Effective discard reduction in European fisheries

Options for fishers and fisheries managers

April 2009

Acknowledgements

The author would like to thank Andy Revill at Cefas and Giles Bartlett, Fisheries Policy Officer at WWF-UK for their input. WWF is grateful to Cefas for the permission to reproduce its photos in this report, and to Fisheries Research Services Scotland for providing the illustrations used here.

WWF is also indebted to the Countryside Council for Wales for its kind permission to use many definitions from its 2001 Glossary of Marine Nature Conservation and Fisheries.

A fully referenced version of this WWF report is available on request. Please contact Giles Bartlett at WWF-UK: *gbartlett@wwf.org.uk*

Prepared by:
Tom L Catchpole, Cefas, Lowestoft
thomas.catchpole@cefas.co.uk

Contents

Foreword

Throwing unwanted fish or 'bycatch' back into the sea is known as discarding. Unfortunately, this has become an increasingly common aspect of European fishery management, because fishermen are required to land a fixed quantity of each species – known as a 'quota'. So any excess that is accidentally caught, or other species for which fishers do not have a quota, cannot be landed and is thrown back – usually dead.

Fishermen, government ministers, scientists and the seafood industry have all agreed that throwing away thousands of tonnes of dead fish is wasteful and must stop. Fish traders, processors, retailers and consumers can help to stimulate better fisheries practice through their purchasing decisions – by choosing seafood products from fisheries with low or no bycatch. This document was commissioned because WWF and Marks & Spencer believe that reducing discards must be a high priority and is vital if Europe's fisheries are to be both environmentally and economically sustainable.

By sourcing seafood from fisheries that apply the most selective gears, fish processors, traders and retailers can reward responsible fisheries and create a powerful incentive for other fisheries to improve their fishing practices. By adopting more stringent policies, suppliers can make buying sustainable fish an easier option for consumers than it currently is. This is where the market can play a crucial role in changing how marine resources are used. Ultimately, such change can assist in achieving Marine Stewardship Council certification – a mark which is increasingly recognised by consumers as the best choice in sustainable seafood.

Marks & Spencer has always sought out the most sustainable sources of seafood for our customers. We hope the examples used in this report will show that there are ways to reduce the problem of discarding, and encourage others to make the most of the new net designs available.

Andrew Mallison
Technical Manager, Marks & Spencer
April 2009

MARKS & SPENCER

Introduction

Discards refer to that part of the catch which is not retained on board during commercial fishing operations and is returned to the sea. Discards can include non-commercial species, non-marketable commercial material and marketable organisms. Discarding can be highly variable in time and space. Catches of fish are influenced by environmental factors, fishery regulations and individual fishers' behaviour. Which part of that catch is retained onboard and which part is discarded is determined only by the behaviour of the fishers, who are influenced by economic forces landing constraints.

As well as being a waste of raw materials, discarding commercial fish represents a loss of productivity to fish stocks. The capture of a large number of unwanted marine organisms is widely considered to be unnecessary and incompatible with the sustainable use of marine resources. However, despite an increasing awareness of the harmful ecological effects of discarding and the negative perception towards it, the quantity of unwanted material caught is still high in some fisheries. In the seas around the UK, about one million tonnes of fish, cephalopods (squid) and commercial shellfish are discarded each year. In England and Wales, around 40% of fish caught by commercial vessels are subsequently thrown away. *(See Summary table, on page 6.)*

The scale of the problem indicates that the reduction of discards is an important management objective. It is now regarded as a priority issue by national and EU fisheries managers. There are various methods available to reduce discarding, including spatial management, restricting fishing time, and improving the selectivity of the fishing gear. Most discarded marine organisms are either species of no commercial value or commercial species that are too small to land. Marketable fish that cannot be landed owing to quota constraints are also discarded. Therefore, the fishing gears used by fishers are often not effective at catching only what the fishers want to keep or are allowed to keep.

The least selective fishing gears are trawls that are towed along the seabed. These account for more than 80% of the discards generated in the seas around the UK. Improving the selectivity of these demersal trawls therefore offers a way to substantially reduce discards. This paper describes some of the advances that have been made in improving the selectivity of demersal trawls.

Table summarising the potential for reducing discards across different fisheries.

Area/Fishery	Year
UK sea all fisheries (excluding west of Scotland). All EU vessels	2005 – 2007
Farne Deeps Nephrops fishery	2001 – 2002
North Sea shrimp	1998
South-west beam trawl mixed fishery (English and Welsh fleet)	2002 – 2005
North Sea roundfish otter trawl fishery (English fleet)	2003 – 2005

Number of fish/species discarded	Percentage discarded	Potential for reduction using different methods
1,000,000 tonnes	40%	Various methods across a range of fisheries and gear types, some examples are described below
4,890 tonnes	43% by weight	70% reduction in undersized fish when using selection grid and square mesh panels
900 million juvenile plaice	100%	33% reduction when using sieve net or 39% when grid is used
68 million fish	71% by number	60% fewer fish discarded using benthic release panels and square mesh cod ends
10.5 million fish	59% by number (predominantly whiting, haddock and cod)	50% reduction of undersized whiting and haddock with square-mesh panels. 90% reduction in cod catches using the Eliminator trawl

1 Trawl types

All trawls are basically funnel shaped nets that are towed through the water. Here we look at the two types of bottom or demersal trawl that are most commonly used in the UK: otter trawls and beam trawls. Seine netting uses a similar capture method and many of the modifications described in this report can be used with this method.

1.1 Otter trawls (and pair trawls)

Otter trawls are named after the devices they use to spread the net, called otter boards. Fishing vessels can tow two otter boards, which spread horizontally when pulled through the water. A net attached to the otter boards via cables called 'warps' is held open by the spreading force of the otter boards *(Figure 1)*.

In pair trawling, two vessels tow a single large trawl; the spread of the net is maintained by the distance between the vessels, which eliminates the need for otter boards. These two types of trawls are widely used in fish and squid fisheries (catching species like whiting, haddock, lemon sole, monkfish, squid and cod) and Nephrops fisheries (Nephrops are also know as langoustine, Dublin Bay prawns and scampi). There are several otter trawl fisheries targeting fish all around the UK and there are Nephrops otter trawl fisheries off the coasts of Scotland, north-east and north-west England, and Northern Ireland.

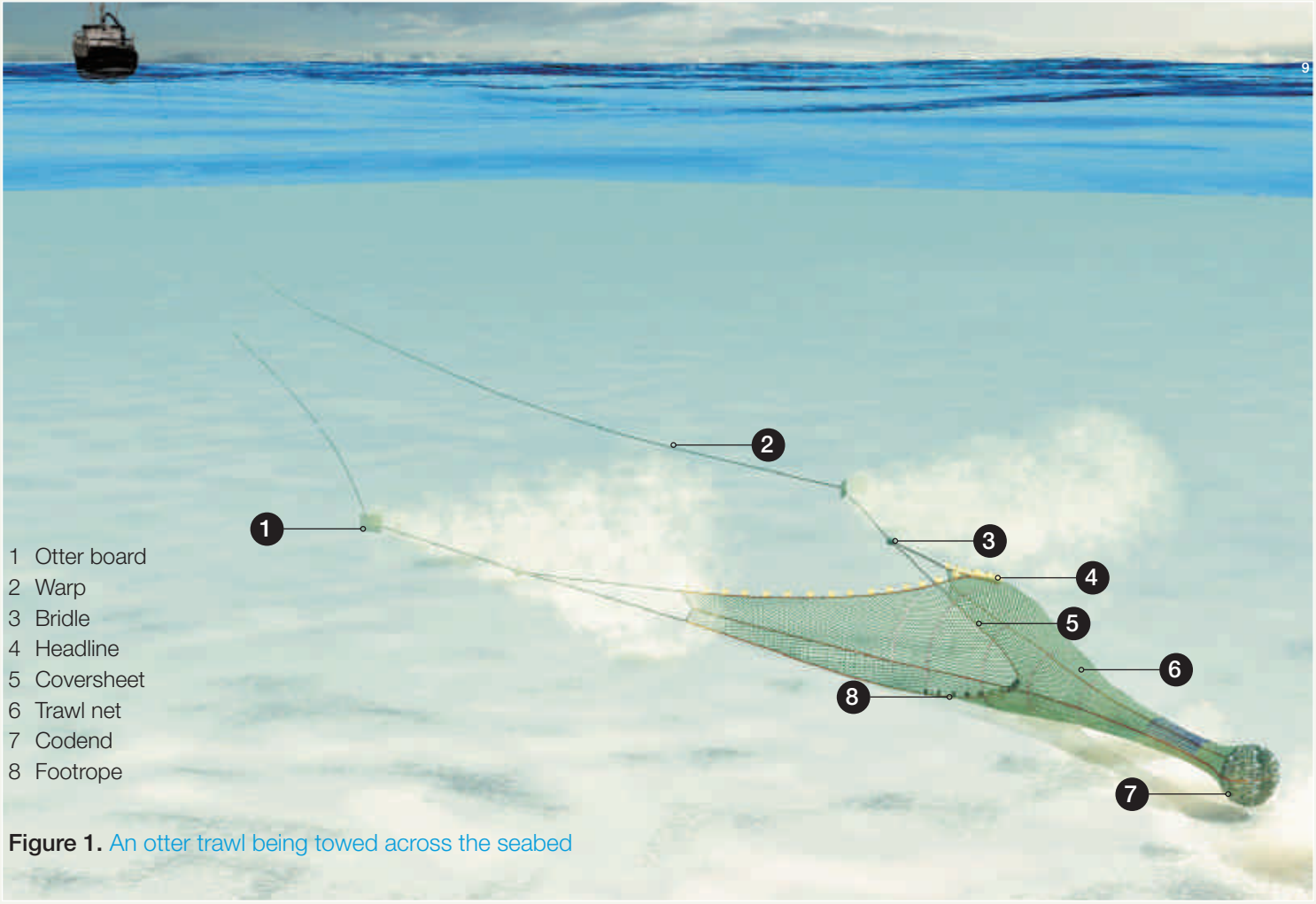


Figure 1. An otter trawl being towed across the seabed

1.2 Beam trawls

Beam trawling involves each net being attached to a boom, one on each side of a vessel *(Figure 2)*. From each boom a cable or warp attaches to a beam, and the beam holds open the mouth of the net *(Figure 3)*. Beam trawls are used to catch bottom dwelling fish, mainly flatfish (like plaice, Dover sole and megrim) but also other fish including monkfish, gurnards, as well as cephalopods such as cuttlefish. UK vessels using beam trawls work from several areas around the English and Welsh coasts but there is a concentration of beam trawl activity targeting fish and cuttlefish in the south-west of England. Another fishery that uses beam trawls is the brown shrimp fishery. The main beam trawl fishery for brown shrimp is in the Wash sea area off the east coast of England.

