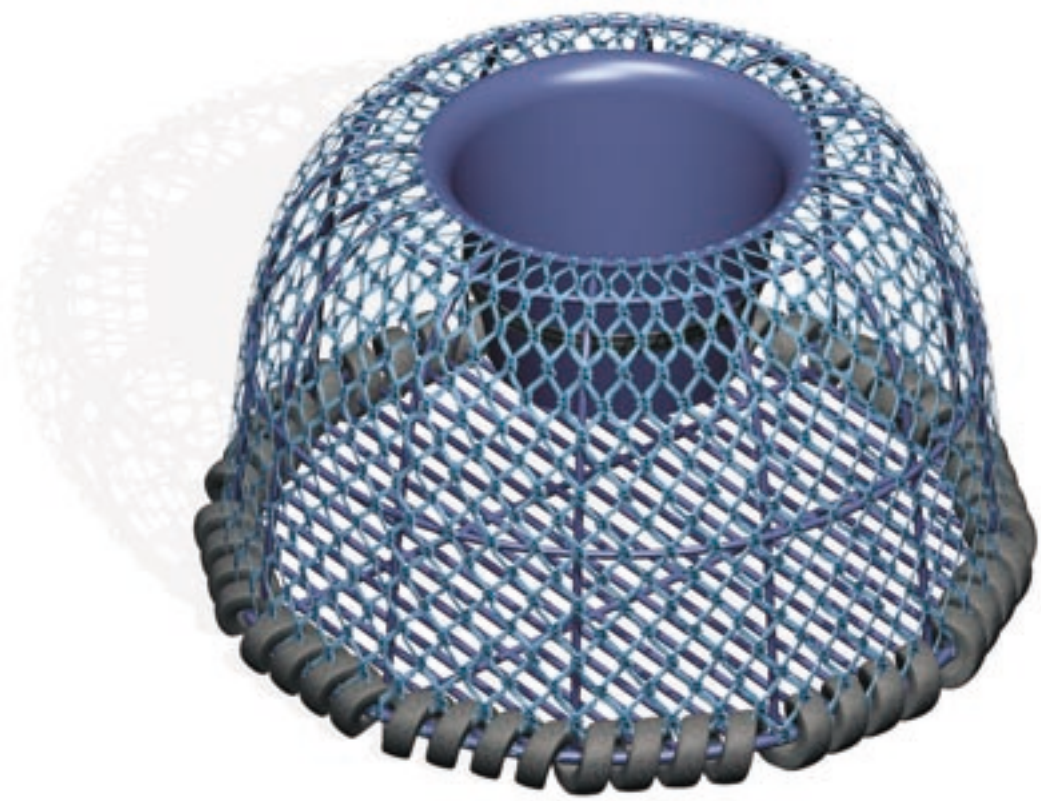


Figure 24.

Fishing Creels and Pots

Operation of both creels and pots may be divided into vessel size, roughly translating into offshore and inshore operation, however this distinction is greatly dependant on prevailing weather conditions and target species.

Creels - (Offshore)

Many creel vessels both large and small tend to exploit the four main shellfish, lobster, brown crab, velvet crab and *Nephrops* with varying effort depending on season, area and personal skill or preference using variations in creel design. Generally, this class of vessel will haul approximately 500 to 700 creels in any one day, but may also have other creels fishing which may only be lifted three or four times per week, such as lobster or brown crab gear. A 10 m creel boat may work 700 *Nephrops* creels but also have another 100 dedicated solely to lobster and crab. Creel vessels in this class tend to be somewhat smaller than the boats solely fishing for brown crab using pots and generally don't have vivier capability. If there is a requirement for in-water storage deck tanks may be fitted. However, these vessels tend to operate on a daily basis, returning to the home port each night and storing catches in large 'keep' boxes on a permanent mooring to await the weekly or bi-weekly market.

Creels - (Inshore)

These vessels are typically 7 to 10 m in length, and may or may not have a mechanical hauling device fitted. This class typically fish primarily for lobster and velvet crab, with limited catches of *Nephrops* and brown crab. The number of creels operated varies from 100 to 400 and as with the larger vessels in this class, a rotational hauling pattern is used. Velvet and *Nephrops* hard eye gear is usually hauled each day with the lobster gear hauled every few days. Due to the physical size of these boats, operation is highly weather dependant.

Pots- (Offshore)

In recent years the number of large vessels operating in Scottish waters has increased dramatically, the vessels are either migratory from areas such as the Channel Islands and south coast ports such as Salcombe and Brixham in Devon, or vessels purely based in Scottish ports such as Stornoway. These vessels, commonly known as 'Super-Crabbers' are between 15 to 20 m in length and have pumped vivier holds for keeping the catch alive for many days depending on catch rate and carrying capacity. The pots are worked in fleets or 'strings' with up to 120 individual pots on one string 15 to 20 fathom apart. A vessel may work up to 20 strings, but usually 10 to 14 is usual with each string being lifted each day if possible. If large numbers of strings are used a rotational hauling pattern is adopted. Most vessels in this class have aft wheelhouses with the hauling block and slave winch on the starboard quarter forrard. The more modern vessels are fitted with shelterdecks to provide crew protection. The areas fished are usually the waters to the west and north of Scotland such as the Butt of Lewis and around the Orkney Isles.

