FISHING AND SUBMARINE CABLES

WORKING TOGETHER

Second Edition

Catch fish, not cables!

If your fishing gear catches a cable, **DO NOT TRY TO LIFT IT!**

Contact the Coast Guard or the local submarine cable operator

By Stephen C. Drew and Alan G. Hopper

FISHING AND SUBMARINE CABLES

WORKING TOGETHER

February 23, 2009

The information supplied in this document ("Information") has been compiled by members of the International Cable Protection Committee ("ICPC") based upon their shared experience and knowledge of the industry and is published in good faith with the aims of promoting the highest standards of reliability and safety in the submarine cable environment.

While the ICPC believes the Information to be valid, it is up to the individual members or others who may seek to rely on such Information to satisfy themselves as to the accuracy thereof. The ICPC and the authors do not accept any liability for any errors or omissions in the Information or for any adverse consequences arising from its adoption. Nothing in the Information relieves anyone of complying with any applicable national or international legal requirements, including the United Nations Law Convention on the Law of the Sea, or the ordinary practice of prudent seamanship based on the circumstances that may confront mariners at sea.

Acknowledgments

This booklet was produced by the International Cable Protection Committee with support from Tyco Telecommunications (US) Inc. Many Committee members provided technical information, advice and illustrations. Additional drawings were provided by Alan Hopper, Lillian Harris, Riley Young, SMD and Marco Marine, Inc. Doug Burnett assisted in drafting the section on Legal Aspects. The authors are also grateful to Barry Peck, former Secretary of the ICPC for his support, technical expertise and guidance; and to Skipper Ken Knox for the help and advice he has given in the preparation of this book and for his comments on the draft.

Cover photo: Many types of fish traps such as this wing net are used in coastal Asia. Their anchors have caused numerous cable breaks.

Contents

1. Introduction 5
2. The history and importance of submarine cables 6
Cables are the leading means of communication across oceans 6
The history of submarine cables 6
Damage to cables causes big problems 7
3. Cable construction, installation, protection and repair 8
Coaxial cables 8
Fibre optic cables 9
Power Cables 12
Cable installation 13
Exposed submarine cables 16
4. How fishing can damage cables 19
Anchoring 19
Fishing methods most likely to damage submarine cables 19
Bottom (otter) trawl 19
Trawl doors (Otter boards) 23
Trawl ground gear 23
Trawling in deep water - special concerns for cables 24
Unusual trawling conditions 25
Beam trawling 25
How trawl gear can damage cables 27
Impact of a trawl door, beam trawl or dredge 28
Cutting or tearing action from sharp or jagged edges 28
Bottom pair trawling 29
Dredging 29
The scallop dredge 29
The box dredge 30
Mechanised (hydraulic) dredges 30
Bottom longlines 31
Fishing Anchors and Grapnels 32
Fishing methods less likely to damage cables 33
Midwater trawling 33
Boat seining 34
Midwater longlines 34
Stationary gear types fixed on stakes 34
Entangling nets 34
Fish traps 35
Pots 36
FADs 36
5. The dangers of catching cables and how to reduce them 39
Capsizing as a result of cable entanglement - one risk too many 40
6. The Royal Resolution - a case study of capsize 44
Other factors affecting stability of fishing vessels 48
IMO Stability Criteria 49
7. How to avoid catching cables 50
Submarine cable awareness charts and electronic data services 50
Out-of-service cables 52
8. Legal aspects 53
9. Improving communication among cable companies and fishermen 54
10. The International Cable Protection Committee 54