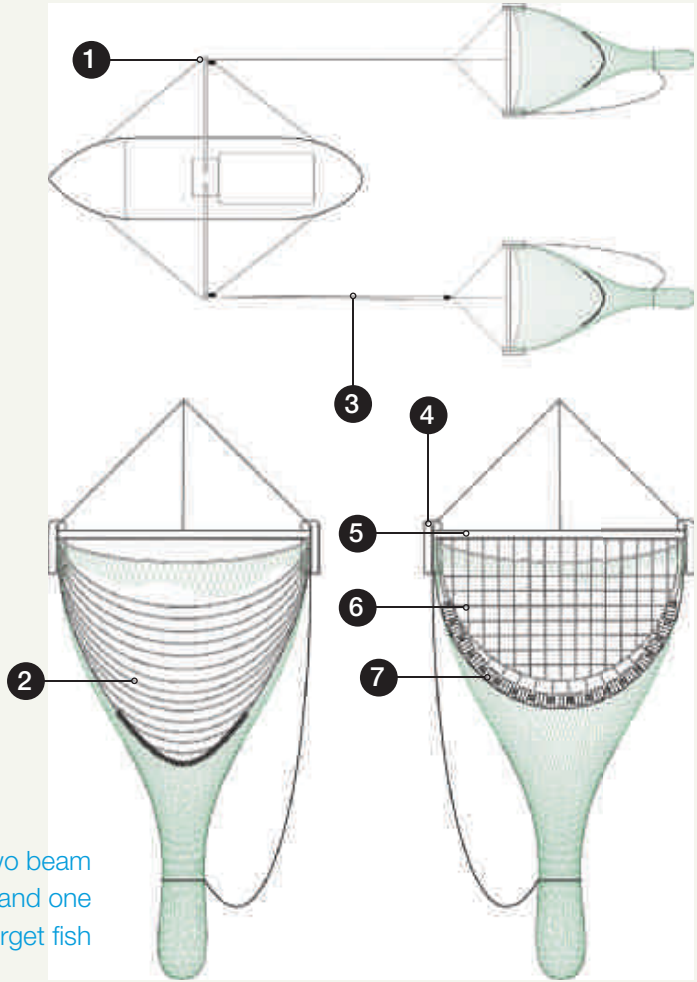
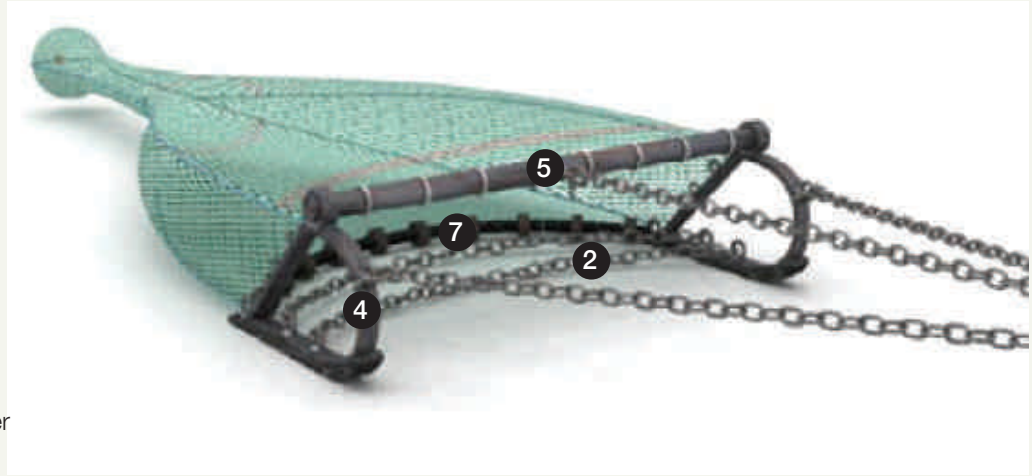


Figure 2. Top, a plan view of a beam trawler towing two beam trawls. Bottom, a beam trawl with tickler chains *(left)* and one with a chain matrix *(right)*, both used to target fish



1 Boom or outrigger
2 Tickler chains
3 Warp
4 Shoe
5 Beam
6 Chain matrix or chain mat
7 Footrope

Figure 3. A typical beam trawl with tickler chains used to target fish

Figure 4. A beam trawl used to catch brown shrimp

Figure 5. A beam trawl with chain matrix used to catch fish (this one also has a blue drop-out panel – *see Section 2.3*)

2 Improving trawl selectivity

Using a trawl to capture fish and crustaceans is not always a simple sieving process. For example, in otter trawling, many fish are herded into the mouth of a trawl by the otter boards, sweeps and bridles (and the sand or mud cloud they create). They remain swimming there until they become tired and drop back into the net. Beam trawling for fish relies less on the herding behaviour of fish and instead uses metal chains positioned in front of the net to disturb fish on the seabed, causing them to swim up off the bottom and be caught in the net *(Figures 3, 4 and 5).*

Crustaceans react to trawls differently to fish. For example, when Nephrops and brown shrimp (which are caught by otter trawls and beam trawls respectively) come into contact with the net, they display erratic escape responses that lift them from the seabed. Beam trawls used to catch brown shrimp *(Figure 4)* are much smaller and lighter than those used to catch fish and they do not use tickler chains.

There are two main approaches to improving trawl selectivity:

1. The first is to mechanically separate the organisms entering the net by size or shape. An example of the mechanical method is the selection grid which, when inserted into the net, allows for the selection of either small or large fish *(see Section 2.5).*
2. The second approach is to utilise the differences in behaviour to separate species. When inside the net, different species react in predictable and different ways. For example, haddock rise up inside the trawl, up to 10m from the seabed, whereas cod remain close to the bottom of the net. An example of utilising behavioural differences is the separator panel. Inserting a panel of netting that divides the trawl horizontally means that species like haddock can be separated from others that stay near the bottom of the net, such as cod.

Modifications to trawls, developed by scientists and fishers to improve selectivity, are described here.

2.1 Conventional codends

The bag at the end of the net is called the codend. In the UK all codends are made with diamond-shaped meshes. Once fish reach the codend and it begins to fill, the netting stretches into a bulbous shape. Only a small proportion of the meshes in a conventional diamond-mesh codend are open wide enough to allow small fish to escape; most fish that escape from such nets do so from the open meshes at the front of this 'bulb'. **Increasing the mesh size of the codend is the most common modification to a trawl that will reduce the capture of unwanted organisms.** The smallest codend mesh size currently used in beam trawls and otter trawls in the UK to catch fish and Nephrops is 80mm.

2.2 Square and diamond-mesh netting

Trawl nets are traditionally made from diamond-shaped meshes. When a diamond-mesh net is towed through the water many of the meshes close under tension, providing little escape opportunity for unwanted fish. It has been seen that when diamond-mesh netting is rigged at a right angle, the meshes adopt a square shape. Experiments have shown that these square-shaped meshes remain more open during trawling, so allowing fish to escape. This configuration of netting is called 'turned 90' or T90. Purpose-made square-mesh shaped netting also demonstrates the same properties and is now being used in different locations on the net to provide escape opportunities for unwanted fish

2.3 Square-mesh panels (or windows)

Using a square-mesh panel in the net is believed to alter the physical conditions in the trawl in a way that encourages an escape response from several fish species. Observations indicate that fish respond actively to a sudden change in water flow and light conditions when they pass from diamond to square-mesh sections of netting. These square-shaped meshes remain more open compared with diamond meshes and so provide escape opportunities for fish and benthic, or bottom-dwelling, organisms. There have been many experiments using square-mesh panels in otter and beam trawls.

Square-mesh panels inserted in the top of the net have been shown to allow the escape of small whiting, haddock, hake and other fish species that rise upwards once inside the trawl. Square-mesh panels of this type are currently used in the whitefish and Nephrops otter trawl fisheries in the UK *(Figure 6)*. Square-mesh panels inserted in the bottom of the trawl have been shown to reduce the capture of unwanted benthic organisms that live in or on the seabed, such as starfish and sea urchins. Beam trawls are designed to dislodge fish on or just under the seabed and in doing so can also catch large amounts of unwanted species. Square-mesh panels in the belly of the trawl, also called drop-out panels or benthic release panels, have been shown to be an effective way to allow these animals to escape. The same method has been shown to work for undersized Nephrops in otter trawls.

It is possible to have several square-mesh panels in one trawl – for example, one in the belly of the trawl and one in the top of the trawl. Similarly, having two square-mesh panels in different places in the top of the trawl can be more effective than only one. Diamond-mesh panels have also been used in the top of beam and otter trawls. Using sections of diamond-mesh netting with meshes that are substantially larger than the surrounding net has an effect similar to using square-mesh panels. Using meshes that are at least twice the size of the surrounding net in sections at the front and top of the trawl has been tested in beam and otter trawls *(Figure 7)*. Some UK Nephrop and beam trawlers are using these large mesh diamond-shaped panels to reduce catches of unwanted fish.