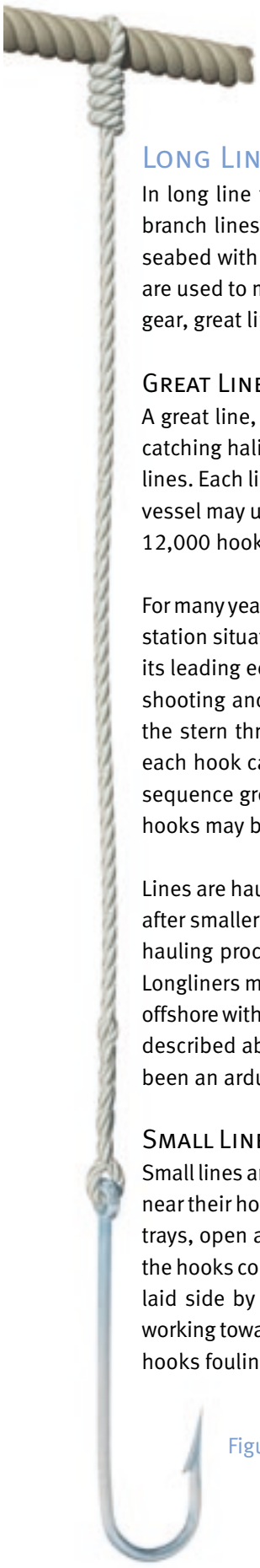
Pots- (Inshore)

Very few inkwell pots are used by small inshore craft, only vessels in the upper size range of this class tend to use them in deeper water for crab. Many fishermen also suggest that this type of pot does not fish as well on the inshore grounds in comparison to the tradition 'D' shape creel.

Scallop Dredging

Each dredge consists of a ruggedly constructed triangular steel frame and tooth bearing bar or sword, behind which a mat of linked steel rings is secured (Fig.25). A heavy netting cover or back (a) is laced to frame, sides and after end of this mat to form a bag in which the catch is retained. Scallops, which usually lie recessed in sand and fine gravel, are raked out by the teeth and swept into the bag. Several dredges are shackled to a hollow steel tow bar (b) fitted with chain bridles (c), one for each dredge. The entire assembly is towed on a single wire warp (d) and larger vessels generally tow two bars, one on each quarter. Ships rigged for beam trawling deploy dredge arrays from outrigger booms in the manner of beam trawls. The number of dredges used varies with towing power, handling capabilities and area, with fourteen (i.e. seven on each side) a fairly typical number, although the largest vessels may deploy more.

Figure 25.



Long Lines

In long line fishing a number of strings each consisting of a main line with baited hooks on branch lines called snoods (Fig. 26), are connected end to end and placed on or just off the seabed with an anchor and dan (marker buoy) at each end. Intermediate dans called 'tellings' are used to mark changes in the direction of the long line (Fig. 27). There are two classes of this gear, great lines and small lines. The main difference lies in the sizes of the components.

Great Lines

A great line, as the name suggests, employs heavier main lines and is used in deep water for catching halibut, cod, ling, tusk and skate. A traditional great line may consist of up to 30 long lines. Each line is typically made up of six strings of 16 hooks fastened together end to end. One vessel may use three or four great lines, with a total length of up to 20 kilometres, bearing up to 12,000 hooks.

For many years pre-baited strings were shot from wooden tubs placed in sequence at the shooting station situated at the vessel's side or stern. As one string was shot the next was moved up and its leading edge joined to the tail end of the preceding string. On modern long liners, however, shooting and hauling procedures have become fully mechanised. Lines are shot directly over the stern through a small hatch in the deck shelter. Automatic baiting machines ensure that each hook carries fresh bait every haul and the line magazines which store line and hooks in sequence greatly reduce the possibilities of foul gear. With mechanised systems up to 48,000 hooks may be worked per day.

Lines are hauled using a constant tension combination hauler which untwists and racks the line after smaller fish are removed by the hook cleaner. Larger fish may have to be gaffed aboard. As hauling proceeds the line magazines are automatically filled in sequence ready for shooting. Longliners may spend many days, even weeks, at sea on fishing banks many hundreds of miles offshore with the catch preserved on ice or frozen. Enclosed deck shelters as well as the machinery described above have considerably improved working conditions for crews in what has always been an arduous and sometimes perilous fishery.

Small Lines

Small lines are much lighter than great lines and are fished from small boats operating on grounds near their home port. The hooks are usually baited ashore and the strings laid in special wooden trays, open at one end and deeper at the other. Each string is coiled into the deep end, and as the hooks come to hand they are baited with mussel, lugworm or pieces of fish, and then carefully laid side by side and row upon row in the shallow part of the tray, starting at the back and working towards the open end. Each row is separated by material such as newspaper to minimise hooks fouling when shooting.

Figure 26. Attachment of Hook to Main Line.

On board the vessel the trays are placed in series near and leading to a metal chute over the stern. After the anchor and first dan are lowered on the fishing grounds the vessel steams slowly along with the strings running out over the metal chute. Each line can bear up to 1,200 hooks and three or four lines may be fished per day. When the lines are shot and the end anchor and dan set they are left for several hours, during which time the crew may fish with hand lines before starting to haul. This may be done by hand but a small mechanical line hauler can be used if engine power is available. After recovering all the gear the vessel immediately returns to port to land the catch in prime condition.

