Scottish Government
Riaghaltas na h-Alba
gov.scot

Selectivity in Trawl Fishing Gears

Scottish Marine and Freshwater Science Vol 8 No 01

F.G. O'Neill and K. Mutch

marinescotland

SELECTIVITY IN TRAWL FISHING GEARS

Scottish Marine and Freshwater Science Vol 8 No 01

F.G. O'Neill and K. Mutch

Scottish Government
Riaghaltas na h-Alba
gov.scot

marinescotland
science

DiscardLess

www.discardless.eu/
selectivity_manual

Published by Marine Scotland Science

ISSN: 2043-7722

DOI: 10.4789/1890-1

Marine Scotland is the directorate of the Scottish Government responsible for the integrated management of Scotland's seas. Marine Scotland Science (formerly Fisheries Research Services) provides expert scientific and technical advice on marine and fisheries issues. Scottish Marine and Freshwater Science is a series of reports that publishes results of research and monitoring carried out by Marine Scotland Science. It also publishes the results of marine and freshwater scientific work that has been carried out for Marine Scotland under external commission. hese reports are not subject to formal external peer-review.

Report designed by Marine Scotland Communications 2017

THE MANUAL SHOULD BE CITED AS

"O'Neill, F.G. and Mutch, K., 2017. Selectivity in Trawl Fishing Gears. Scottish Marine and Freshwater Science Vol 8 No 01"

INDIVIDUAL FACTSHEETS SHOULD BE CITED AS

"Author, A, 2017. factsheet title. In O'Neill, F.G. and Mutch, K. (Eds): Selectivity in Trawl Fishing Gears. Scottish Marine and Freshwater Science Vol 8 No 01"

The full citation for each factsheet can be found on the Discardless website.

CONTENTS

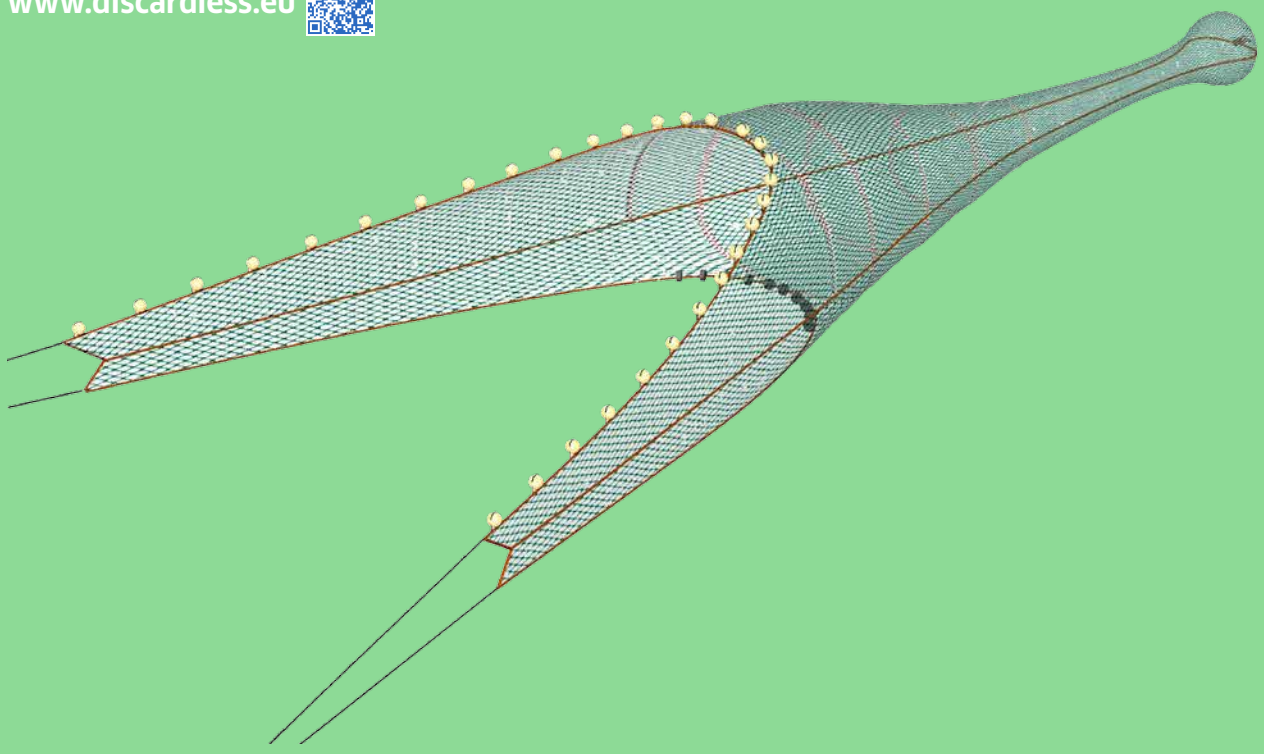
INTRODUCTION

In this manual we describe the different stages of the fish capture process, highlight how different parts of the gear may influence selection and identify possible design changes which can alter the selectivity of the gear. The intention is to make fishermen, net makers and fisheries managers more aware of the possible modifications that can be made to their gears so that they can design and develop gears with a selective performance suitable for their particular fishery.

We have also assembled a catalogue of fact sheets which provide brief descriptions of many of the catch comparison and selectivity trials that have taken place in the North Atlantic and adjacent seas. This is again to highlight the potential gear modifications that can be made and to provide an indication of their likely effect. It is important to bring together this type of information and to disseminate it as broadly as possible. Not only will the preferred selective performance differ at a fishery by fishery level, it may also vary at a vessel by vessel level, as individual fishermen may wish to tailor their gears to the specific catch and quota restrictions they may face and/or to optimise their response to the prevailing market forces.

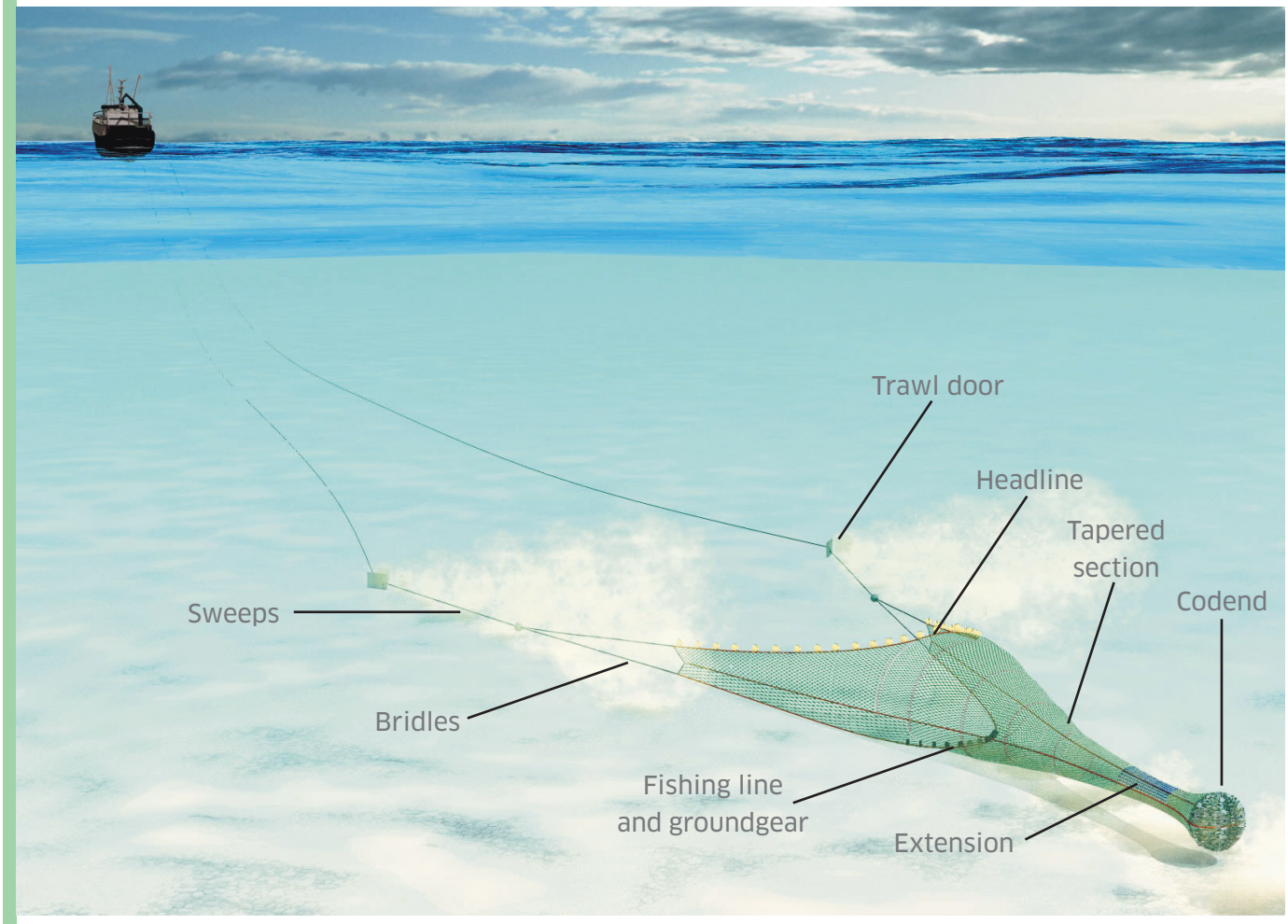
The catalogue of factsheets is by no means exhaustive, indeed, it is just a starting point, and it is anticipated that the web version will be added to and built upon.