List of figures

Item Page

Figure 1. Submarine cable with repeater ... 7
Figure 2. Lightweight Fibre Optic Cable ... 10
Figure 3. Double Armoured fibre optic cable ... 11
Figure 4. High Voltage (HV) AC Cable, 300 mm (12 inch) diameter ... 12
Figure 5. High Voltage DC Cable ... 13
Figure 6. Cableship Cutaway ... 15
Figure 8. Plough for cable burial ... 16
Figure 9. Loop of cable above seabed and final splice ... 17
Figure 10. Cable spanning between rocks ... 18
Figure 11. Cable spanning between sand waves ... 18
Figure 12. Bottom (otter) trawl catching cable ... 20
Figure 13. Twin trawl rig. ... 21
Figure 14. Examples of clumps used in twin/triple trawls ... 21
Figure 15. Shrimp trawler ... 22
Figure 16. Beam trawl. ... 26
Figure 17. Shoe of beam trawl ... 27
Figure 18. Scallop dredge, European type. ... 30
Figure 19. Mechanised (hydraulic) clam dredge. ... 31
Figure 20. Bottom longline. ... 32
Figure 21. Fishing gear anchor recovered with end of cable ... 33
Figure 22. Bottom gillnet. ... 35
Figure 23. Traditional style FAD. ... 37
Figure 24. Midwater FAD. ... 38
Figure 25. Basics of Stability of Fishing Vessels ... 41
Figure 26. The physics of capsize ... 42
Figure 27. Effects of freeboard & reserve buoyancy on safety of fishing vessels ... 43
Figure 28. Capsize situation ... 46
Figure 29. Beam trawler snagged on out-of-use cable. ... 48
Figure 30. Cable awareness chart ... 51
Figure 31. Electronic navigation chart ... 52

FISHING AND SUBMARINE CABLES: WORKING TOGETHER

Second Edition

1. INTRODUCTION

This booklet is intended to help fishermen avoid catching submarine cables and to provide information about what to do if fishing gear is snagged in a cable area. It provides updates to the 1996 edition by Drew and Hopper, based on developments in both the fisheries and cable sectors.

Cable breaks can have major impacts on international communications and electrical power transmission, affecting business transactions, telephone, internet, and electricity grids. Over 95% of overseas communications are now carried by cables, not satellites. The increased capacity, speed and security of cables have made them the preferred medium. The growth of international commerce and the internet have made the world far more dependent on communications than it was in the past. Although in many areas communications are protected by redundant capacity on other cables, some breaks have caused outages impacting millions of customers.

Catching a cable can also be dangerous. If a skipper tries to lift the cable, it may affect stability, endangering the vessel and crew. Modern communications cables may carry more than 10,000 volts of electricity which can cause electrocution. Power cables may carry up to 500,000 volts. Both can be lethal. Other major risks are loss of gear, fishing time, and a valuable catch. It is against the law to damage a cable wilfully or through negligence. Heavy penalties including fines, reimbursement for cable repair costs and impoundment of vessels have been levied on violators.

The number of cables laid on the seabed is increasing rapidly with the growth of telecommunications, offshore renewable energy, and power transmission between islands and states. On a global scale, cables are broken by fishing or anchors about 100-150 times a year. Each time a cable is broken, communications and data transmission may be interrupted, and in the case of power cables, electrical supplies may be cut. The high cost of cable breaks must eventually be paid by the governments, businesses, and people using communications and electrical power. It is hoped that this booklet will strengthen the understanding and cooperation between fishermen and cable companies so that both may use the seabed without conflict.

2. The history and importance of submarine cables

Cables are the leading means of communication across oceans

Since the first fibre optic submarine telephone cable was laid in the 1980's, underwater cables have overtaken satellites as the leading means of overseas communication. Cables now carry more than 95% of all telephone, fax, internet, email and data transmissions, as well as television programming crossing oceans. People, businesses and governments depend on the real-time communication and instant information provided by cables. Power cables are commonly used between islands and nearby countries, or as connections to offshore renewable energy sites.

The history of submarine cables

The era of seabed cables began around 1850, when the first telegraph cable was laid across the English Channel. Unfortunately, and perhaps as a sign of things to come, this cable lasted only a few days before it was cut by a curious fisherman who thought he had discovered a new kind of seaweed and wanted to take a sample. During the next 100 years over 725,000 km (450,000 miles) of submarine telegraph cables spread rapid communications around the world with signals in Morse code.