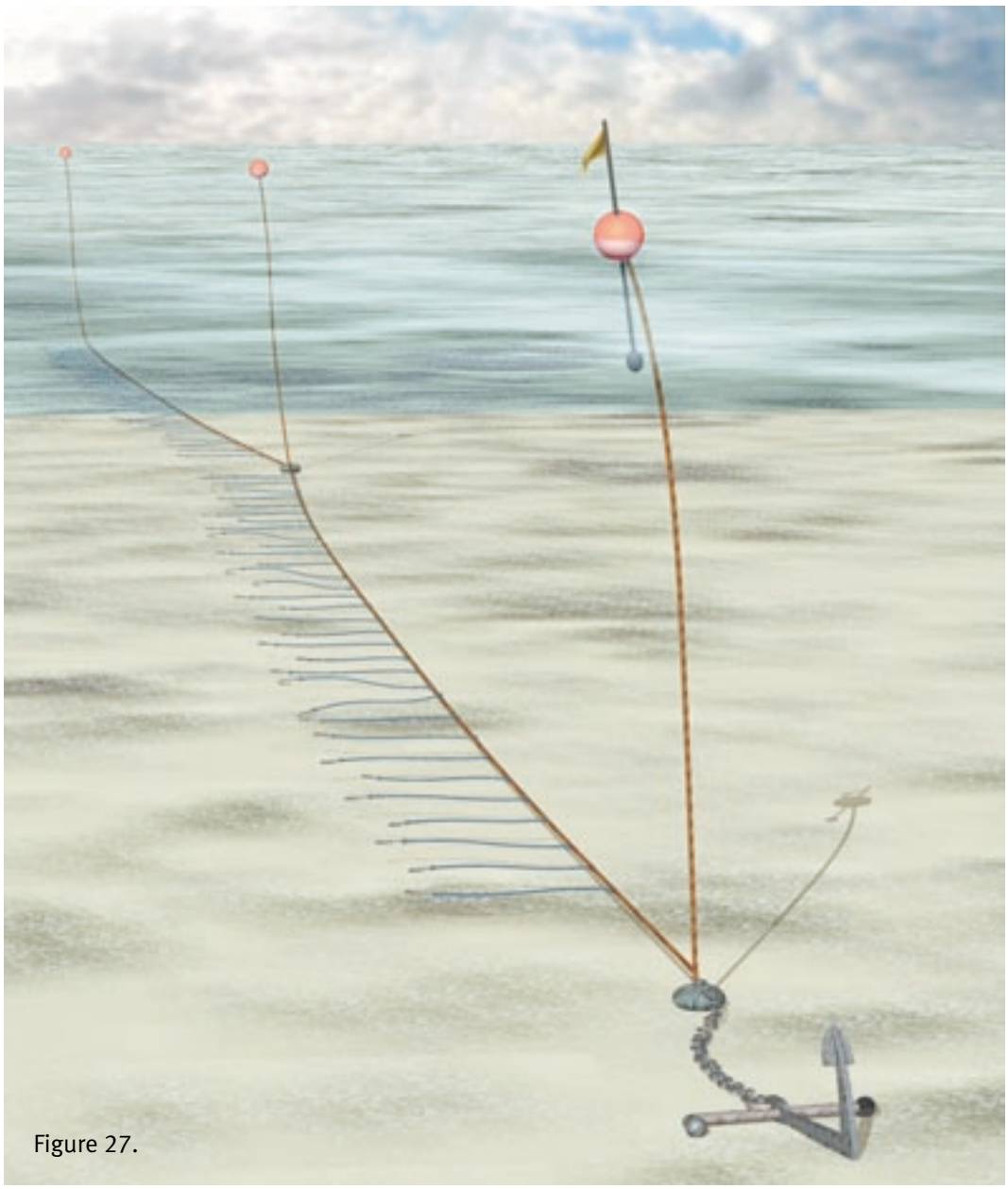


Figure 27.

Set-Nets

Set-nets are long walls of netting which trap fish either by gilling or entanglement, depending on the size of mesh and the tightness of the netting. The netting is hung on ropes and the hanging ratio can range from a loose 0.3 for tangling fish to a tight 0.6 for gilling. Nets for demersal fish are 1.5 m - 6 m deep and between 50 and 200 m long. The netting is mostly woven from fine nylon twine, which is practically invisible underwater under most conditions. Twine thickness ranges from 0.2 to 0.9 mm. Several types of twine are available and the choice is a compromise between stiffness for ease of handling and softness for catching efficiency. Multi-monofilament twine is commonly used and this consists of 8 to 12 strands of thin monofilament, about 0.15 mm thick, lightly twisted together. Scottish vessels are not permitted to carry monofilament nets under 250 mm mesh size within six miles of the coast.