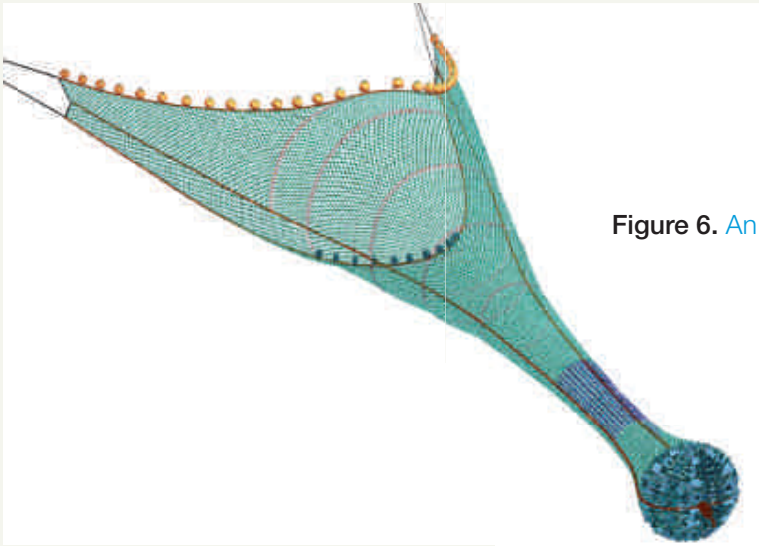


Figure 6. An otter trawl with a square-mesh panel (in blue) near the codend

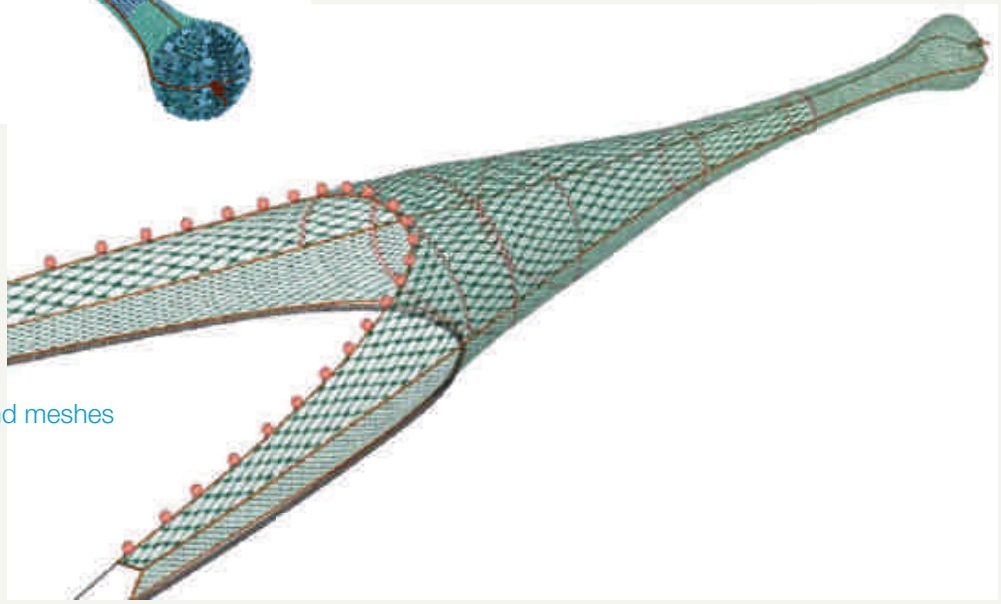


Figure 7. An otter trawl with large diamond meshes in the top of the net

2.4 Square-mesh and T90 codends

Square-mesh netting or T90 netting can be used in the construction of the whole codend. These materials provide more consistent selectivity, as the meshes remain uniformly open under tension in the trawl. In traditional diamond-mesh codends there are only certain areas in which the meshes are spread to allow fish to escape. **With square-mesh or T90 codends the meshes are more likely to remain open, which creates more opportunities for fish to escape.** Square-mesh codends *(Figure 8)* have consistently been shown to be more selective, but so far have not been adopted by fishers in the UK. The use of a square-mesh codend in combination with a selection grid is mandatory in Sweden's Nephrops otter trawl fishery.

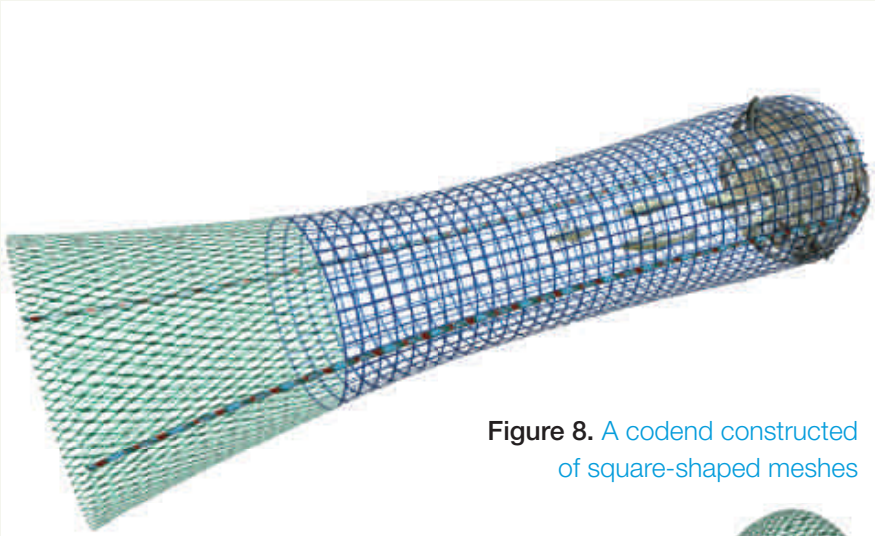


Figure 8. A codend constructed of square-shaped meshes

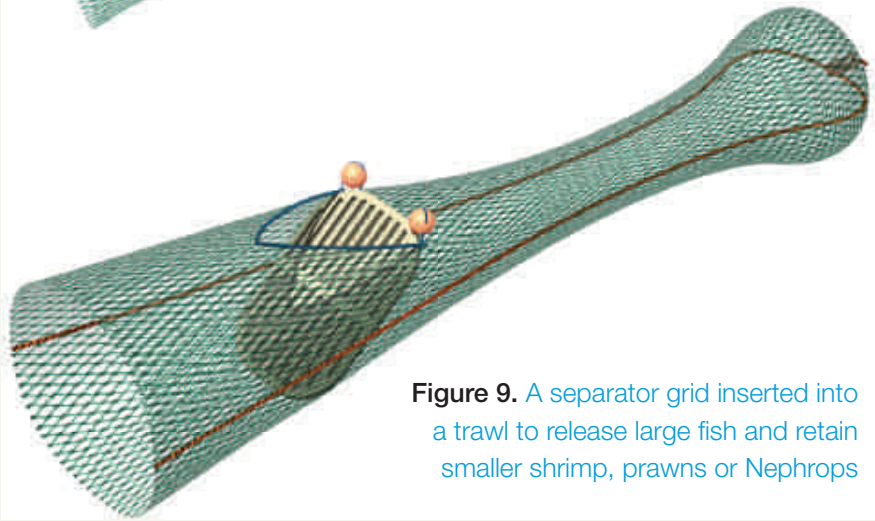


Figure 9. A separator grid inserted into a trawl to release large fish and retain smaller shrimp, prawns or Nephrops

2.5 Selection grid

The use of grids to improve trawl selection relies more on mechanically filtering the catch than other modifications that rely on fish behaviour, such as square-mesh panels. There are two main grid designs. The first allows only smaller animals to be caught, because they pass through a row of vertical bars and move into the codend, while those that are too large are guided to their escape. This design has been used in the UK bass pair otter trawl fishery to reduce the catch of dolphins. Once inside the trawl the dolphins cannot pass through the bars of the grid and instead are guided to their escape *(Figure 9)*. This design is also used to reduce the capture of fish in Nephrops fisheries and its use is mandatory in the Swedish Nephrops fishery. Here a grid with a bar spacing of 35mm is used in combination with a 70mm square mesh codend to allow fish of all sizes to escape the trawl.

This type of grid system has also been show to work in prawn and brown shrimp trawl fisheries. In the Belgian brown shrimp fishery a selection grid reduced catches of unwanted fish by 70%. Some fishers criticised the grids, saying that they are difficult to handle especially in poor weather conditions. In response to this, flexible grids made of moulded plastic or plastic tubes rather than metal are being developed to make the grids easier to use and safer (the ‘Flexigrid’ was the runner-up entry in the 2006 WWF Smart Gear competition).

The second type of grid design is used to retain large organisms that cannot pass through the grid while those small organisms that do pass through the bars escape from the trawl. Fishers in the French Nephrops fishery are currently using this system to avoid catching undersized Nephrops.

2.6 Separator and guiding panels

To utilise species behavioural reactions in trawls, horizontal separator panels have been inserted inside the net. These panels are designed to separate species that remain on the bottom once inside the trawl from those that rise upwards. For example, whiting and haddock have been successfully separated from Nephrops, cod and flatfish. The separator panel is inserted at an appropriate height inside a trawl that has two codends. These codends can then have different mesh sizes appropriate for what is being retained in each *(Figure 10)*. For example, a larger mesh size for the upper codend, retaining whiting and haddock, and a smaller mesh size for the lower codend that retains Nephrops. Although separator panels have consistently shown high levels of separation they have not yet been used commercially in EU waters. This is because separator trawls have never been legislated for and there has been no incentive for fishers to use them.

Guiding panels work using the same principle as separator panels, but once separated, the fish are guided to either an escape hole or to a square-mesh panel instead of a second codend. Guiding panels are generally shorter than separator panels and are set at an incline. The Inclined Separator Panel is one such design. It was developed to release all sizes of cod from Nephrops trawls in the Irish Sea *(Figure 11)*, and was used as part of the Irish Sea cod recovery programme. This panel is fitted into the trawl at an angle of 30 degrees, starting 30cm above the bottom sheet. The panel diverts cod and other whitefish upwards towards an escape hole while Nephrops pass under the panel and are retained.

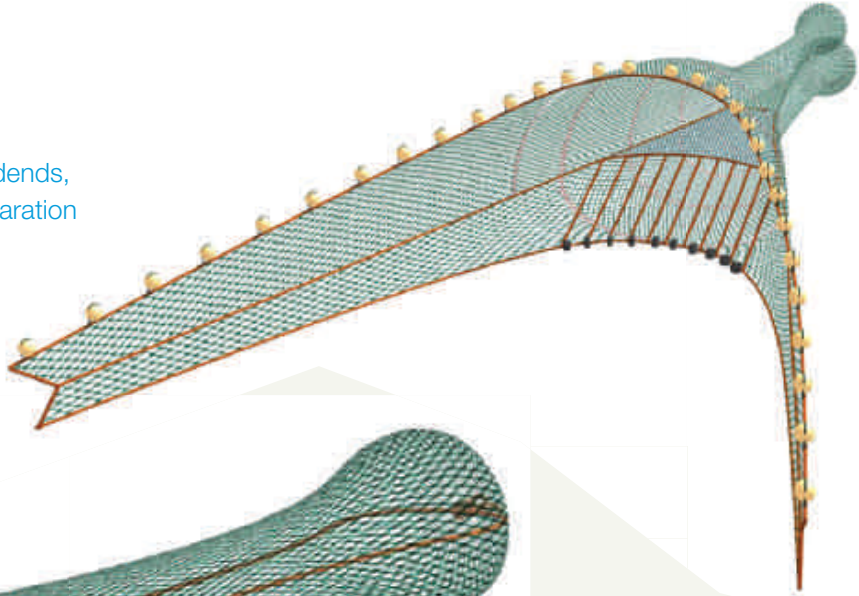


Figure 10. A separator trawl dividing into two codends, this version has guiding ropes to improve the separation

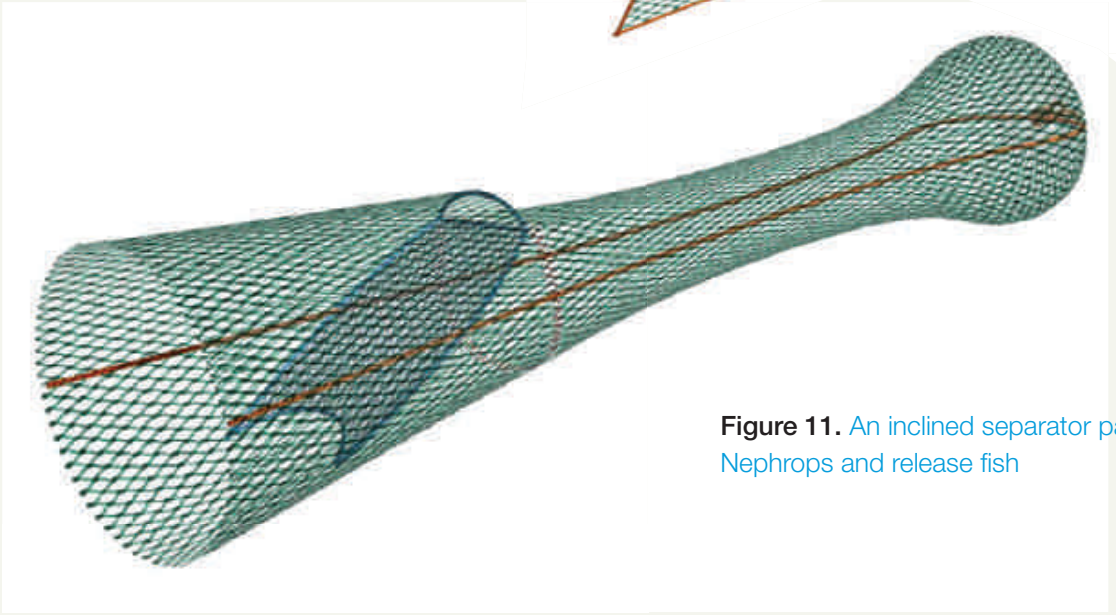


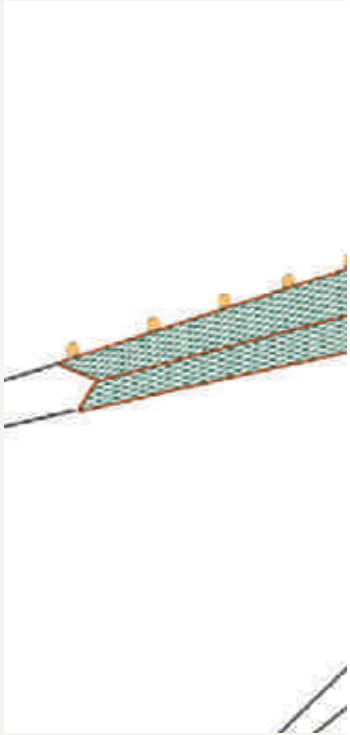
Figure 11. An inclined separator panel designed to retain Nephrops and release fish