The era of submarine telephone cables began to grow in the 1950's, when the first transatlantic telephone cable was laid. By 1983, over 190,000 km (120,000 miles) of undersea telephone cables connected many sites worldwide. During this period, undersea cables had copper wires carrying analogue electrical signals. The technology developed to where one cable could carry over 4,000 calls at one time. In the 1970's and early eighties, satellite communications became dominant. However, this trend changed with the installation of the first transatlantic fibre optic cable in 1988. A fibre optic cable sends information (including pictures, video and sound converted to digital signals) by shooting pulses of light through tiny glass fibres as thin as a human hair. Fibre optic cables offer a number of advantages over satellites.

- Cables have very high capacity, appropriate for carrying the high bandwidth communications and applications that continue to grow very rapidly with internet, data and voice. A modern fibre optic cable can carry millions of voice circuits at a time. Cable capacity has been doubling every few years, and is expected to continue increasing.

- A signal relayed by a geostationary satellite must travel about 72,000 km (45,000 miles) up to the satellite and back to earth, so there is a noticeable time delay (at least one quarter of a second) in most conversations sent by satellite. In contrast, the time delay of a signal travelling 8,000 km (5,000 miles) across an ocean by cable is only about one thirtieth of a second. This is not noticeable in conversation.

- The quality of sound received over fibre optic cables is extremely clear and it does not vary with atmospheric conditions.

- Cables offer excellent confidentiality and reliability.

The demand is growing very fast for long distance communication. Over 800,000 km (500,000 miles) of fibre optic cable have already been laid on the seabed, and this number is increasing rapidly.

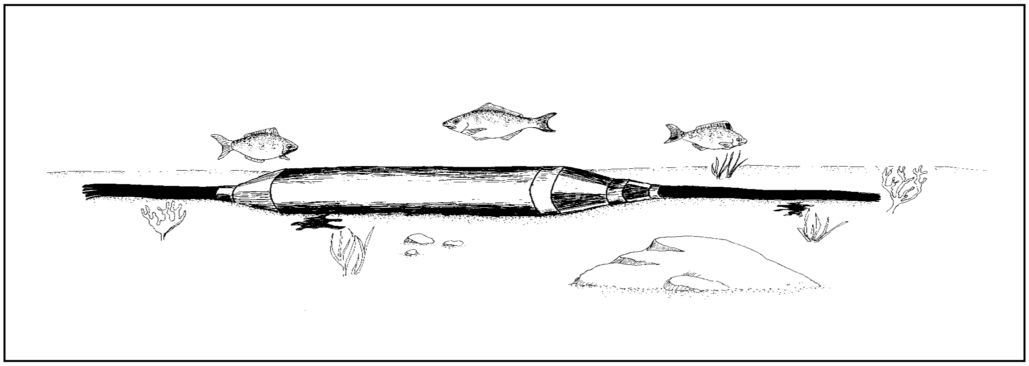


Figure 1. Submarine cable with repeater

Submarine power cables developed in the 1950's linking isolated communities to the mainland. Two forms of the technology developed, alternating current (AC) where three separate cores are formed and direct current (DC) where two cores are used for the supply and return. In the earlier years the DC systems contained only one cable, using the water as a natural return. This practice has now been stopped, as magnetic interference with compass systems was sometime experienced.

AC systems will be less than 100 km in length, while DC systems are now reaching several hundred km in length. The emergence of commercial renewable technologies offshore (such as windfarms) has greatly increased the number of power cables offshore since 2000.

Damage to cables causes big problems

More than two-thirds of all submarine cable faults are caused by fishing and anchors. When a vessel catches a cable, the results for the fisherman may include danger to the vessel and crew, lost gear, lost catch and lost fishing time. The fisherman may also be held liable for the cost of the repair and he may face criminal charges.