Plastic floats, either ring, cylindrical or egg-shaped, are attached to the headline to keep the netting upright. Floats need to be slightly larger than the mesh opening to prevent them from tangling the netting. Ring floats are convenient as the nets can then be mounted on a solid rod for shooting without snagging. A lead-cored line is attached to the footrope to ensure bottom contact. On large mesh nets for groundfish such as angler (monkfish) and skate that are found tight on the bottom, a polypropylene headline rope without floats provides sufficient uplift. In areas where currents are strong, additional weighting may be added to the solerope. The nets may be used singly or a number joined in fleets with suitable moorings to hold them in place (Fig. 28).

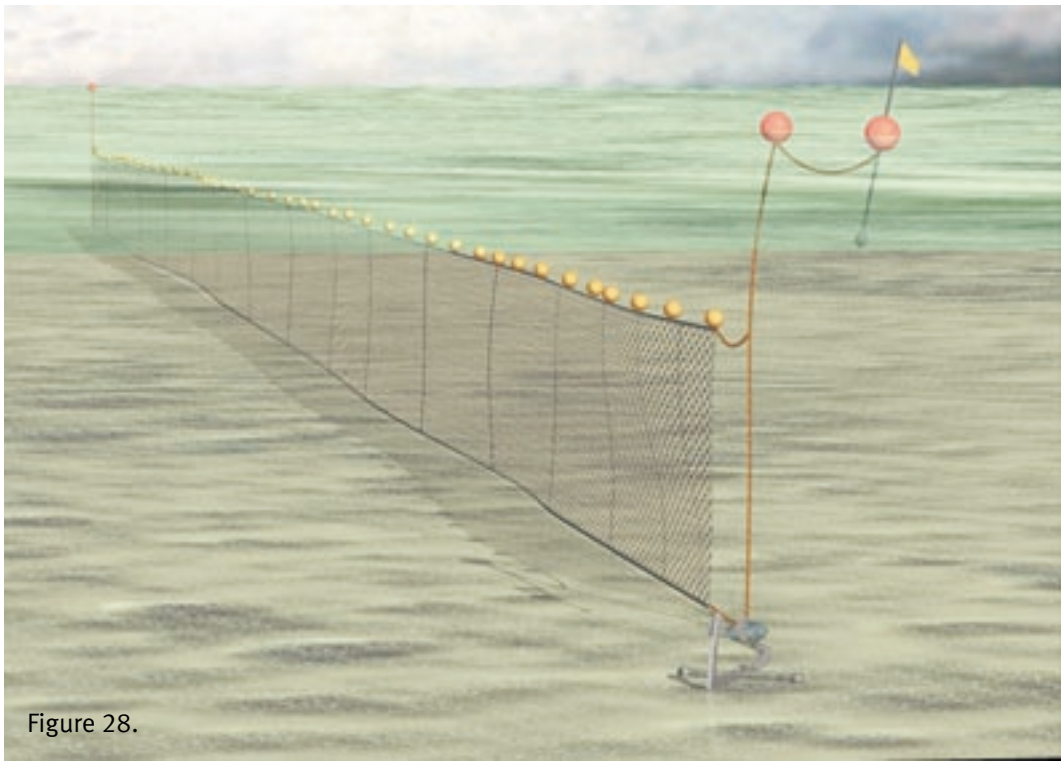


Figure 28.

In tightly hung gill nets the mesh size is chosen to allow only the head and gill covers of the targeted size of fish to pass through and be trapped. Mesh sizes range from 60 mm for bait nets to over 200 mm for large bodied cod and saithe. Mesh size is less important in loosely hung tangle nets. Most fish twist and turn when trying to escape and become very entangled, but a sizable proportion are still caught by gilling. Much larger mesh sizes over 250 mm are used in tangle nets for skate, crayfish and occasionally lobster.

A more complex type of set-net is the trammel-net, with three panels of netting hung together. The inner panel of small mesh netting is very loosely hung between two outer panels of large mesh netting (Fig. 29). When a fish strikes the net it pushes the small-meshed netting forward through the large mesh, forming a pocket in which it is trapped.

In inshore waters set-nets are mainly fished seasonally by small boats for a variety of demersal species. Wrecks and other areas where fish concentrate are fished, and the nets are usually left in the water overnight. If they are left much longer the catch attracts crabs which quickly destroy the trapped fish. Removing crabs from the netting is a tedious and time consuming business. Most small vessels now have powered haulers to recover their nets. Larger vessels which fish offshore may have more elaborate machinery for hauling, clearing and stacking the nets and can work over 20 km of nets.

The main advantage of set nets over towed nets for demersal species is that when tightly hung they are very size selective and retain few juveniles. If shot and hauled quickly the fish quality can be good. They can be used on very rough grounds inaccessible to towed gears. By-catches of crabs are a problem in some fisheries and there is also a risk of catching sea birds and large mammals in larger mesh nets in shallow water.