2.7 Capture-avoidance designs

The aim of capture-avoidance trawls is to avoid the initial capture of unwanted fish rather than to improve their chances of escape from the trawl. One example of this method is the trawl design previously used to target Nephrops in single-species fisheries. Historically, Nephrops trawls had no sweeps and bridles, so there was little herding of fish towards the trawl, and a low headline (<2m) with no coversheet, so even whiting and haddock that encountered the trawl escaped over the headline (see Figure 1). These are still used in some inshore fisheries as they enable access to areas in which it is not possible to manoeuvre larger trawls.

A contemporary version of the traditional design has been developed, called the cutaway trawl (or coverless trawl), which incorporates a reduced headline height, shortened wing length, removed cover, and increased mesh size in the upper panels of the net *(Figure 12)*. These modifications are designed to reduce trawls' ability to herd fish and allow them to rise over the trawl before entering the net. Trials of this design have demonstrated a considerable reduction in the numbers of haddock and whiting retained across the full size range, and a reduction in catches of small cod.

The Eliminator trawl, developed in the US, is another example of a capture-avoidance trawl design. It uses the same principle as the separator trawls in utilising the different behaviours of species once they encounter a trawl. The Eliminator trawl is designed to avoid catching cod, while allowing fishers to catch haddock and whiting. The Eliminator is rigged with very large meshes of 2.4 metres located around the trawl mouth and in the belly. The mesh size reduces incrementally towards the codend. These large mesh sizes mean that those fish that stay on or close to the seabed pass through the large meshes of the trawl and only haddock and whiting, which rise when encountering a trawl, are retained. Although cod are herded towards the trawl, this design is such that cod are not required to actively escape through the meshes of the trawl because the meshes are so large.



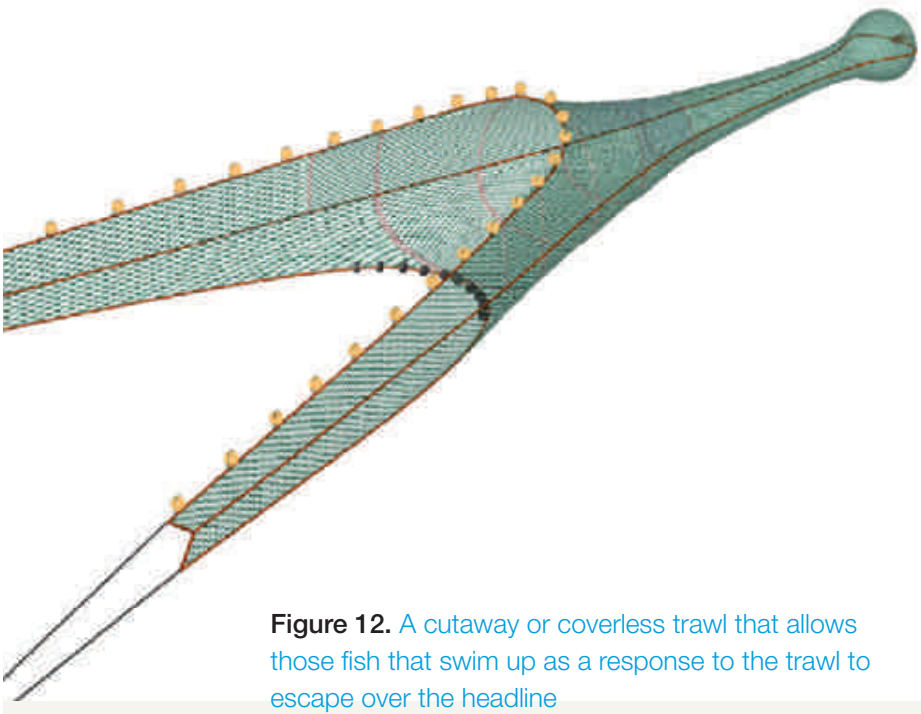


Figure 12. A cutaway or coverless trawl that allows those fish that swim up as a response to the trawl to escape over the headline

2.8 Sieve nets (or veil nets)

Sieve nets, also called veil nets, are used in the brown shrimp beam trawl fishery. Sieve nets are made using large diamond meshes and are inserted inside the small diamond-mesh brown shrimp trawls. The sieve net is attached to the full circumference of the shrimp trawl near the beam, and tapers to an apex where it is attached to the belly of the shrimp trawl. An exit hole is cut where the sieve net and shrimp trawl join, allowing organisms too large to pass through the sieve to escape, whereas the shrimp can pass through the sieve and into the codend. Sieve nets are used in European waters; in the UK the mesh size of the sieve must measure no more than 70 mm, and the exit hole must be large enough to allow all fish that do not pass into the codend to escape.

3 Case study 1

3.1 Farne Deeps Nephrops otter trawl fishery

Background

Otter trawlers targeting Nephrops *norvegicus* (commonly known as langoustine, Dublin Bay prawn or scampi) use nets with meshes that are smaller than those used to target roundfish. Several other important commercial fish species occur in the same areas where Nephrops are caught, so there can be a large catch of fish in Nephrops trawl fisheries. Some fish are retained: the most commercially important of which are whiting, haddock and cod. However, much of the fish caught is undersized and discarded, usually dead or dying. Whiting is the most discarded species in Nephrops trawl fisheries in the Irish Sea, North Sea, Celtic Sea and Clyde Sea.

An important Nephrops fishery in the North Sea is adjacent to the Farne Deeps, off the north-east coast of England *(Figure 13)*. The principal port for this fishery is North Shields on the River Tyne; other ports include Blyth, Amble and Hartlepool. The Farne Deeps Nephrops fishery is seasonal and runs from September to May; the season is dictated by the emergence behaviour of Nephrops, which live in burrows. The amount of material discarded in the Farne Deeps Nephrops fishery was estimated in the 2001/2002 season at 4,890 tonnes. This was 43% of the total catch weight of fish and Nephrops. Whiting accounted for 72% of the discards by weight, and 86% of the whiting caught was discarded.

Whiting discards from this fishery have been estimated to account for around 16% of the total whiting discards from the North Sea. All Nephrops fisheries combined account for 46% of whiting discards in the North Sea. The minimum landing size for whiting is 27cm in length. However, the trawls currently used catch most of the whiting over 24cm that they encounter. The removal of these fish brings obvious economic and ecological consequences in that they could have been left in the sea to be caught and landed when they have spawned at least once and grown to minimum legal landing size. In the long term, if too many undersized fish are caught, the stock may be reduced to a point at which it cannot replenish itself and profits are lost

permanently. It has been demonstrated that using more selective trawls in this fishery could increase the North Sea whiting stock, and potentially increase profitability.

Several technical regulations have already been introduced to reduce the catch of unwanted whiting. For example, in 2002 the minimum permitted codend mesh size for a Nephrops trawl was increased to 80mm. There is also a requirement for a large mesh (140mm) diamond-mesh panel to be inserted near the headline, and a 3m-long 90mm square-mesh panel inserted within 18m of the codline.

These regulations have improved the selectivity of trawls in this fishery although discarding of fish, in particular whiting, still remains a problem. Working together, scientists and fishers have developed several trawl designs that further reduce the capture of unwanted fish. These designs include the cutaway trawl; a selection grid in combination with a square-mesh codend; and the use of additional square-mesh panels. These designs were tested on commercial vessels working on the Farne Deeps Nephrops fishery but the designs also have application in other Nephrops fisheries. The designs can be categorised as those that aim to reduce discards (cutaway trawl and square-mesh panels), and those that reduce the catch of fish of all sizes (the selection grid with square-mesh codend). This provides fishery managers with two options: the first is to minimise discards in a mixed fishery; the second is to establish separate fish and Nephrops fisheries.

3.1.1 Cutaway trawl

The cutaway trawl *(Section 2.7)* was extensively tested on commercial vessels and demonstrated a considerable reduction in the numbers of whiting and haddock retained across the full size range. Whiting discards were reduced by around 50%, and haddock by 60%, but only in proportion to the retained fraction. So the design did lose marketable whiting and haddock but at the same time the cutaway trawl did increase Nephrops catches by up to 20%.

3.1.2 Square-mesh panels

Work has been conducted to improve the effectiveness of the currently used square-mesh panels *(Figure 14).* Different twine material, panel position and multiple panels have been tested. The use of high-strength thin-diameter knotless twine has been shown to allow more whiting and haddock to escape the trawl than panels made from conventional twine *(Figure 15)*. Also, inserting a second square-mesh panel improved trawl selectivity. Having a second 3m long square-mesh panel between the existing panel and the codend was shown to reduce discards and retained whiting by 50% *(Figure 16)*. The second panel was effective only when inserted close to the codend.