www.discardless.eu



TRAWL SELECTIVITY

The selection process of towed demersal fishing gears begins once fish become aware of the on-coming vessel. They are then likely to hear the approaching vessel and the gear as it makes its way over the seabed. As it gets closer, the sight of the gear, the visual contrast it makes with its surroundings and possibly the pressure field associated with the gear will become apparent. The resulting selectivity of the gear will depend on how fish react to these stimuli: whether they are directed into the path of the on-coming gear; whether they avoid entering the gear; or, if they enter it, can escape from the gear.



AHEAD OF THE TRAWL NET

TRAWL DOORS

The first part of a trawl gear that a demersal fish is likely to encounter is the trawl door. They will at first hear it approach and then depending on light levels, turbidity and the visual acuity of the fish, see it. In the wake of the door there will also be a sediment cloud which again may be visible to the fish and present a region of turbulence where swimming and respiration may be impaired. Some fish will react to these stimuli by being directed either outside the doors away from the trawl or between the doors where they may be further herded by the sand cloud into the path of the trawl.

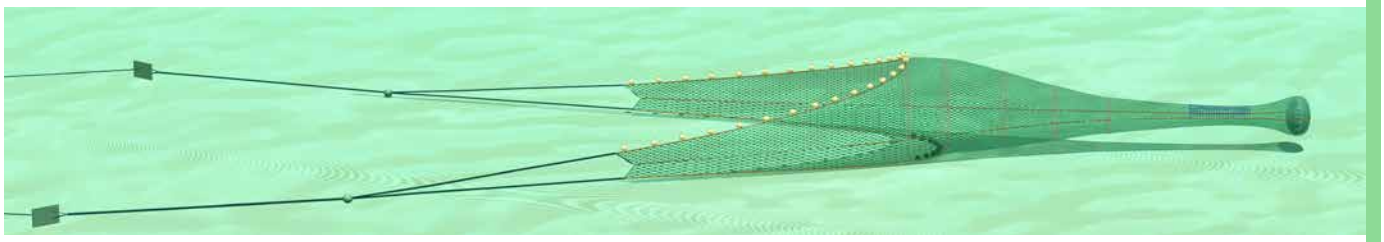


Figure 1. A typical single trawl fishing gear.

One way of reducing this type of directing and herding of fish is to use semi-pelagic doors that do not come into contact with the seabed or to use gears that reduce the amount of sediment put into the water column behind the trawl doors.

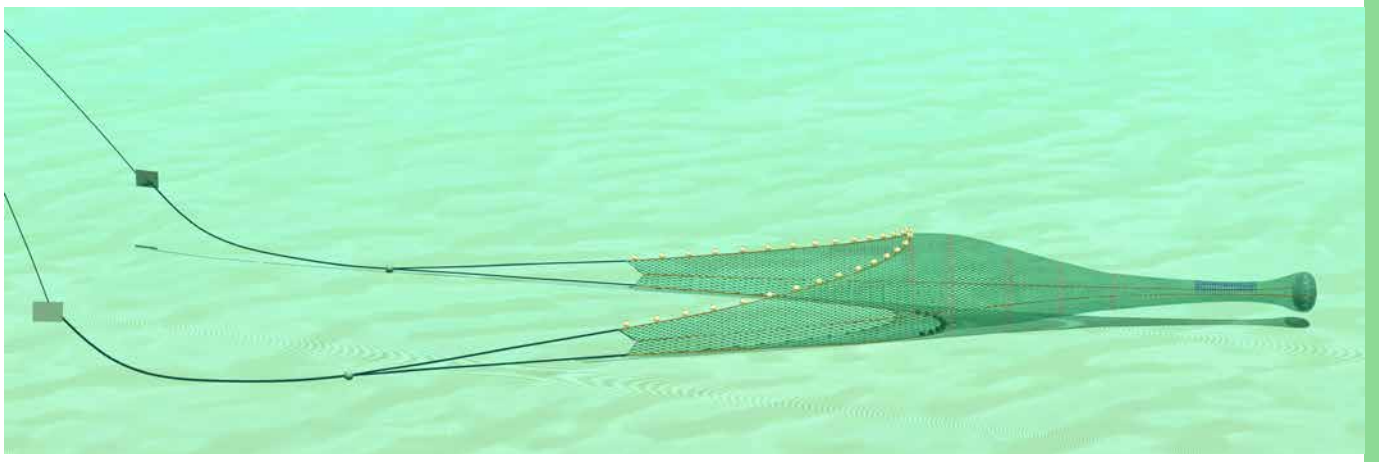


Figure 2. A single trawl with semi-pelagic doors

Semi-pelagic doors have been tested in many fisheries and are usually used with weights or chain that come into contact with the seabed further back along the sweeps. Hence, not only is the sand cloud likely to be reduced, the area swept by the gear is also likely to be smaller which will reduce the area over which the gear fishes.

Door designs that reduce the strength of the wake coming into contact with the seabed will reduce the amount of sediment put into the water column as it is the turbulence in the wake which entrains the sediment and creates the sand cloud. This can be achieved by using high aspect doors or doors which are raised mechanically from the seabed with skids

SWEEPS

The next part of the gear that fish encounter will be the sweeps. The sweeps will also herd fish into the mouth of the trawl. This is particularly the case for flatfish and it is has been shown that the proportion of fish in the path of the sweeps that are herded into the trawl path is dependent on the sweep angle, the sweep length and the contact the sweep makes with the seabed.

If the sweep angle is large, it is more difficult for fish to move out of the way of the advancing sweeps. The sweeps are more likely to overtake the fish and as a result fewer fish are directed inwards towards the gear. The sweep angle can be increased by increasing the spreading force of the doors which can be achieved by modifying the rigging of the backstrops at the back of the doors or by increasing the size of the doors.

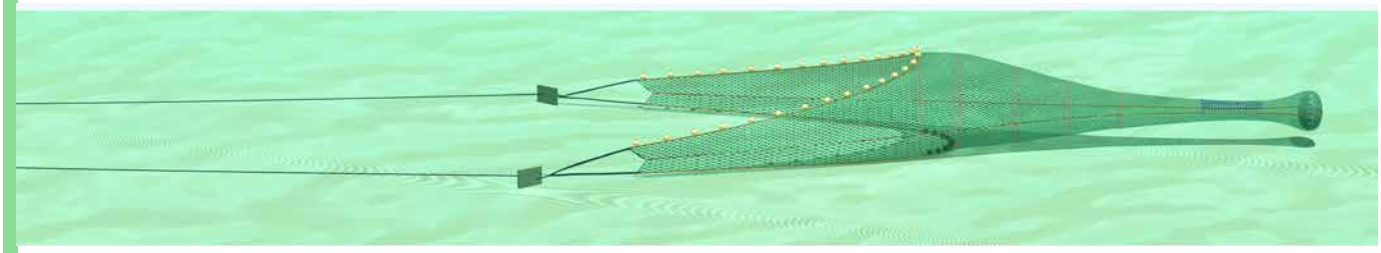


Figure 3. A single trawl with shortened sweeps and bridles.

A relatively simple way of reducing the number of fish that make their way into the trawl path is to shorten the sweep/bridle length. The first otter trawls that were developed had their otter boards attached directly to the wings of the trawl. Sweep bridles were introduced to increase the area swept and to improve catching performance. By reversing this process and shortening the sweeps, fewer herded fish will be directed into the path of the trawl and end up in the catch.