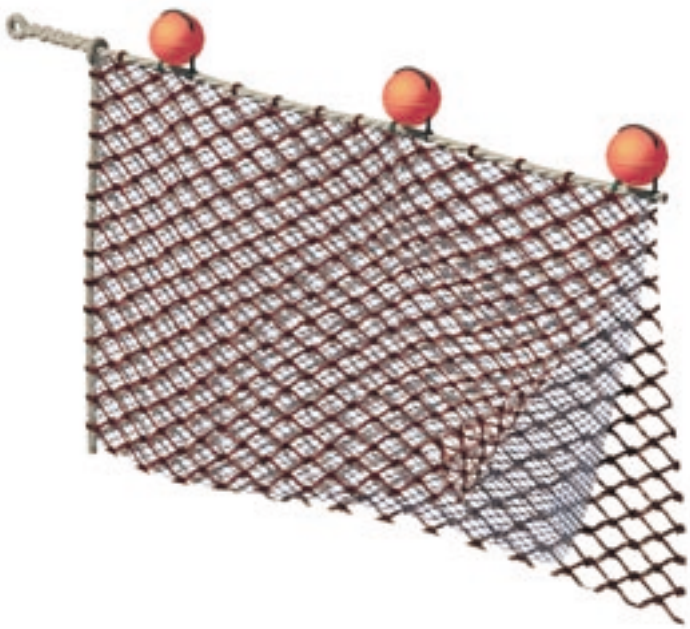


Figure 29.

Bag Nets and Stake Nets

Bag-nets and stake-nets are the commonest types of gear used to catch salmon in Scottish coastal waters. It is unlawful to use these gears inside defined estuary limits. Both nets are designed to take advantage of the habit of salmon of swimming close to the surface when they are following the coastline on their way to fresh water to spawn. Bag-nets and stake-nets are commonly referred to as fixed engines (in contrast to net and coble or beach-seining, *see* below) and no part of either fixed or mobile nets may be constructed for the purpose of catching fish by enmeshment. The minimum mesh size permitted is 90 mm for all of the following gears.

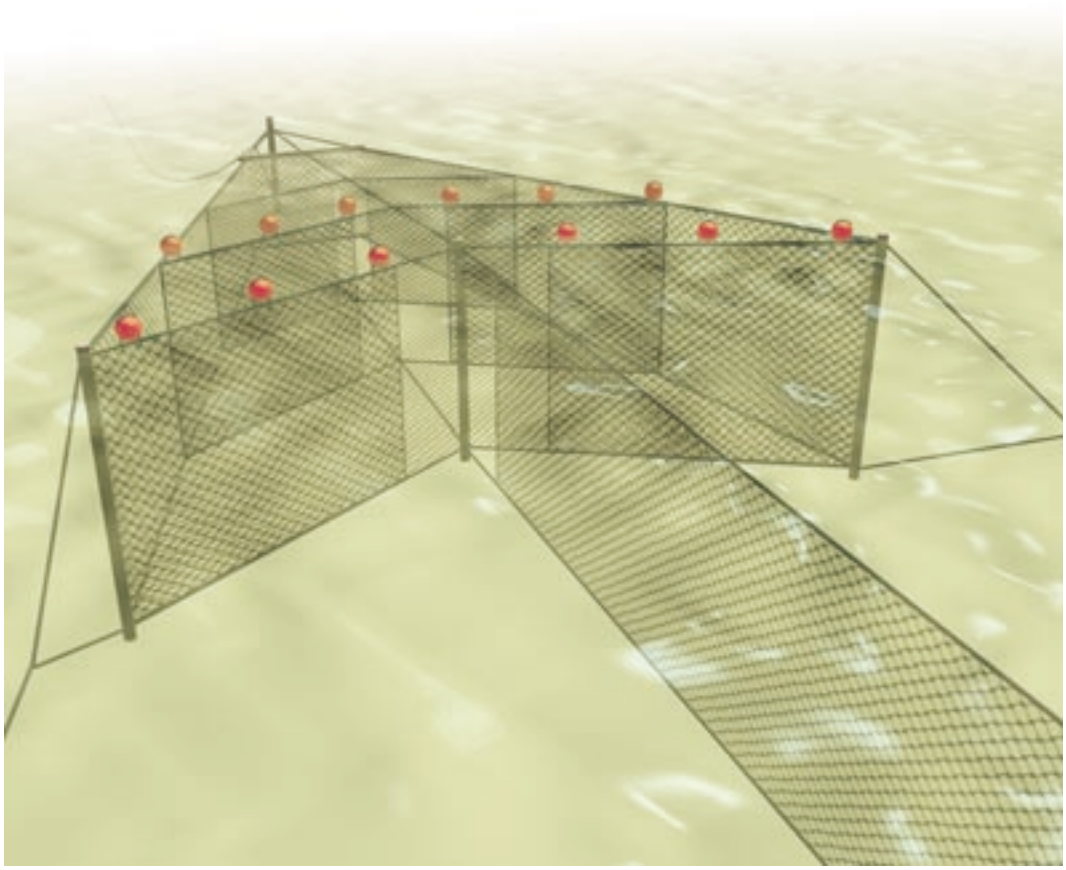


Figure 30.

The Bag-Net

A bag-net consists of two principal parts, the trap and the leader (Figs 30 and 31). The trap is approximately 13.5 m broad and 4.5 m deep at the land end and tapers through three compartments, cleek, doubling and fish court, to about 3 m wide and 2.5 m deep at the head. The compartments are separated by net walls called scales. Each compartment has a net floor or apron, and a net roof covers the the doubling and fish court. The top ropes of the cleeks and the front rope of the roof are fitted with floats. Three poles, the head pole and two cleek poles, hold

the net upright and provide some rigidity. The head of the net is connected to the head pole by bridles. The leader is a curtain of netting fitted with floats on the top rope and extending from the entrance of the trap to the shore. The leader may not exceed 300 m in length and must be mounted so that the hanging ratio is at least 66%. The shore end of the leader is attached to a pole known as a land-stick.