Figure 13. The Farne Deeps fishing grounds off the north-east coast of England, where around 16% of whiting discards for the whole North Sea are derived

Figure 14.
A 3m square-mesh panel constructed of 90mm square-mesh white knotless twine inserted into the top of the trawl to allow small whiting and haddock to escape

Figure 15.
Underwater photos of whiting escaping from a square-mesh panel

Whiting catches with one and two square mesh panels

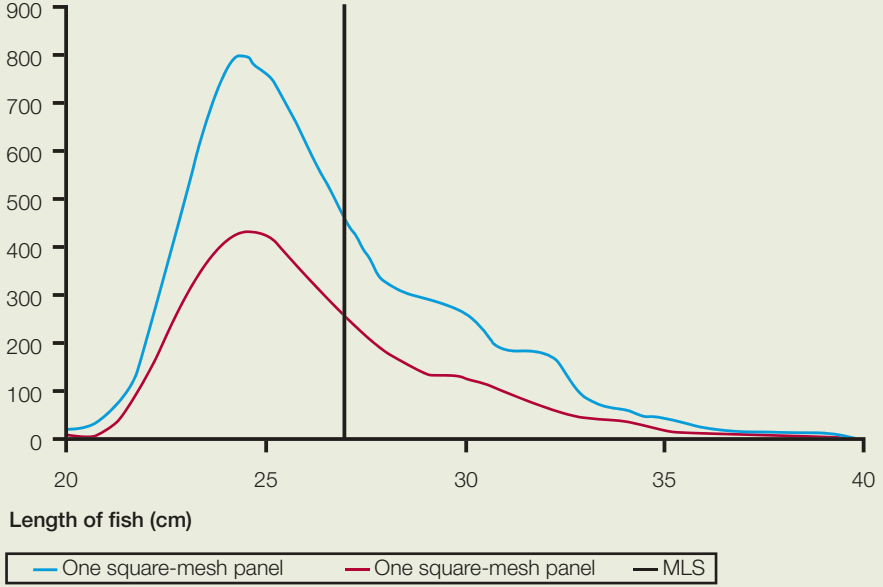


Figure 16. Results from testing a trawl with one square-mesh panel inserted close to the codend alongside a trawl with two square-mesh panels situated close to the codend (MLS, minimum landing size)

3.1.3 Selection grid and square-mesh codend

A trawl with a selection grid *(Section 2.5)* combined with a square-mesh codend *(Section 2.4)* showed that it was technically possible to have a single species fishery whereby only Nephrops are caught. The selection grid prevented large fish from entering the codend and instead guided them to their escape and the square-mesh codend released the smaller fish. Tests have shown that catches of undersized and small fish can be reduced by around 70% and larger fish by 90% with this system. This design is currently used in Sweden.

There are obvious cost implications associated with catching no marketable fish, but it is currently possible to gain more permitted fishing days in the UK when using the selection grid. However, so far, this has not been a sufficient incentive for UK fishers to use the grid. Furthermore, often when catching fewer fish the trawls are more efficient at catching Nephrops. This design is useful for Nephrops fisheries in which fish is not an important component of the landings, or for vessels that do not have fish quotas. It can also be used to create separate fish and Nephrops fisheries where they require different management strategies.

4 Case study 2

4.1 The Wash brown shrimp beam trawl fishery

Brown shrimp *(Figure 17)* are caught in estuaries and inshore areas of countries bordering the North Sea. The main fishing areas for brown shrimp are also nursery grounds for important commercial fish, including plaice, Dover sole, whiting and cod. Brown shrimp are small and grow to only 90mm long, therefore catching them requires a net with small meshes. The minimum mesh size for nets in EU waters is 20mm. Due to this small mesh size and the location of the fishery, large numbers of juvenile fish are also caught with the brown shrimp. These fish are often too small to be landed and are predominantly discarded; many are dead, or damaged to such an extent that they do not survive.

Of particular concern is the catch of juvenile plaice. Before any measures had been taken to reduce discards, it was estimated that more than 900 million juvenile plaice were discarded every year by brown shrimp beam trawlers working in the North Sea. This level of discarding was believed to have an impact on the North Sea plaice stock and its fishery potential with an estimated 7,000-19,000 tonnes of annually of forgone plaice landings, estimated to result in an economic loss of €25.7m.

Once this problem had been recognised, several trawl modifications were developed to reduce the amount of discards. After extensive testing of these designs, new rules were introduced for all EU countries in 2003 that meant fishers had to use either a sieve net *(Section 2.8)* or a selection grid *(Section 2.5).* UK fishers prefer to use sieve nets, and there has been 90% compliance with the new rules.

The main UK brown shrimp fishery is located on the east coast of England in the Wash. There is some fishing throughout the year, but the main season runs from August to April. Most of the fleet operates from the ports of Boston and Kings Lynn, and fishing trips generally last 12-48 hours. In 2006, there were 60 UK vessels actively fishing for brown shrimp; most were small, under 10m in length.

4.1.1 Sieve net

The sieve net allows the brown shrimp to pass through the trawl to the codend, while larger fish are guided to an escape hole through a funnel of netting *(Figure 18)*. The effectiveness of the sieve net was tested in 2006 by taking samples from two fishing vessels. The sieve net was left in one of the two beam trawls and was removed from the other, and the catches were compared. In the vessel using the sieve net, there was a mean reduction of 14% in marketable shrimp. Numbers of plaice discards were reduced by 33%, whiting by 27%, and cod by 70% *(Figure 19, Figure 20)*.

4.1.2 Selection grid

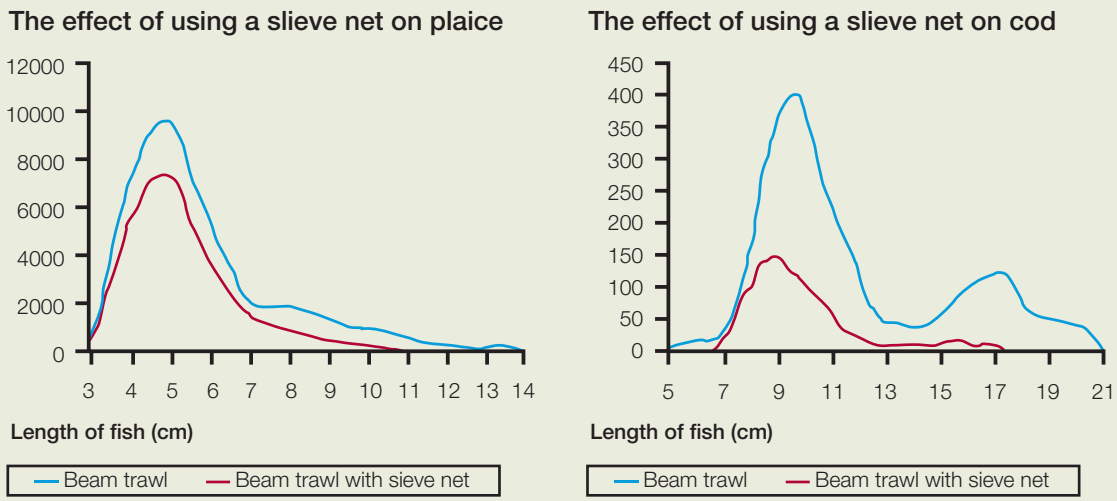
A selection grid was also developed for this fishery *(Section 2.5)* which would allow brown shrimps to pass through the bars to the codend but would guide larger fish to their escape. Various designs were tested and these showed that discards could be reduced by around 39% for plaice and 55% for whiting, with a loss of 10-15% of marketable shrimps. However, because the sieve net is a more simple design and easier to use, fishers do not use the selection grid.

Figure 17. Brown shrimp, which are cooked on board the fishing vessels

Figure 18. The sieve net (in blue) attached to the inside of the trawl

Figure 19. A comparison of discards caught without a sieve net (bottom), and with a sieve net (top)

Figure 20. The number of discarded plaice and cod caught when using a sieve net and when not using one



5 Case study 3

5.1 South-west beam trawl fishery

During the 1980s, the number of beam trawlers increased in the UK when fishers realised that beam trawling is a more effective gear than otter trawls for catching flatfish and can be worked on much rougher ground. Now beam trawlers target Dover sole, monkfish, megrim, lemon sole, plaice and cuttlefish *(Figure 21).* There is a focus of activity by beam trawlers in the south-west of the UK and in particular in the ports of Brixham, Plymouth and Newlyn. Brixham and Newlyn are two of the largest ports in the UK and each has a large daily fish market. There are around 20 beam trawlers operating out of Brixham and the same out of Newlyn. Plymouth has around 8 local beam trawlers. These vessels are between 15m and 35m in length; some fish inshore, while the majority of more powerful beam trawlers are prohibited from fishing inside 12 nautical miles.

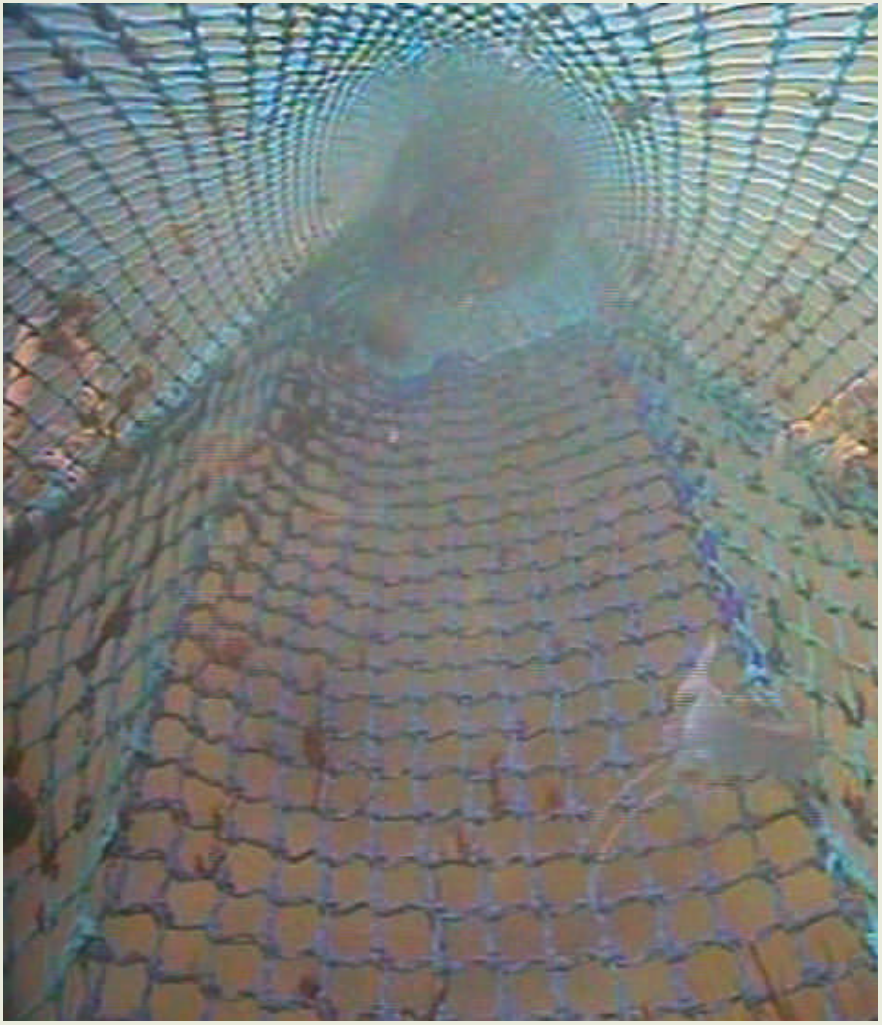
Information collected onboard these vessels between 2002 and 2005 showed that more fish were discarded during beam trawling than in any other type of fishing. Beam trawlers also discarded the highest proportion of their catches. These fish are both commercial species and non-commercial. The commercial species include plaice, of which 43% are thrown back, monkfish of which 48% are thrown back, and lemon sole of which 37% are discarded. The majority of these fish are thrown back because they are too small; most do not survive. The total number of fish discarded by beam trawlers working in the region was estimated at 68 million per year. In addition, beam trawls impact bottom-dwelling animals such as starfish and sea urchins, because the ground gear crushes and dislodges animals on the seabed, and because animals are caught in the trawl and subsequently die.