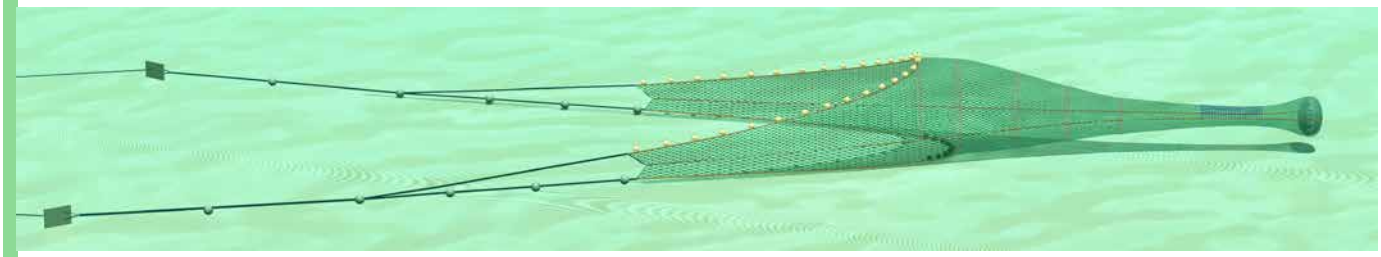


Figure 4. A single trawl with sweeps and bridles raised using bobbins.

Reducing the contact sweeps make with the seabed has also been shown to select fish. This can be done, by adjusting the rigging of the sweeps and, as mentioned above by, using semi-pelagic doors. They can be raised mechanically from the seabed by fitting bobbins at intervals along them; and by using sweeps made from floating or negatively buoyant materials they can be kept above the seabed along their length.

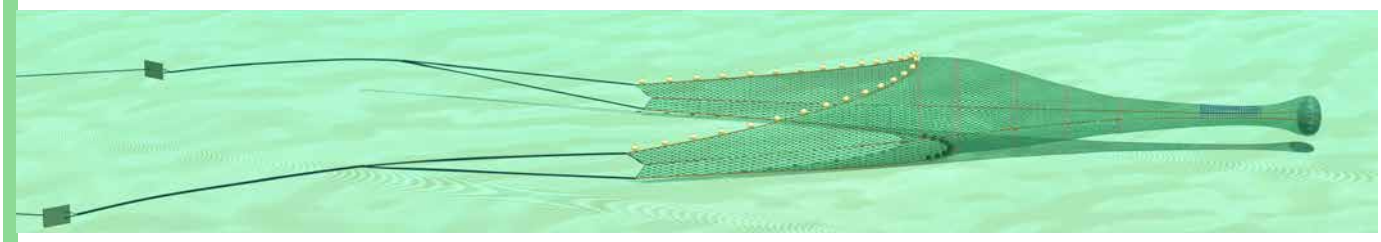


Figure 5. A single trawl with negatively buoyant sweeps and bridles.

MOUTH OF THE TRAWL NET

Once in the path of the trawl fish will either go under the fishing line, into the gear or above the headline as the trawl overtakes them.

UNDER THE FISHING LINE

Some species tend to remain on or close to the seabed and the extent to which these fish go under the fishing line will depend on the height of the fishing line above the seabed and the type, size and design of the groundgear.

One way of setting the height of the fishing line is to use 'dropper' chains. For dropper chains to work successfully the gear must be rigged so that the fishing line fishes above the seabed. The distance between the fishing line and the seabed can then be reduced by attaching dropper chains and can be adjusted by varying their number and density (weight per metre).

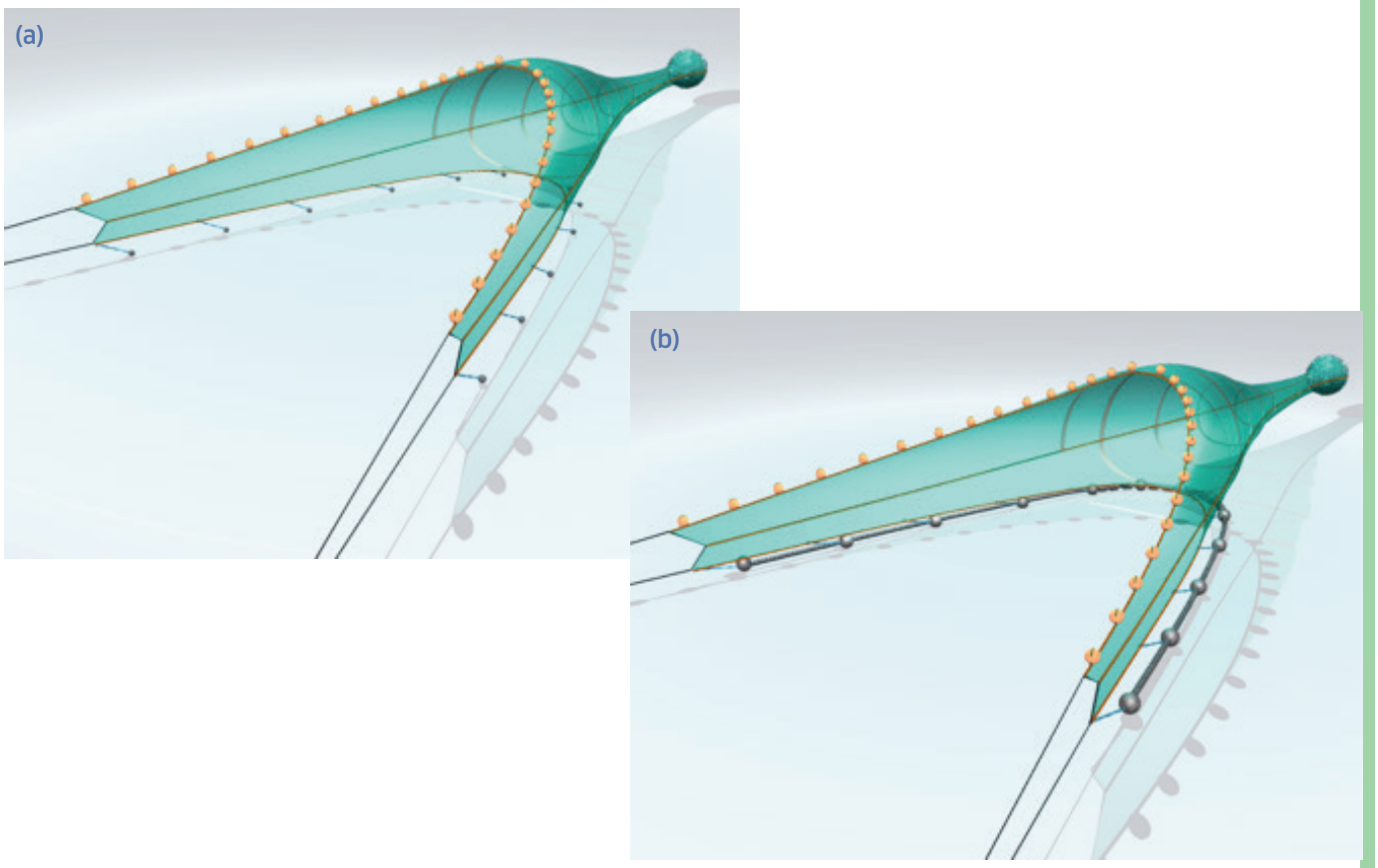


Figure 6. Single trawls with (a) dropper chains along the fishing line and (b) a bobbin ground gear.

Most trawl gears, have a ground gear attached to the fishing line, which both protects the trawl netting from the seabed and ensures that the gear maintains contact with the seabed. Increasing the length of the attachment chains/ropes between the groundgear and the fishing line will increase the height at which the fishing line fishes and increase the possibility of fish passing between the groundgear and the fishing line.

A wide range of ground gears are used, from something as simple as a chain wrapped around the fishing line to large rubber rock hoppers or bobbins. While the specific design will depend to a large degree on the species targeted and the seabed fished, there may still be scope for modifications to provide additional opportunities for fish to pass under the groundgear or between the groundgear and the fishing line. These include changes such as increasing the spacing between disks/bobbins; using fewer of them; and using larger diameter disks/bobbins.