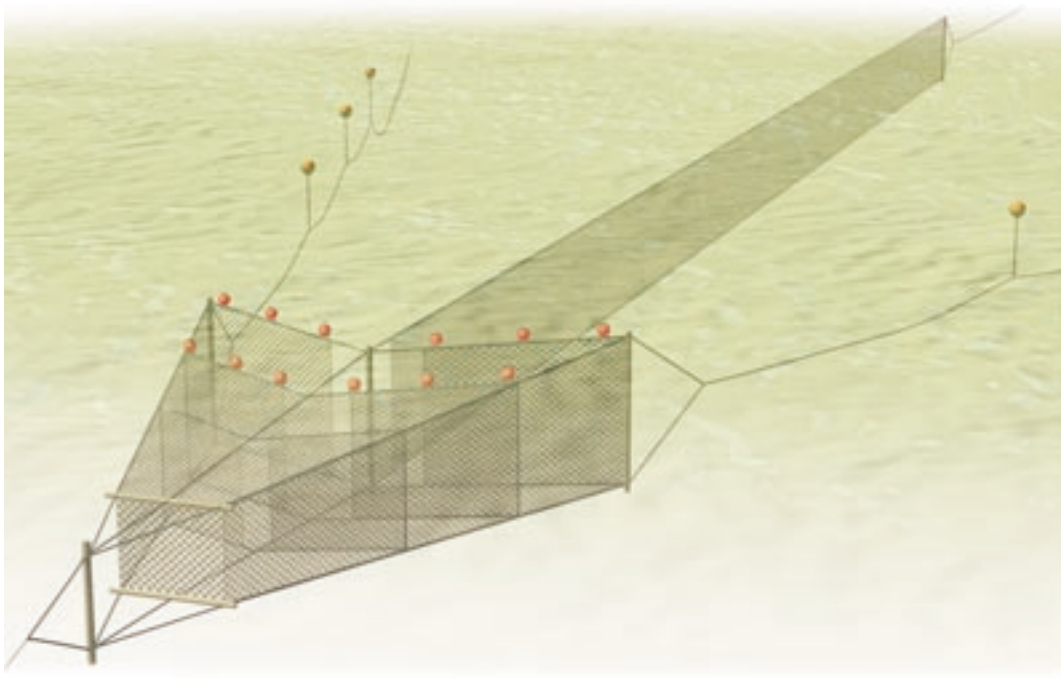


Figure 31.

Bag-nets are set to fish just below the surface, where they are often subjected to broken water and strong tidal currents, and require substantial moorings to ensure they are held in place in good fishing trim. Three sets of moorings are required for the trap. One set heads seawardsfrom the head pole and the other two angle outwards from the cleek poles towards the shore. Each set of moorings consists of an eke rope several fathoms long with which to adjust the set of the trap, up to 70 m of wire rope and 20-40 m of heavy chain ending with a heavy anchor. On rocky coasts the chains attached to the cleek moorings may be fastened directly to the shore by means of ring-bolts driven into the rock. Three or four large floats are attached to each mooring at intervals to provide some buoyancy. The land-stick of the leader is secured to a rock fastening or an anchor.

A further modification has been the introduction of double bag-nets. In this net two traps are joined at the cleeks on one side and fixed with their entrances facing each other at the seaward end of the leader, the whole net taking the form of a ‘T’ with the traps forming the bar.

Fishing the Bag-Net

Bag-nets are normally set on rocky coasts where they will not ebb dry at low tide. They may be set singly or a number may be connected to form a line of nets stretching seaward from the shore. The entire net or line of nets, including leaders or traps but excluding any mooring warps or anchors, must not extend seaward more than 1,300 m from the mean low water mark.The net must be rendered inoperable during the weekly close time from 6 pm on Friday until 6 am on Monday. The net is said to be 'slapped' by the removal of the leader which is replaced by a 'slap-line', a length of rope running from the entrance of the trap to the land-stick.

When returning salmon encounter the leader they tend to turn away from the shore and follow the netting until they are led to the enterance of the trap, where they take the easier route into the cleek. Once within the cleek, the easiest way out is through the large door to the doubling and from there through the small door into the fish court.

The catch is usually removed at high or low water when the tide is at its slackest. Fishing is carried out from a boat, usually a coble, an open decked vessel with flat bottom and high prow. The coble approaches the side of the net from which the the tide is flowing. The top bridle is detached from the head pole to allow the bottom of the net to be pulled to the surface. The crew then bring the boat across the net by pulling on the meshes of the roof and apron together to isolate the fish in the pocket of net formed by the flowing tide. A slit in the side of the fish court is then unlaced and the fish are taken into the boat and killed. The slit is then re-laced, the top bridle re-attached to the head pole and the net put in fishing order again.