In addition, when a cable is damaged, the resulting break in communication causes great trouble and expense, and may involve interrupted telephone calls and broken data transmission. Cable ships are kept on standby around the world to deal with these problems.

The repair of a submarine cable is difficult and costly. A break is almost always detected immediately by shoreside instruments, which monitor the condition of the cable and determine the location of the fault. A cable ship is mobilised and sails to the site to find the cable, which may have been moved from its original location. A Remotely Operated Vehicle (ROV) which moves underwater near the seabed monitoring electrical currents may help find and retrieve the cable.

Once the fault is located, the cable is cut and lifted to the surface with an ROV or grapnel, just as fishermen use a grapnel to recover lost gear. When an end of the cable has been brought aboard, the damaged part is removed and a new section added with extra length to compensate for the water depth. After all sections have been spliced together, the cable is lowered to the seabed. Attempts may be made to lay the cable flat on the seabed and later bury it. However, the section which was added to compensate for water depth may remain on top of the seabed for some time. The cable's tendency to twist may cause loops to stand a few metres above the seabed. Until the cable can be buried with an ROV, it is especially vulnerable to further damage.

Even when damage occurs in shallow water where a cable ship is close by to fix it, the total cost of repair often exceeds US$ 1 million. In remote areas, it may take many days for a ship just to take on spare cable and reach the site of the damage. Repairs are more difficult in deep water so some cable faults are much more costly. Aside from the expense of the repair, telecommunications companies may be required to pay to restore the interrupted traffic on other facilities, which further adds to the cost of the break.

3. Cable construction, installation, protection and repair

Coaxial cables

In the first submarine telephone cables, the signals were carried by copper wire. These were called coaxial or analogue cables and they may last longer than 30 years. Many such cables were laid between 1950 and 1988. A few are still in use today.

Common outside diameters for coaxial telephone cables range from 40 to 100 mm (1.5 - 4 inches). In areas where there is a risk of damage, cables are normally protected by steel armour wires within a waterproof coating. Even in low-risk areas, steel components are used to give the cable enough tensile strength to support the weight of the cable during laying and repair. Coaxial cables may weigh up to 22 tonnes per mile and have a breaking strength of more than 65 tonnes.

The polythene or polyethylene used for cable insulation is basically the same plastic used in much modern fishing gear such as ropes, netting twine, and many kinds of floats.

In order to prevent signal loss through very long cables, amplifiers called repeaters were spliced in at intervals ranging from two to forty miles along coaxial cable. A repeater appears as a torpedo-shaped object spliced into the cable. Some early repeaters were 300 mm (1 foot) in diameter and almost 3 m (ten feet) long. Later models were much smaller.

Fibre optic cables

In the 1980's, a new kind of cable was introduced which revolutionised communications. The heart of this new cable is a set of tiny glass fibres, with each fibre about the thickness of a human hair. Computers at each end of a fibre convert sounds (such as voices) and other data to digital pulses. Lasers shoot these pulses of light through the glass fibres of a cable. Computers at the other end convert the pulses back to sounds and data. Most undersea communications cables contain between six and twenty-four glass fibres. Fibre optic cables are often thinner than coaxial cables. Common outside diameters range from 12 to 50 mm (0.5 - 2 inches).

Fibre optic submarine cables carry devices called repeaters, similar to the repeaters of coaxial cable. They are placed at intervals (often 30-80 km or 20-50 miles) along a cable. An insulated copper sheath carries electrical current (sometimes over 10,000 volts!) to power the repeaters. There is particular interest in protecting repeaters, because each one may cost one million US dollars! In some cases Branching Units connect cables from a trunk to local landing sites.

One disadvantage of fibre optics is that glass is more fragile than copper. Any sharp bend or crushing force may cause fibres to crack and signals to be lost. The minimum bend radius for fibre submarine cables is usually about 1 to 1.5 m (3 - 5 feet). A trawl door, beam trawl or dredge striking a fibre cable can easily render it useless without actually parting it.