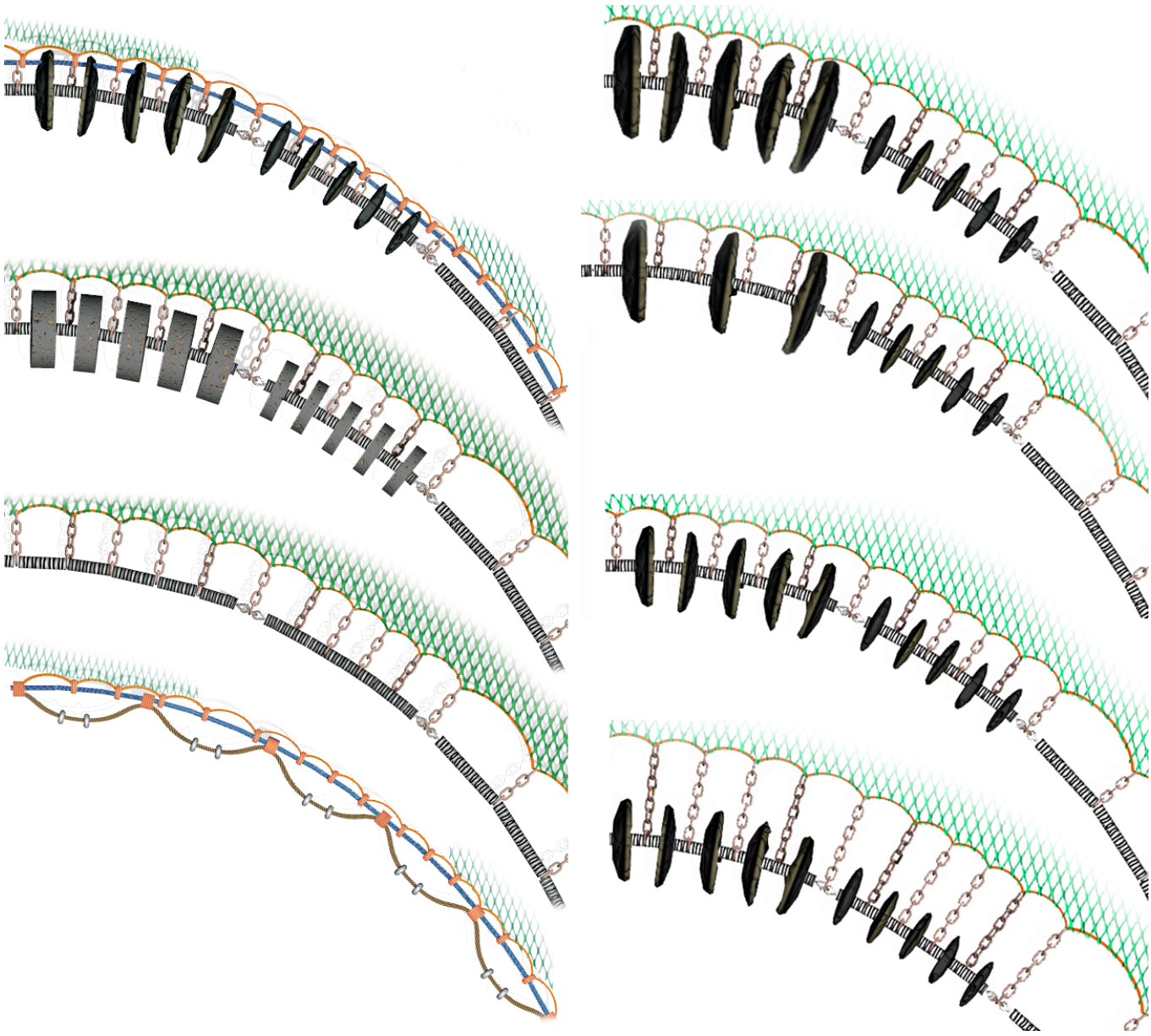


Figure 7.
The first panel illustrates rockhoppers, wheel bobbins, rubber discs and a lead weighted fibre rope. The second panel shows how selection under the fishing line may be modified by increasing the length of the attachment chains, using larger rockhoppers (or bobbins), or using fewer rockhoppers (or bobbins)

ABOVE THE HEADLINE

Some species of fish will maintain their height above the seabed or turn and rise as the trawl overtakes them. Low headline gears, coverless gears and gears with cut-away headlines have been designed to reduce the capture of species that exhibit this type of behaviour. The fish species and the proportion of it caught will depend on the headline height and/or the distance it is behind the fishing line.

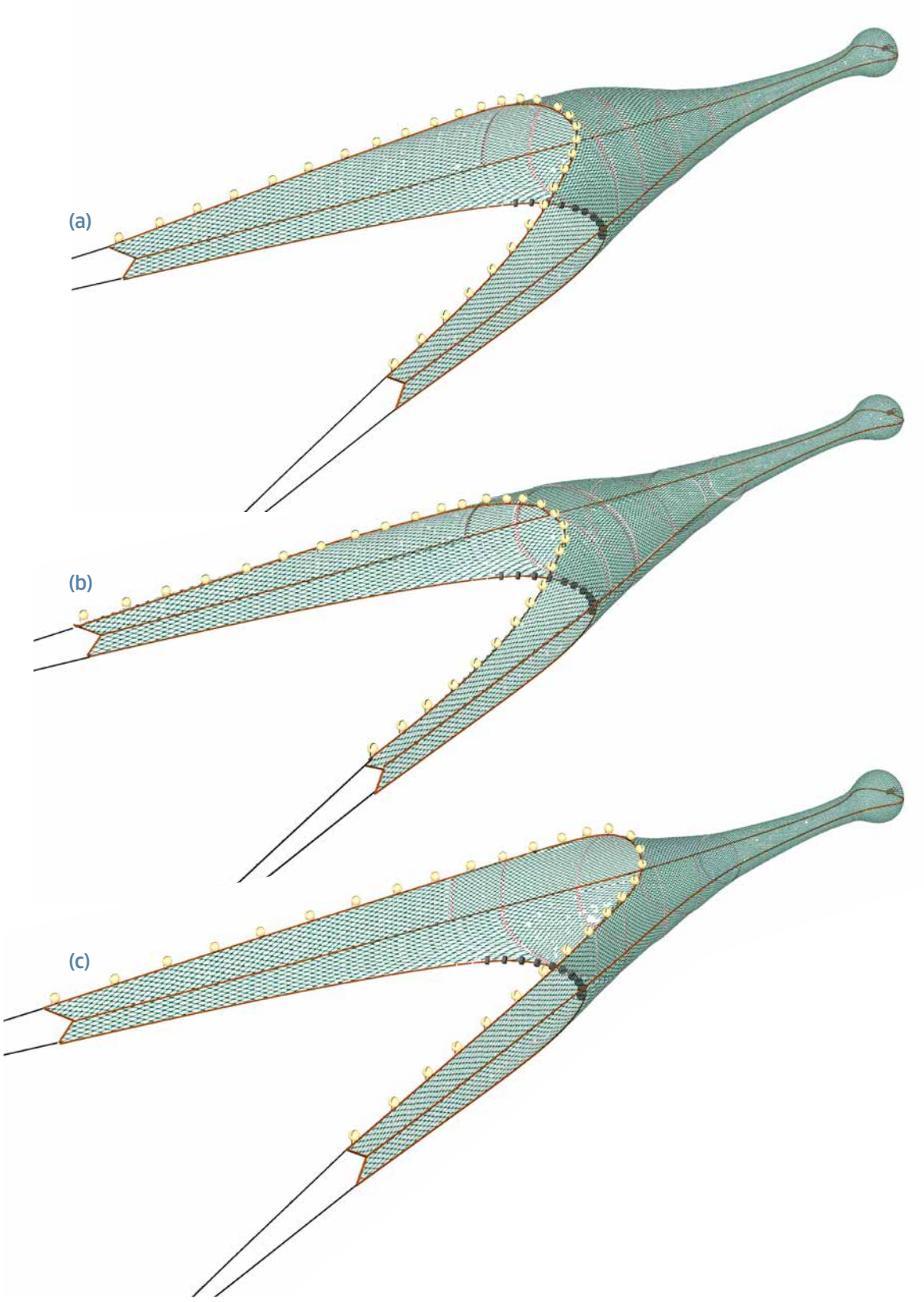


Figure 8. (a) a typical single trawl, (b) a low headline trawl and (c) a cut-away or coverless trawl.

IN THE TRAWL GEAR

The fish that don't escape under the fishing line or over the headline will enter the trawl gear. How and where they enter will vary by species (and within species by size). Some will enter across the full width of the trawl while others are more likely to be herded and enter more centrally. They will also be vertically distributed and having entered the gear will follow specific behaviour patterns. These include:

- **orientating themselves and swimming in the towing direction of the gear;**
- **swimming from side to side;**
- **actively swimming further back into the trawl; and,**
- **more passively, being overtaken by the trawl.**

FRONT END OF A TRAWL

It may be possible to reduce the number of fish retained by the gear at this stage of the capture process by increasing the mesh size, changing the mesh shape or altering the hanging ratio of panels or sections of netting in the upper or lower wings, or in the upper or lower belly sections.