Considerable work has been done to develop trawl modifications to improve the selectivity of beam trawls. These include drop-out panels, square-mesh panels, square-mesh codends and large diamond-mesh escape panels. All of these have been shown to improve selectivity, but none have been legislated for, although large mesh escape panels are being used by some fishers.

5.1.1 Drop-out panels

Drop-out panels are designed to reduce the capture of unwanted benthic, or bottom-dwelling, organisms *(Figure 22)*. Several designs of drop-out panel have been tested in the south-west beam trawl fishery. Drop-out panels of 150mm square-mesh in the bottom of the trawl reduce catches of unwanted benthic animals by up to 80%, and more than 90% of the animals released survived. It has been calculated that the use of drop-out panels therefore reduced the overall environmental impact of beam trawl fisheries by 5-10% without affecting their profitability.

Figure 21. A typical catch from a beam trawl



5.1.2 Square-mesh codend

Square-mesh codends have repeatedly been shown to be more selective than commonly used diamond-mesh codends *(Figure 23)*. Because the holes in square-mesh netting remain open, more animals have an opportunity to escape from the trawl. In the south-west beam trawl fishery, square-mesh codends have been tested alone and in combination with square-mesh panels *(see above)*. The combination of having a square-mesh codend and panels gave the best results – reducing discards of fish by around 60% and discards of benthic animals by around 40%. When tested against a normal trawl, the fish from the modified trawl fetched a higher market value.

Figure 22. A drop-out panel constructed of square-mesh netting (in blue) inserted into the bottom of a beam trawl to reduce the capture of unwanted organisms

Figure 23. The catch when using a selective square-mesh codend (left) compared with a diamond-mesh codend (right)

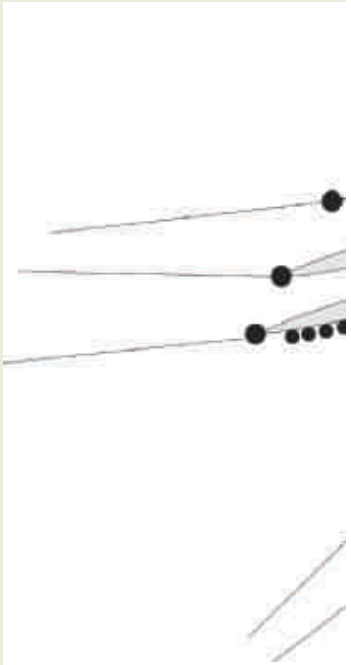
6 Case study 4

6.1 North Sea roundfish otter trawl fishery

In the central and northern North Sea, an important otter trawl fishery has historically targeted haddock, whiting and cod – collectively known as roundfish. However, with the decline in the North Sea cod stock, several measures have been put in place that restrict fishing opportunities to catch cod, including reducing quotas and reducing the number of vessels fishing and the time vessels can spend fishing. Catching fewer cod means that the stock is more likely to recover; however, these measures mean that the fishers catch less of other species too and have to discard cod of marketable size when quotas have been exhausted.

Recent advances have shown that trawl modifications may be able to provide an additional solution. As with other mixed species fisheries, the different species in this fishery grow to and mature at different sizes. Therefore the size of the net mesh is a compromise that is not ideal for any one of the species. For example, at 35cm, less than 1% of cod are mature, while at only 27cm, 90% of whiting are mature. The estimated codend mesh size that would ensure the highest long-term yields in this fishery are 90mm for whiting, 140mm for haddock and 250mm for cod. The minimum legal mesh size for this fishery is currently between 80mm and 120mm depending on location. Consequently, large numbers of juvenile cod and haddock have historically been discarded. More recently, many large cod have also been discarded as the quota restrictions mean they cannot be landed.

To reduce the capture of small haddock and whiting, the same methods can be used as those shown in the Case study 1: Farne Deeps Nephrops fishery *(Section 3.1)*, namely square-mesh panels and square-mesh codends. These designs have been successfully tested in the roundfish fishery. Currently, UK vessels working in the North Sea roundfish fishery are required to use a square-mesh panel of between 90mm and 110mm depending on where they fish. Separator panels *(Section 2.6)* have also shown potential in separating haddock and whiting from cod, but the fishers have not taken up this design. The differences in behaviour of these species has also been utilised in the Eliminator trawl design, developed in the US.



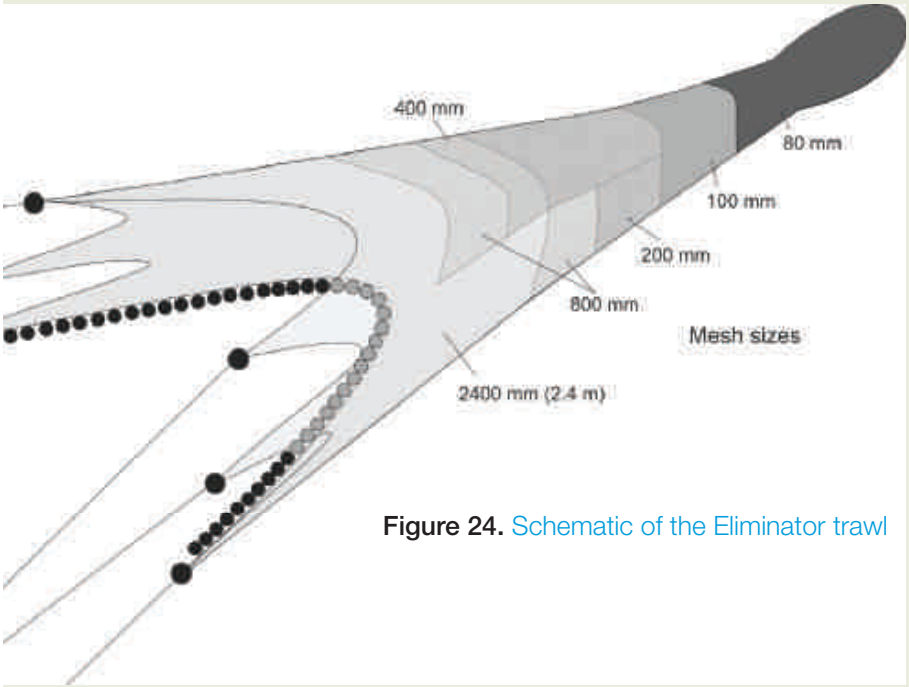


Figure 24. Schematic of the Eliminator trawl

6.1.2 Eliminator trawl

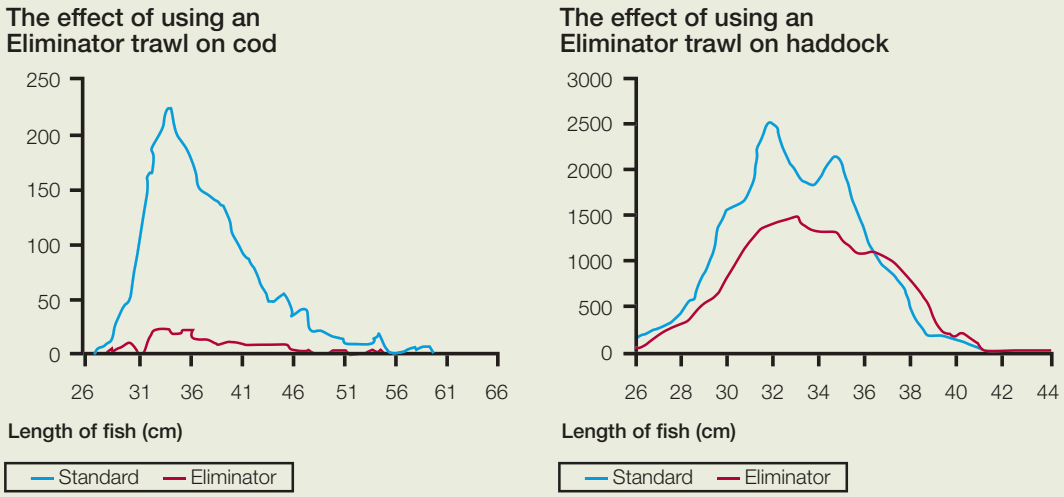
The Eliminator trawl was developed to catch haddock without catching cod. The Eliminator is rigged with very large 2.4 metre meshes around the trawl mouth and in the bottom of the trawl *(Figures 24 and 25 and Section 2.7)*.

It was tested against a standard trawl off the Yorkshire coast in the North Sea. Cod catches were reduced by 90% of all sizes with the Eliminator trawl *(Figure 27).* Only limited tests have been conducted so far in the UK but when tested in the US, catches of haddock were the same as a standard trawl. It is considered that similar results could be achieved in UK waters. In 2007, the Eliminator trawl was the winner of WWF's international Smart Gear competition. There may be some interest in its use from UK fishers who may be able to gain more fishing opportunities by using this design, as it substantially reduces the catch of cod *(Figure 26)*.

Figure 25. Hauling in the Eliminator trawl. Very large white meshes are used in the mouth of the trawl

Figure 26. A clean catch of whiting and haddock achieved with the Eliminator trawl

Figure 27. The results of the UK test of the Eliminator trawl



Summary

Discarding large amounts of fish and other marine species threatens the health of the marine environment and the sustainability and profitability of commercial fisheries. Most of the discards are unwanted fish and are caught because the fishing gears are not selective. Beam trawls and otter trawls are considered the least selective fishing gears; these trawls can catch more unwanted fish than marketable fish.

Scientists and fishermen have been working together to improve trawl designs so that only those fish that can be landed are caught. Considerable progress has been made in this research area. The main solutions that have been developed are described in this report.

In some cases fishers have adopted these designs but in many cases they have not. The main reason for not using them is that they can lead to losses of marketable fish. Usually some incentive is required for fishers to use selective trawl modifications – this can be legislating for the use of these designs, imposing a cost on the level of discards, or gaining a better price for fish caught using more environmentally-friendly methods. With increasing recognition from fishery managers, fishers, buyers and the public of the damaging effects of discarding, it is likely that more of these designs will be implemented by the fishing industry.