Stake-Nets

Stake nets include fly-nets and jumper nets. These are similar in design and operation to bag nets but, whereas bag-nets are floated in deep water and require substantial moorings, stake nets are fished on sandy beaches where the tide recedes sufficiently to leave them high and dry (Fig. 34). Supporting stakes can be erected in the sand without the need for either boat or moorings. Regulations regarding hanging ratios, length of leader and total lengths of net are similar to those for bag-nets.

Traps are usually smaller than in bag-nets and the cleek has neither roof nor apron. In a fly-net up to a dozen stakes may be used to support the trap and up to 35 stakes may be used to support the leader, which is known as the 'tiering'. Fly-nets may be set singly or several sets of tiering and trap may be set in line, usually on beaches with a fairly gentle gradient. The jumper net trap is supported by three stakes and the leader is held at each end in such a manner that it is free to rise and fall with the tide. Jumper nets are almost always fished singly on beaches with steeper gradients than where fly-nets are used.

In the Solway Firth there are some old-fashioned stake-nets whose detailed design and siting are laid down in certificates issued under the Solway Salmon Fisheries Commission (Scotland) Act 1877. They operate on the same principle as fly-nets but they are of a more irregular shape.

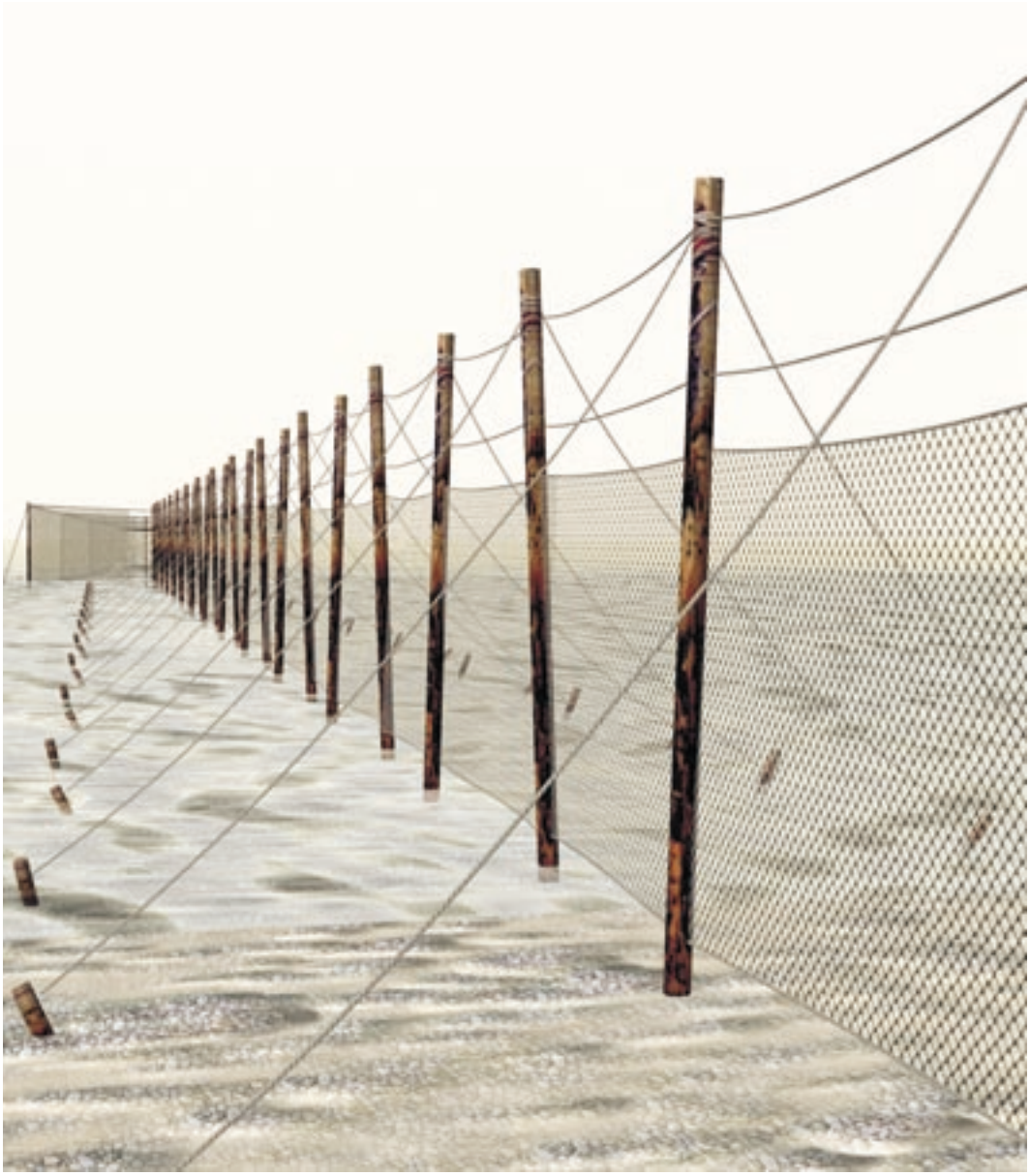


Figure 32.