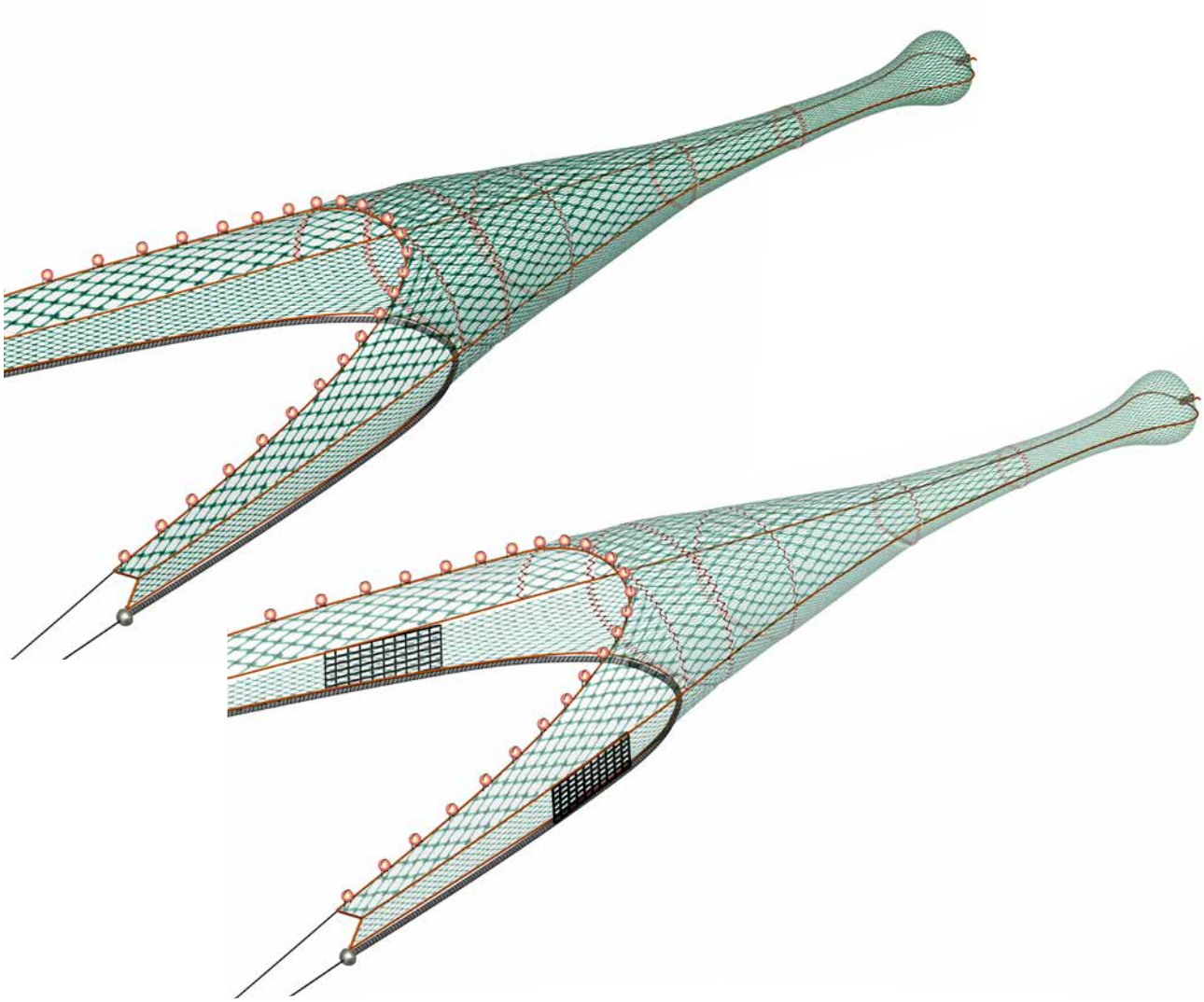


Figure 9. Examples of possible modifications at the front end and taper section of a trawl gear.

Horizontal separator panels have been used to harness the vertical separation behaviour of some species on entering a trawl gear. These operate in much the same way as the low headline, coverless and cut-away headline gears above, but offer more flexibility, insofar as they allow further selection of the separated fish. There have been many trials with these gears and it has been shown that the extent to which a species can be directed above or below the horizontal panel depends on (i) the height of the panel above the fishing line and (ii) the distance it is behind the fishing line.

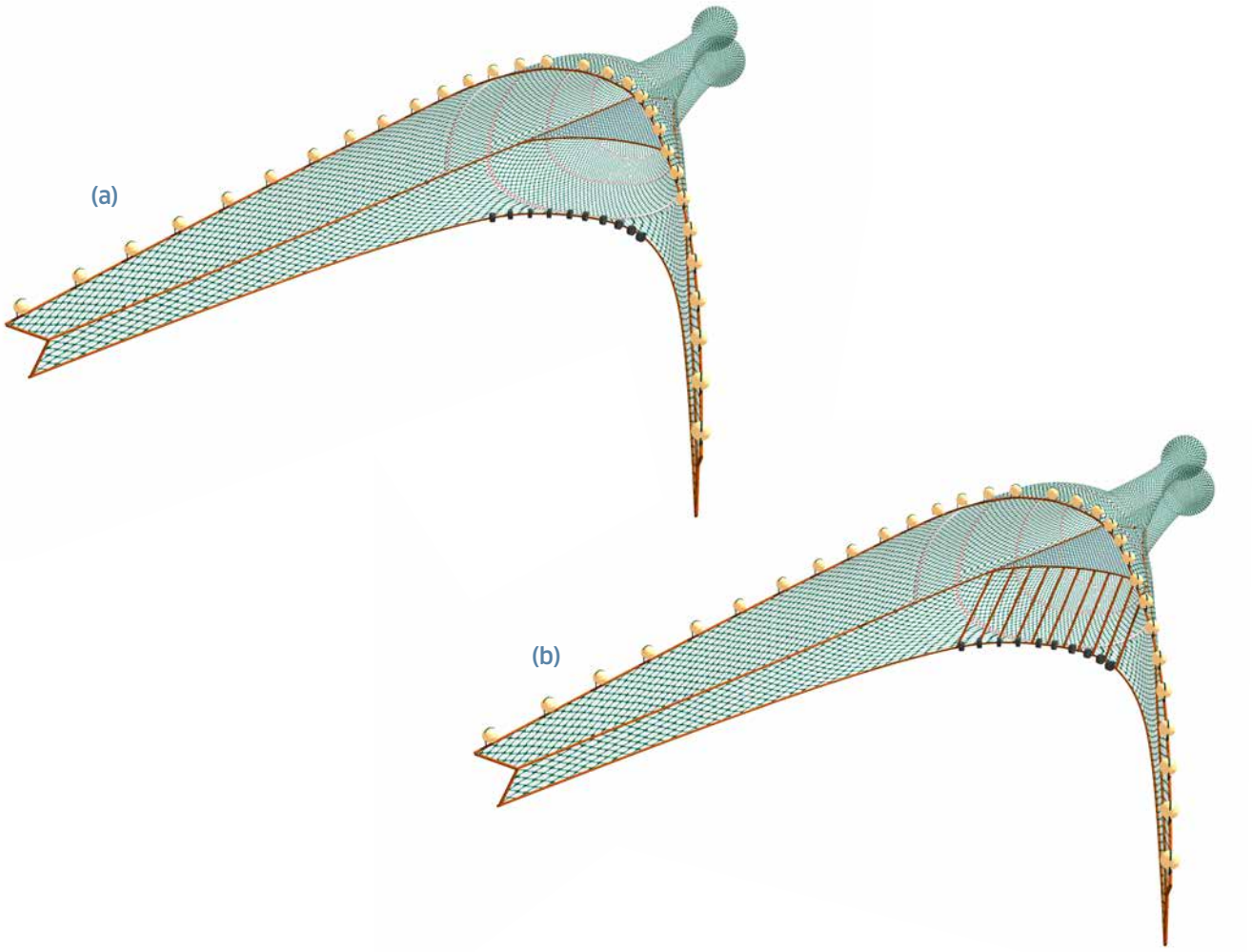


Figure 10.
(a) a single trawl with a horizontal separator panel leading to two different codends and (b) a single trawl with guiding ropes ahead of a horizontal separator panel.