Species index

Common name	Scientific name
Bass	*Dicentrarchus labrax*
Brown shrimp	*Crangon crangon*
Cod	*Gadus morhua*
Cuttlefish	*Sepia officinalis*
Dover sole	*Solea solea*
Haddock	*Melanogrammus aeglefinus*
Lemon sole	*Microstomus kitt*
Megrim whiffiagonis	*Lepidorhombus*
Monkfish	*Lophius piscatorius*
Plaice	*Pleuronectes platessa*

Common name	Scientific name
Nephrops – Dublin Bay prawn – Langoustine – Norway lobster – Prawns – Scampi	*Nephrops norvegicus*
Squid	*Loligo spp.* *Alloteuthis spp.*
Whiting	*Merlangius merlangus*

Glossary

attachments – modifications of, or additions to a trawl, usually on the outside. Some are legal, e.g. chafers attached to the underside of the codend to reduce wear. Similarly, weights must not be attached to a codend as they serve to close the codend meshes and prevent the escape of undersize fish.

belly – the under-part of a bottom trawl.

beam trawl – a bottom trawl that is kept open laterally by a rigid beam. Each end of the beam is attached to the apex of a roughly triangular metal 'trawl head' or 'shoe'.

biomass – the total weight of living matter, either by species or all species combined. Also referred to as the standing stock.

bottom fishing gear – any fishing gear that is operational when in contact with the seabed but usually applied to trawls, dredges and some seine nets.

bottom trawl – a trawl net that is towed across the seabed rather than through mid water. They are also referred to as demersal trawls and include both beam trawls and otter trawls.

bridle (sweep) – the wires that connect an otter trawl's doors, or 'otter boards', to the wing (front, outer) ends of the trawl *(Figure 1)*. They help to increase the distance between the doors and thereby increase the width of the swept area or track from which fish can be caught.

bycatch – the catch of non-target species and undersized fish of the target species. Bycatch of commercial species may be retained or discarded along with non-commercial bycatch.

catch (C) – the total quantity of fish that is retained by fishing gear and brought onto the deck or fishing station, i.e. landings plus discards.

cephalopods – molluscs that have eight or ten sucker-bearing tentacles around the mouth – including squid, cuttlefish and octopus.

chafer – a sheet of material, often old netting, attached to the underside of demersal trawls, particularly beneath the codend, to reduce wear and tear.

chain mat or matrix – an interlinked network of lateral and longitudinal tickler chains across the mouth of a beam trawl between trawl heads ('shoes') and groundrope. Mats are fitted when trawling on rough ground to minimise the amount of stone entering the trawl.

codend – the narrow, back end of a trawl into which the catch is funnelled while towing, and from which it is released after hauling.

commercial fisheries – any fishery that is undertaken for financial gain but particularly one that generates sufficient revenue to contribute a significant proportion of the total income of those engaged in the fishery.

coversheet (cover or square) – the cover can be referred to as any netting panel spanning the width of the upper half of the net extending forward of the footrope. This can be checked by tracing the row of meshes attached to the footrope fishing line around the fishing circle (mouth of the net). Any netting panel extending across the full width of the net, from selvedge to selvedge forward of this point is classed as cover.

crustacea – invertebrates with a shell and many legs that are used for walking or swimming. Commercial species include shrimps, prawns (e.g. Nephrops), crabs, lobsters and crawfish.

demersal – species of fish that live on, or in close proximity to, the seabed – e.g. flatfish, cod, haddock. The term also applies to fishing gear that is worked on the seabed.

demersal seine – a trawl-shaped net with extended wing ends each side of the net mouth. It is set in the middle of a long rope that is shot in a wide circle. When the two ends of the rope are hauled, they gradually draw the ropes and wing ends together and herd the fish towards the net and the codend.

demersal trawl – a net that is towed on the seabed rather than through mid water.

discards – any fish or other living matter caught when fishing that is not retained but returned to the sea – alive or dead.

doors – a generic name for a wide variety of 'otter boards' that are attached to trawlers' warps (towing wires). They work like a kite, but horizontally, pulling the wings of the trawl out to the side and holding it open laterally.

dredging – a method for catching molluscs that live on or in the sea bed – e.g. clams, native oysters, scallops. Boats tow groups or 'gangs' of dredges, each dredge rarely more than a metre in width. They are made of a robust steel frame, often with a toothed bar across the lower edge, and a heavily reinforced or chain link bag.

dumping – a colloquial term for the deliberate disposal of catch. It implies a scale rather greater than discarding and usually refers to fish that would normally be landed for sale. The causes of dumping can be market saturation, closure of quotas and high-grading.

ecosystem approach – the pursuit of a simultaneous understanding of the dynamics of all the populations in an ecosystem and their interactions with each other and their environment.

ecosystem management – a framework for maintaining the equilibrium between all the component parts of an ecosystem rather than focusing on individual parts of the ecosystem, which is the current practice with fishery management.

effort (F) – the total quantity of fishing gear in use for a specific period of time. Effort can be expressed in a multitude of ways: days away from port, hours trawling, length of drift net, number of hooks used, and so on. At its most basic, it is the total number of boats engaged in a fishery and/or the number of days they were fishing.

epifauna – animals that live on the surface of the seabed or other substratum.

endangered – a species, stock or population is 'endangered' if it is facing a high risk of extinction in the wild in the near future.

environmental sustainability – the control of current and future activities to prevent irreversible or other significant, long-term change to the environment or its dependent living resources.

environmentally-sustainable fisheries – fisheries that safeguard the requirements of all animals and plants within an ecosystem or habitat and do not cause irreversible or other significant, long-term change to the environment or the communities of species that live within that environment.

fishing mortality (F) – formally, the instantaneous rate of fishing mortality (the natural logarithm of the change in abundance due to fishing per unit of time), but more simply, the proportion of the population killed each year by fishing.

fish stock – scientifically, a population of a species of fish that is isolated from other stocks of the same species and does not interbreed with them and can, therefore, be managed independently of other stocks. However, in EU legislation the term 'stock' is used to mean a species of fish living in a defined sea area; the two are not always synonymous.

fishable stock or biomass – that part of the total biomass that is exploited.

fishery management – the integrated process of information gathering, analysis, planning, decision making, allocation of resources, formulation and enforcement of fishery regulations which govern the present and future fishing activities, in particular to ensure the continued productivity of the resources.

fishing power – a relative measure of the ability of one vessel or type of gear to catch fish compared to another vessel or type of gear. Thus, a motor trawler is more powerful, in terms of catching capability, than a sailing smack or steam trawler, and a purseseiner is more powerful that a driftnetter.

fixed gear – any fishing gear that is anchored or attached in some other way to the seabed so that it does not drift or move while it is in fishing mode – e.g. crab pots, long-lines and bottom set gill nets.

flatfish – bony fish (i.e. not skates and rays) that live on the seabed and have a pigmented upper surface and a pale or white underside – e.g. Dover sole, megrim, plaice.

fly dragging/seining – a common name for fishing with a fly seine, a lightweight form of demersal seine.

footrope – the weighted rope that forms the lower edge of a drift, gill, tangle or trammel net.

gear – an all-embracing term for fishing equipment in total or in part – e.g. trawl net, warps, tickler chains, bridles, dredges, etc.

groundfish – Fish that live most of their life on or near the sea bottom. Typical groundfish species include sole, ray species and monkfish.

groundrope – the rope that forms the lower, front edge of a trawl or demersal seine and is in contact with the seabed while towing or closing.

growth overfishing – occurs where fish are caught before they are able to make their optimum (in terms of growth) individual contribution to exploited biomass. As a result, the stock as a whole is fished at a level where it cannot deliver the maximum sustainable yield (MSY).

habitat – the place where an organism lives, as characterised by the physical features. For example, rocky reefs, sandbanks and mud holes all provide particular habitats that are occupied by animals adapted to live in or on one of them but probably cannot thrive, or even survive in the others.

headline – The length of rope or wire in a trawl to which the top wings and cover netting are attached.

high-grading – the practice of retaining only the most valuable part of a catch and discarding the species and/or size groups that have a lower commercial value even when it would not be an offence to retain and land them.

incidental catch – sometimes used as an alternative to bycatch and discards, but also used to differentiate the individual captures of (charismatic) species that are not a normal part of the catch. Thus, an incidental catch could be commercial species such as porbeagle or basking shark, or birds, turtles and marine mammals.

indicator species – a species that can be monitored as a representative of a broader community of species or one whose abundance gives an indication of the status ('health') of a particular habitat, ecosystem or environment.

infauna – animals that live buried in the seabed – e.g. cockles and lugworm.

inshore fisheries – occur in coastal waters, overwhelmingly within the Territorial Sea if not within six miles of the coast.

juvenile – an immature fish – i.e. one that has not reached sexual maturity (but could still be larger than the minimum landing size – MLS).

k-selected species – species that tend to be large, long-lived, with low fecundity and are best adapted for stable environmental conditions – e.g. sharks, rays and marine mammals.

landings – that part of the catch which is put ashore. Frequently, landings provide the only record of total catch – i.e. the landings plus discards.

live weight – the weight of fish before it is gutted – i.e. the whole (or live) weight.

natural mortality (M) – formally, the instantaneous rate of natural mortality (the natural logarithm of the change in abundance due to natural causes per unit of time); but more simply, the proportion of the population killed each year by predation, illness (e.g. parasite load), old age, etc.

Marine Stewardship Council – a non-governmental organisation that encourages consumers to purchase fish taken only from environmentally responsible and sustainable fisheries. All fish products that MSC judge to be from such sustainable fisheries will be permitted to carry an 'eco-friendly' seal of approval.

maximum economic yield (MEY) – the maximum, most cost-effective yield (e.g. tonnes per unit of effort) that can be taken on a sustainable basis. On a yield-per-recruit (YPR) curve the MEY is found at a slightly lower level of fishing mortality (F) than the maximum sustainable yield (MSY) is.

maximum sustainable yield (MSY) – the largest average catch that can be taken continuously from a stock under existing environmental conditions. For species with fluctuating recruitment, the maximum might be obtained by taking fewer fish in some years than in others. Also known as maximum equilibrium catch.

mesh selection – the process by which fish above a certain size are unable to pass through the meshes of a fishing net but fish below that size can do so. It works most successfully in free hanging nets such as drift nets and gill nets, but trawls are also regulated by minimum mesh size (MMS). The efficiency of trawl mesh selection varies enormously as the shape of the meshes change in response to changing loads while towing. For example, as catch, and hence drag, increases the codend meshes tend to close.

minimum landing size (MLS) – the smallest length at which it is legal to retain a fish or offer it for sale. Ideally, it is the minimum length at which not less than 50% of a given species first reach sexual maturity. In practice it tends to be set at a level influenced by market acceptability and is frequently less than the biological optimum.

minimum mesh size (MMS) – the smallest size of mesh that can be used legally in any given type of net. It is measured either down one side of the mesh (knot-to-knot) or – more usually – across the diagonal under tension (stretched mesh). The MMS is set to allow at least 50% of the target species at their minimum landing size (MLS) to pass through the mesh.

mortality – the death of organisms through natural causes (M) – e.g. predation, or fishing (F), etc. It is usually expressed as an instantaneous rate: the natural logarithm (with sign changed) of the ratio of number of animals surviving to the end of the year and the number at the start of the year.

non-pressure stocks – are stocks for which the quota allocated to the UK in 1984 (when broad-scale, UK licensing was introduced) were considered large enough to allow unrestricted fishing, i.e. non-sector fishery – that part of the national fishing fleet whose participants are not members of a producer organisation (PO). Most of the national quota for each species is distributed among the PO but a small proportion is retained for the non-sector fleet and is managed by the government fishery departments.