Fishing Stake-Nets

Catches are removed after high water on an ebbing tide and before the water level in the fish court has fallen to about 1 m. In fly-nets the fisherman walks out along a footrope near the top of the tiering, which may be up to 3 m above the seabed at the seaward end. When he reaches the first trap he moves on to the roof of the fish court, unlaces a slit in the roof and removes the fish with a large dip net. The fish are killed and the free end of a holding rope passed through the gills before the fisherman re-laces the slit and moves on to the next trap in the line. He collects the fish when returning to shore. On steeper beaches where jumper nets are fished the depth of water decreases more quickly as the tide recedes. The fisherman can wade into the trap and

remove the fish through the small door in the fish court. Salmon are also taken from Solway stake-nets in this manner.

Fly-nets are slapped for the weekly closing time by untying the top of the net from supporting stakes and tying the top and bottom ropes of the net frame together to prevent fish entering the trap. In the case of jumper nets and Solway stake-nets the gable end of the net, i.e. the seaward end of the fish court, is opened to allow any fish which enter the trap to swim straight through.

Net and Coble (Beach-Seining)

The only form of netting for salmon ordinarily permitted inside defined estuary limits is known as net and coble, a restricted form of sweep-net or beach-seine. This method may also be used outside estuary limits. A beach-seine (Fig. 33) is a small, single panel surround net consisting of a bag in the middle to hold the catch, a shoulder section at each side and a wing section at each end. The top of the net has a floated headline and the bottom is attached to a lightly weighted solerope. Each wing end is connected by short strops to a danleno stick, weighted at the bottom, and each danleno is connected to a hauling rope.

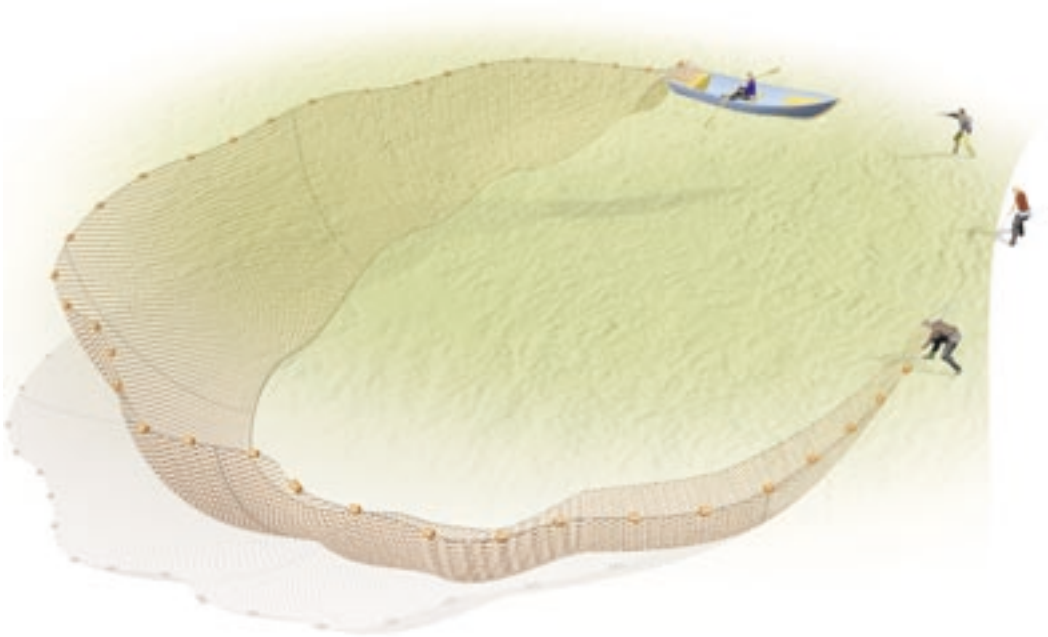


Figure 33.

Fishing the Net and Coble

Traditionally the net is operated from a coble, a small, flat-bottomed, open boat which may be rowed or powered by an engine, particularly at fisheries in larger rivers, and a shore party assists in the operations. The net is stacked on a board at the stern where the downstream hauling rope is also coiled. One of the shore party takes the end of the upstream hauling rope and the net is

paid out over the stern of the coble as it is propelled out into the river then back towards the shore. During netting operations the net and any warps must not be made or held stationary, nor allowed to remain stationary, nor allowed to drift with the current or tide but must be both paid out and hauled as quickly as practicable and kept in unchecked motion by and under the effectual command and control of the fisherman to surround the fish and draw them to the shore. No stakes, dykes, other obstructions or other nets may be used in association with the sweep net and the water must not be disturbed by throwing stones or other objects or by splashing or by any other activity in order to drive salmon into the area to be swept by the net. Typically the shoreman walks slowly down the bank to the point where the boat lands and the hauling rope at the boat end is passed ashore. Both ropes are then hauled simultaneously to draw the net ashore where the fish are removed. The net is then prepared for the next shot while the boat returns to the starting point for the next sweep. Sweep netting is not permitted within 50m of any other such net already being paid out or hauled.

Haaf-Net

The haaf-net, as used in the Solway, is a framed, bag shaped net which is held against the flow of the tide until a salmon is felt to have entered it. The operator then lifts the net to enclose the fish fully (Fig.34). The beam of the net is typically 5m long with the side sticks about 1m. A net may be fished singly or a group of fishermen may form a row across the current; as the tide floods and the water becomes deeper the fisherman furthest from the shore leaves his position in the line and returns toward shore.

Figure 34.

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