There have also been attempts to modify the vertical separation of species in these types of trawls by using ropes or netting panels to guide fish above or below the separator panel. The success of guiding ropes and panels depends on there being behavioural and/or size differences which favour the passage of one species past the ropes or through the panel and inhibits another.

THE TAPERED SECTION

As the fish travels down through the fishing gear the net tapers progressively until it reaches the extension section. Escape is also possible though the netting panels that make up the tapered section and many of the approaches, mentioned above, such as increasing the mesh size, changing the mesh shape or altering the hanging ratio of panels or sections of netting have been examined. Guiding panels and grids have also been used in this area of a trawl to direct fish to netting panels through which they can escape or to exit holes where the netting has been cut out.

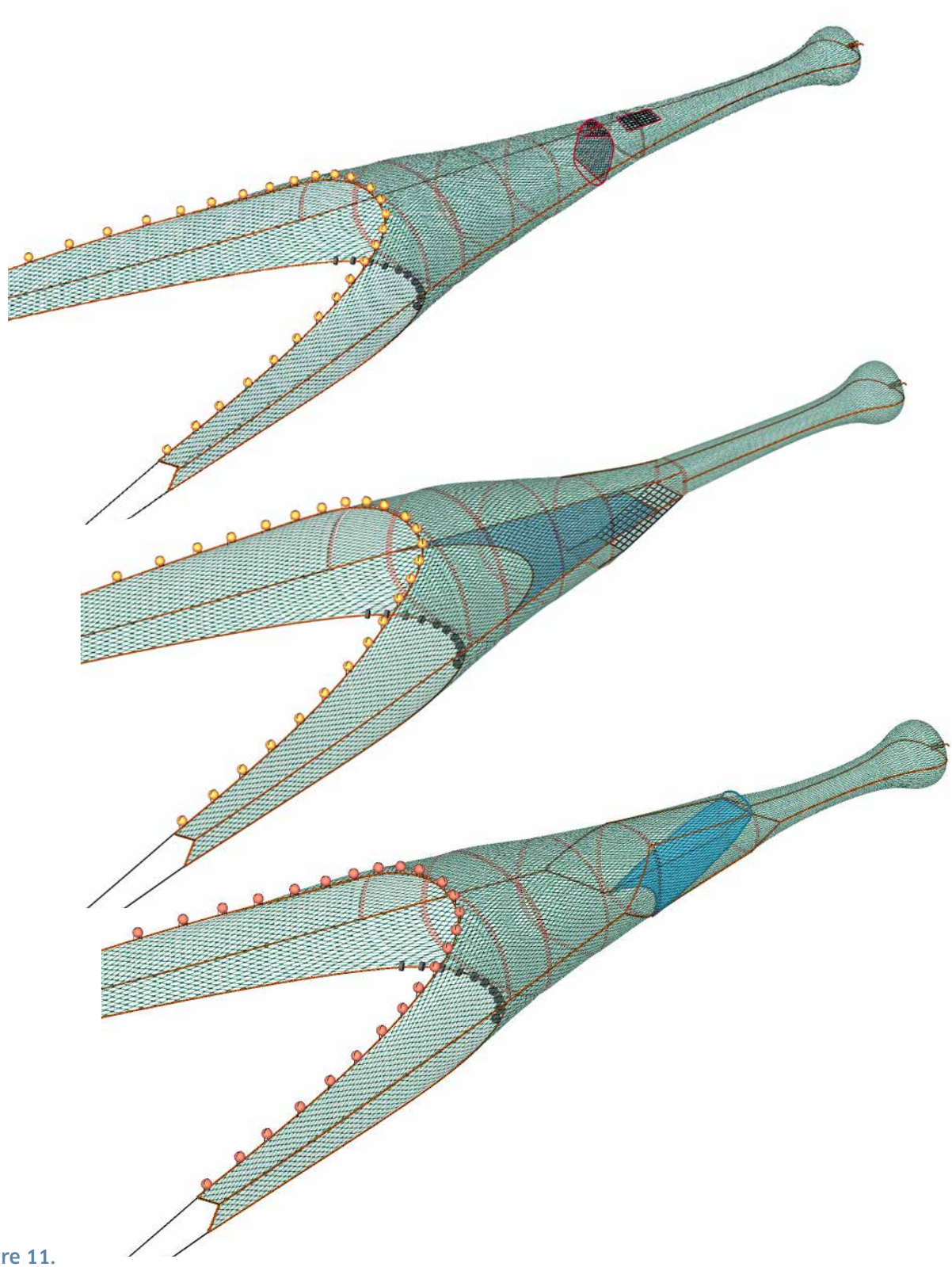


Figure 11.
Examples of the types of modifications that have been made to the tapered and extension sections of a trawl gear.

THE EXTENSION

Many trawls have a straight section called the extension between the end of the tapered section and the codend. It is generally made of diamond mesh netting, the meshes of which tend to close as the netting come under tension as the gear is being towed. The selectivity of a trawl gear decreases as the extension length increases. In long extensions, the meshes close more, the extension is narrower and opposite netting panels are more likely to meet. It is thought that as fish pass down the extension, they are more likely to be abraded and stressed, limiting their ability to make successful escape attempts. Consequently, a simple way of improving selectivity is to reduce the extension length as much as possible.

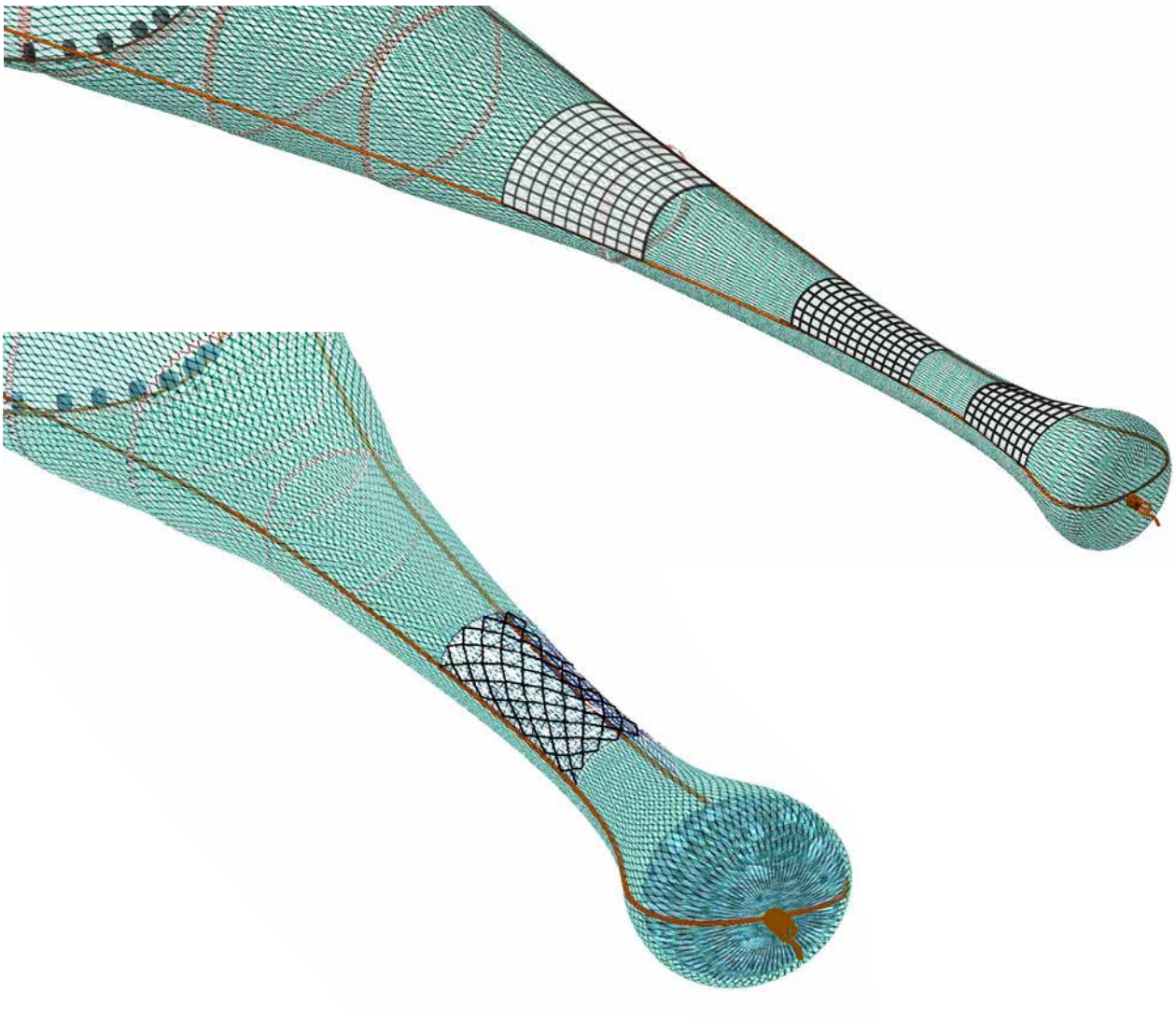


Figure 12.
Netting sections and panels fitted to the tapered and extension sections and the codend of demersal trawls.