non-target species – any species that form part of the bycatch but are not (one of) the principal species that the fishery is exploiting. For example, turbot are a valuable bycatch in beam-trawl catches but there is not a directed turbot fishery by beam trawlers.

otter board – a board or plate attached to each side of the mouth of a otter trawl net to keep it open as it passes through the water.

over-fishing – any fishery where the total fishing effort is greater than is required to meet or match a specific management objective – e.g. maximum sustainable yield (MSY). *(See also recruitment overfishing)*.

pair fishing/trawling – a method where two boats tow a trawl between them to hold it open laterally – i.e. there are no trawl doors. In the UK fleet it is widely used by boats engaged in fishing for pelagic species.

pelagic – relating to mid water – e.g. herring, sprats and mackerel are all pelagic species that are vulnerable to capture in mid water by pelagic trawls.

precautionary principle – the principle of safeguarding the marine ecosystem by reducing emissions of hazardous substances at source and minimising physical disturbance of marine habitats caused by human activities using appropriate technologies and measures. This applies to all human activities for which there exists a scientific basis for believing that damage to living resources is likely to result. Measures adopted should be based on pessimistic assumptions regarding uncertainties in the measurement and prediction of effects on the marine environment.

pressure stocks – are those for which the quotas allocated to the UK in 1984 (when broad-scale UK licensing was introduced) were considered insufficient to allow unrestricted fishing by the UK fleet. Only vessels <10 m or those holding a Class A licence can fish pressure stocks.

producer organisation (PO) – association of individuals, companies and other bodies within the fishing industry intended to optimise supply and increase efficiency of marketing – both fundamental objectives of the CFP. Some POs also manage the quotas awarded, under licence, to members' boats.

recruit – a young fish joining the exploited or spawning stock for the first time.

recruitment – the number of young fish joining the stock each year. Juvenile fish recruit to the exploited stock once they have grown to a length greater than the minimum landing size (MLS) and/or they move onto the fishing grounds. They recruit to the spawning stock once they reach sexual maturity.

recruitment overfishing – the situation that results from fishing the spawning stock biomass (SSB) down to a level where it cannot produce sufficient juveniles each year (recruits) to replace the total annual losses through fishing (F) and natural causes (M).

quota – a fixed proportion of the total allowable catch (TAC) allocated to each fishing nation. This national quota allocation is further sub-divided into quotas for specific areas, seasons, fisheries or organisations – e.g. producer organisations (PO).

responsible fisheries – fisheries combining respect for ecosystems and biodiversity with the needs of consumers and the interests of the fishery sector (EC 1999).

rock-hopper trawl – a demersal otter trawl with rubber discs fitted to the groundrope. A second wire 'groundrope' passes through the discs off centre; this prevents the discs from rotating freely. If the groundrope snags a seabed obstruction the discs try to turn and the second wire gets wound around the groundrope and acts as an accumulator spring. Eventually, the tension becomes too much and as it is released the trawl 'hops' free of the obstruction.

sampling – the systematic collection of environmental or biological data to measure specific features – e.g. temperature or salinity regime, average size or abundance.

seine net – an encircling net that may be either a curtain of netting, e.g. purse seine and beach seine, or similar in basic design to an otter trawl, e.g. demersal seine.

selection curve – the variation in the proportion of fish encountering a net that are retained by a given mesh (or fish-hook) size as fish size changes.

selectivity – a measure of a gear's ability to target and capture a species of fish while allowing juveniles and non-target species to escape.

sorting grid – a rigid grid inserted into a trawl. It allows target species to fall back into the codend but diverts many unwanted organisms to an escape exit in the top of the trawl.

square mesh – mesh that is square rather than diamond shaped. Under tension there is a tendency for diamond mesh to close and reduce the effectiveness of fish selection.

spawning stock biomass (SSB) – the total weight of all sexually mature fish in a population or stock. It is the sexually mature part of an exploited population upon which the future survival of the stock, and its fishery, depends.

static gear – any form of fishing gear that operates without being towed or moved through the water – e.g. crustacea pots, long-lines, set nets, traps, etc.

stock and recruitment – the notional relationship between the size of the (parent) spawning stock and the number of recruits joining that stock in later years. The probability is that a depleted stock will produce fewer recruits than an abundant stock of the same species but the nature of the relationship between these two extremes is not well understood.

stock assessment – the investigation, analysis and numerical description of the recent history and current state of a fish stock and the fishery that exploits it – i.e. distribution, abundance, size or age structure, fishing effort, catch rates, etc.

stock biomass – the total weight of all fish of all ages in a given population or stock.

sustainability – meeting the needs of the present without compromising the ability of future generations to meet their own needs.

sustainable fisheries – fisheries with an annual catch, including discards, that does not exceed the surplus production of the stock (i.e. annual growth plus recruitment less the annual natural mortality – M).

sweep *(see bridle)*.

TAC – total allowable catch: the agreed quantity of fish that can be taken from each stock during a defined period.

technical conservation measures – fishery management measures aimed primarily at the equipment used in fishing rather than the time and place they fish or what they catch – e.g. minimum mesh sizes (MMS), engine power, width of individual (e.g. scallop) dredges and the number towed by one boat.

technical/technology creep – the continual increase in efficiency of fishing power. This applies to all aspects of fishing operations from stronger twine in trawl construction, through improved designs for propellers, to ever more precise and accurate navigation aids.

tickler chain – a heavy chain across the mouth of a trawl in front of the ground-rope. They penetrate soft seabeds and disturb ('tickle') flatfish buried there and cause them to rise up and enter the trawl. Otter trawls can be rigged with 2-3 tickler chains but a heavy beam trawl may have as many as twelve. *(See also chain matrix)*.

trawl – a large, funnel-shaped net that is towed through the water by single or paired boats. The mouth of the net is held open by a beam (beam trawl) or floats along the headline, and by weights along the groundrope and is pulled open laterally either by the doors attached to the towing wires (warps) or two boats pulling one warp each. *(See also demersal trawl)*.

trawl boards or trawl doors – see otter board.

twin rig – an arrangement of what is essentially two otter trawls joined in the centre by a shared bridle or at the wing ends, to fish side by side when towed by a single boat.

under-reporting – failure to meet the legal requirement to report fully and accurately all the fish that have been caught and landed.

undersize fish – any fish that is less than the legal minimum landing size (MLS).

warps – the heavy wires with which boats tow trawls.

year class – all the fish in a population that were spawned in the same year – e.g. the '1998 year class'.

Many definitions in this glossary were taken from the Glossary of Marine Nature Conservation and Fisheries, Countryside Council for Wales (2001).

Appendix 1 – Summary table

Modification	Method	Examples
Diamond mesh	Increasing the mesh size of diamond-mesh netting in trawls can increase the escape opportunities for marine organisms. This method can reduce the capture of small unwanted organisms.	Increasing the size of diamond meshes in the trawl codend can provide more escape opportunities for small organisms. Panels of diamond-mesh netting twice the mesh size of conventional netting can be used in the top of Nephrops and beam trawls to increase the escape of small haddock and whiting, which rise up when inside the trawl *(see Section 2.3)*. Diamond meshes more than 20 times larger than conventional netting can be used in the bottom of whitefish trawls to avoid catching cod, which stay near the seabed, but can still catch haddock and whiting *(see Section 2.7)*.
Square mesh (and T90)	Unlike diamond meshes, square-shaped meshes do not close up under tension. By remaining open, square-mesh netting provides more escape opportunities than conventionally used diamond-mesh netting. This method can reduce the capture of small unwanted organisms.	Using square-mesh codends in otter trawls and beam trawls instead of conventionally used diamond-mesh codends substantially increases the area of the codend from which small organisms can escape *(see Section 2.4)*. Panels of square-mesh netting can be used in the top of otter trawls and beam trawls to reduce the capture of small fish that rise when inside the trawl. Panels can also be used in the bottom of Nephrops and beam trawls to allow small Nephrops and unwanted benthic organisms to escape the trawl *(see Section 2.3)*.

Modification	Method	Examples
Selection grid	Selection grids provide a physical barrier and can be used to block the passage into the trawl of either small or large organisms and instead guide them to an escape opening. This method can sort marine organisms entering the trawl by size.	The Swedish grid is used in Nephrops trawls to block the passage of fish that are larger than Nephrops. The fish are guided to an escape opening in the top of the trawl while the Nephrops pass through the bars of the grid to the codend *(see Section 2.5*). This design can be used when vessels cannot land the fish which would otherwise be caught (e.g. when they have no quota). Exclusion grids (or trapdoor grids) can be used to prevent the capture of dolphins in trawls. The grid has been used in the bass pair trawl fishery where it blocks the passage of dolphins inside the trawl and guides them to their escape.The sort-x grid design allows large animals to be retained while small organisms are filtered out. This design can be used to reduce the capture of small Nephrops. Situating the grid in the bottom of the trawl allows small Nephrops to pass through the bars to their escape while larger organisms are guided upwards and into the codend.
Cutaway trawl	A cutaway trawl involves cutting back the top of the trawl so it starts nearer to the codend. This design uses the different behaviour of species to reduce the catch of fish that rise up in response to the trawl.	The cutaway trawl can be used in the Nephrops trawl fishery. By having less cover on the top of the net, when whiting and haddock rise up, many pass over the top of the trawl and avoid being caught *(see Section 2.7)*.

Modification	Method	Examples
Separator trawl	Different species react differently to trawls. Some species tend to move up while others stay close to the seabed in response to the trawl. A horizontal panel can separate those species that move up from those staying near the bottom.	A separator trawl can be used in the whitefish otter trawl fishery, which targets cod, haddock and whiting. A horizontal panel separates the trawl into two levels and each level terminates in a separate codend. Cod and other groundfish move into the lower codend while haddock and whiting move upwards into the upper codend. The two codends can be made using the appropriate mesh size *(see Section 2.6)*. Separator panels can be used to guide one group of species to their escape. The inclined separator panel has been used to reduce the capture of cod and other fish in the Nephrops trawl fishery. Nephrops remain very close to the bottom of the trawl. Inserting a panel of netting at an incline starting just above the bottom of the trawl allows Nephrops to pass under the panel, but the panel guides many fish including some cod upwards to an escape hole *(see Section 2.6)*.
Sieve net	This design uses a net within a trawl to guide larger organisms to their escape while retaining small organisms. Organisms too large to pass through the meshes of the inner net are guided to an escape hole in the bottom of the trawl.	The sieve net (or veil net) is used in the brown shrimp beam trawl fishery. The fishery uses a 20mm mesh codend, and inside the trawl is a sieve net of around 60mm. Without the sieve net these trawls catch large amounts of juvenile fish that are too small to retain. Many of these fish cannot pass through the 60mm net and are guided to an escape hole. The shrimp are small enough to pass though the sieve net to the codend *(see Section 2.8)*.

MARKS & SPENCER

The mission of WWF is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by

- conserving the world's biological diversity
- ensuring that the use of renewable natural resources is sustainable
- reducing pollution and wasteful consumption

WWF

wwf.org.uk

for a living planet®

WWF-UK
Panda House, Weyside Park
Godalming, Surrey GU7 1XR
t: 01483 426444
f: 01483 426409