Many other ways have been tried to increase the number of escape opportunities in this part of the gear, including fitting different types of netting panels or netting sections. These can have a larger mesh size, a larger hanging ratio or a mesh shape which remains open when under tension. Depending on the species being selected, the panels or sections can be placed in the upper, side and lower parts of the extension and can also extended the full circumference of the extension. There has been a particular focus on square mesh panels and it has been shown that their effectiveness increases as their mesh size increases and the closer they are fitted to the codline.

Rigid, flexible and netting grids have also been utilized in many different types of configurations for both size and species selection. Depending on how they are rigged and fitted and on their design specification, they can be used to reduce the capture of the smaller fish, which pass through them, and retain the larger ones that can't; or to catch a smaller species and permit the escape of a larger one, in which case they are often used in conjunction with exit holes or sections where the netting has been replaced by ropes.

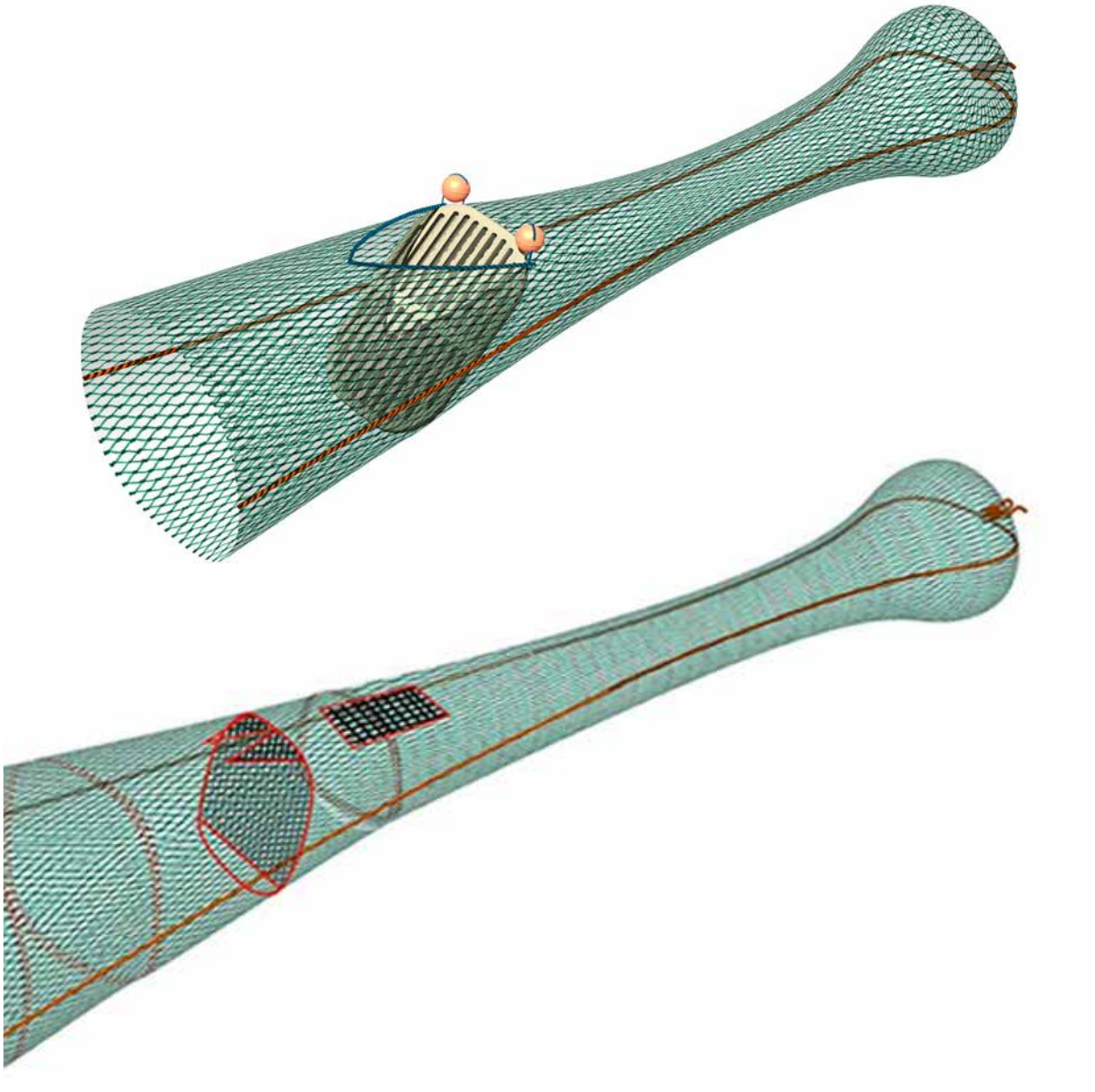


Figure 13. (a) a Swedish grid and (b) a netting grid.

Efforts have been made to improve the effectiveness of these devices. Guiding panels and tunnels, and baffles and deflectors have been used to direct fish towards a selective device or to increase the length of time fish are close to them. Ropes, floats and flapping panels of netting or fabric have been employed to encourage or inhibit the route a fish takes; and deflectors made from fabric, netting or more solid materials have been used to modify the flow patterns in this part of the fishing gear to increase the chance that fish encounter parts of the gear from where they have the possibility of escape.

Attempts to modify the flow patterns in the extension have tried to create areas of low or zero flow in the wake of objects, fine mesh netting or fabric sheets. The idea here is that fish will hold station in the low flow region close to which there will be larger mesh sections or escape holes through which the fish can pass.

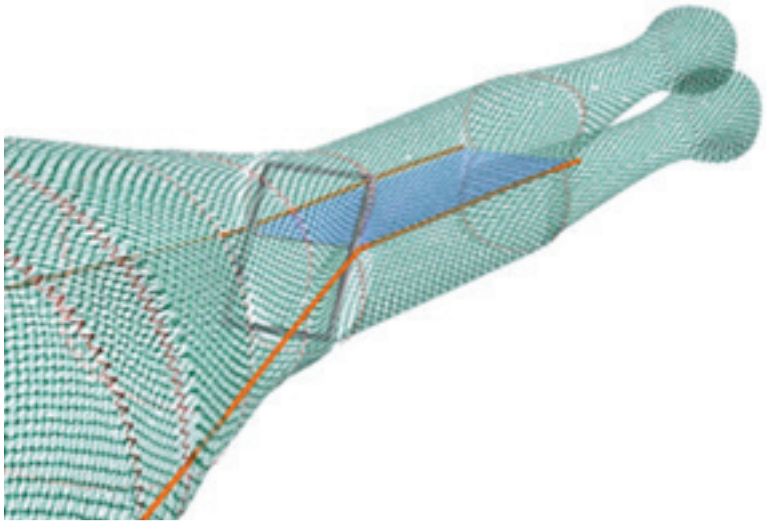


Figure 14. A trawl gear with a frame leading to two separate codends.

Gears have also been developed to separate fish at this point in the gear into different compartments or codends from where further selection can take place. These gears often use guiding panels, grids and/or frames in the extension to enable separation and to facilitate rigging.

THE CODEND

After passing through the extension fish will arrive at the codend. This is the rearmost part of a trawl gear and where the catch accumulates. It offers the last opportunity to escape and most approaches for improving trawl selectivity have focused on selection from this part of the gear.

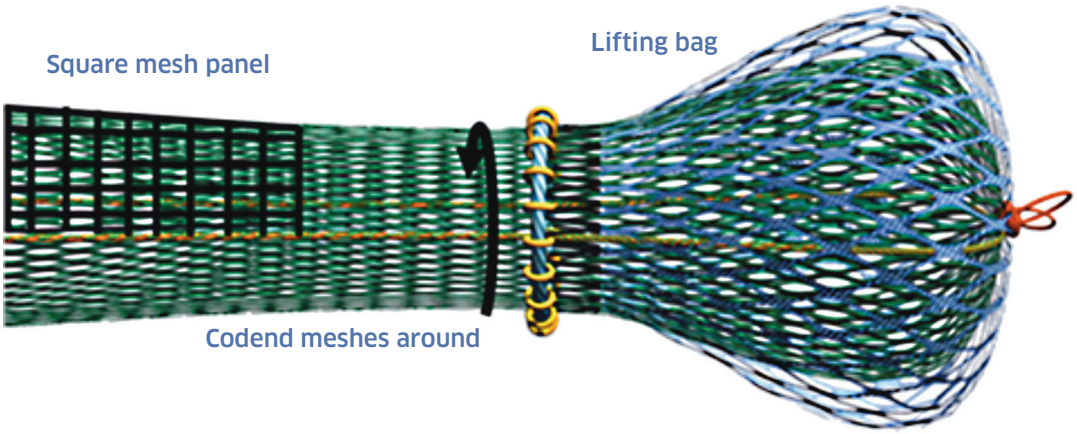


Figure 15. Some of the design characteristics of a codend that influence selection.

The most common way of improving codend selection has been to increase the codend mesh size. However, factors such as mesh shape, twine number and thickness and the number of meshes in circumference have also been shown to be important. The effect of these factors is often more subtle than that for mesh size and can depend on the morphology of the species under consideration. A change of mesh shape (or orientation) from diamond to square or T90 has been shown to improve the selectivity of round fish but can reduce the selection of flat fish or fish with a more elliptical cross-section which can pass more easily through partially opened diamond meshes.

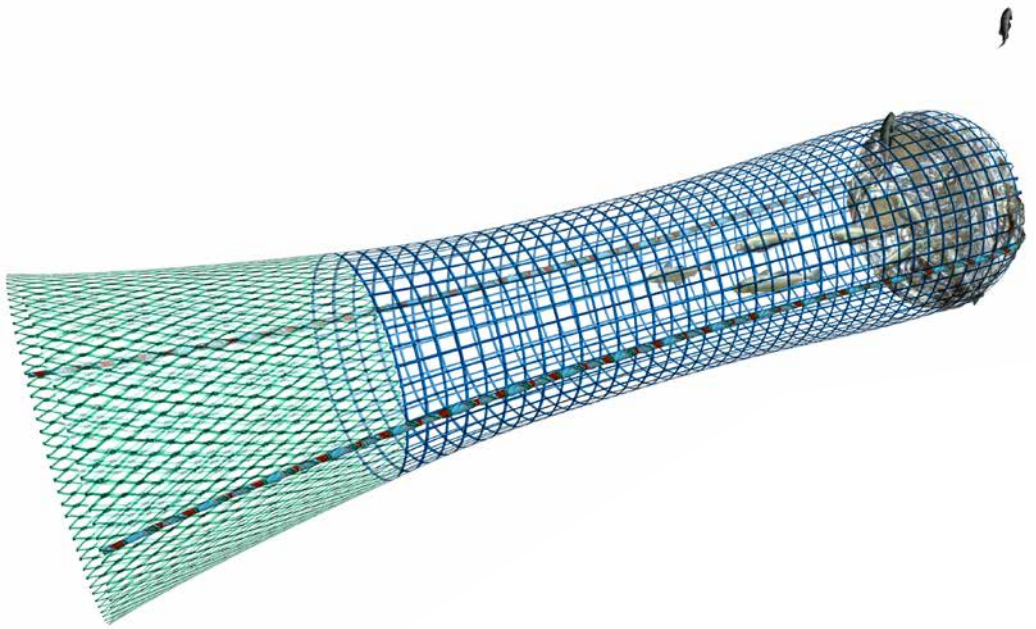


Figure 16. A square mesh codend

Similarly, decreasing the twine thickness or the twine number of the netting material of a diamond mesh codend may improve the selectivity of round fish and reduce that of flatfish. This is because thinner twines are generally less stiff and as a result it may be easier to open standard diamond mesh netting made from thinner twines in the lateral direction. Twine thickness and number may also have a behavioural effect and netting material made from thinner twines will present less of a visual barrier to fish and one which they may be more willing to penetrate. From this point of view the effect of reducing twine number and thickness may increase the selection of both round and flat fish.

Reducing the number of meshes in circumference can also lead to an improvement of the selectivity of roundfish and a reduction of that of flatfish. For a given catch size, the meshes of a codend with fewer meshes around its circumference will have to open more in the lateral direction in comparison to those of a codend with more meshes. As above this can be beneficial for the selectivity of roundfish and detrimental to that of flatfish.

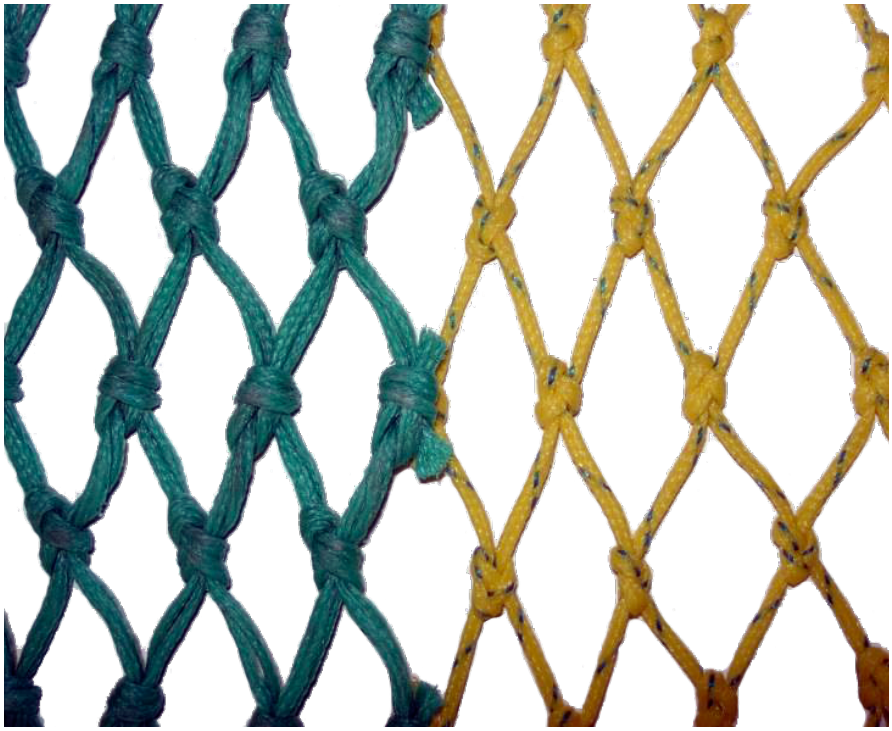


Figure 17.
Two pieces of netting of the same mesh size but made from double and single twine, highlighting how twine num ber may influence the visual contrast of netting.

The use of lifting bags and double codends has been shown to reduce codend selection. In these codends the second layer of netting leads to masking of at least some of the meshes reducing escape opportunities and/or creating a greater visual barrier which fish are less likely to want to penetrate.

Lateral lastridge ropes, lifting beckets or any other attachment which can reduce the cross-sectional diameter of the codend will also reduce the selectivity of roundfish but may lead to an improvement of that of flatfish. Restricting the lateral circumference of the codend also restricts the lateral opening of the meshes which, as explained above, may beneficial for the escape of flat fish and fish with a more elliptical crossection. Longitudinal lastridge ropes fitted in such a way that they are shorter than the stretched length of the netting to which they are attached. These types of lastridge ropes bear the tension that would usually be in the mesh bars allowing the meshes to be opened and deformed more easily. The extent to which this happens will depend on the extent to which the lastridge ropes are shorter than the stretched length of netting to which they are attached.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the many people who have contributed to this manual and the associated factsheets. These include those who were directly involved in the preparation of the factsheets to the fishermen and scientists who took part in the many experimental trials that are reported on. It is important that the results of these types of trials are disseminated as widely as possible as it is by testing and developing new gears to address the discard and unwanted by-catch problems they face, that the fishing industry will ensure a future that is both economically viable and environmentally sustainable.

We must also acknowledge the huge debt we owe the many scientists, fish behaviourists, fishing gear technologists, net makers and fishermen whose research, developments and insights have led us to our present understanding of the fish capture process. Our manual is only the briefest of summaries of this process and, for more comprehensive and in-depth descriptions, we recommend the many reports, studies and reviews that been written by many authors.