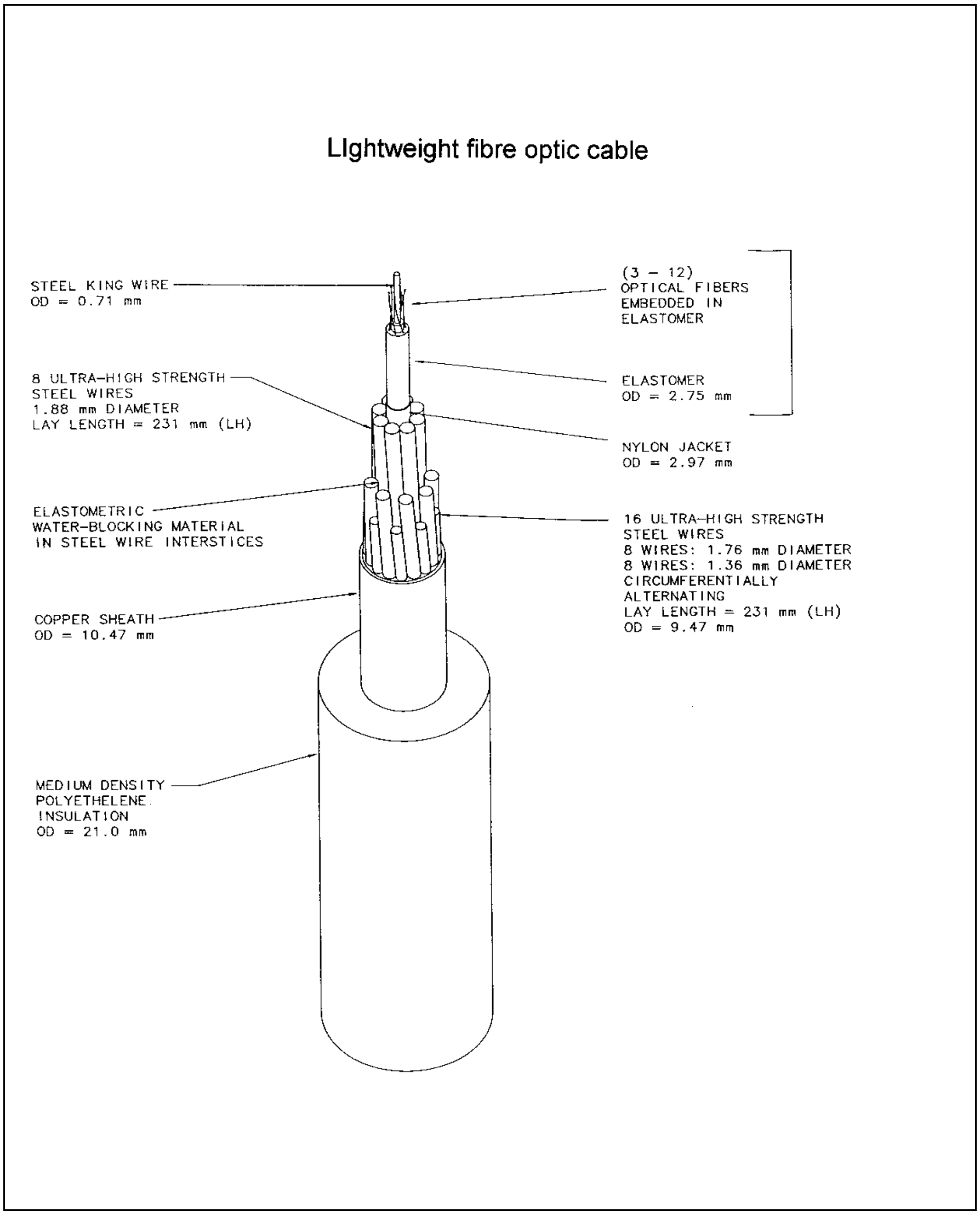


Figure 2. Lightweight Fibre Optic Cable

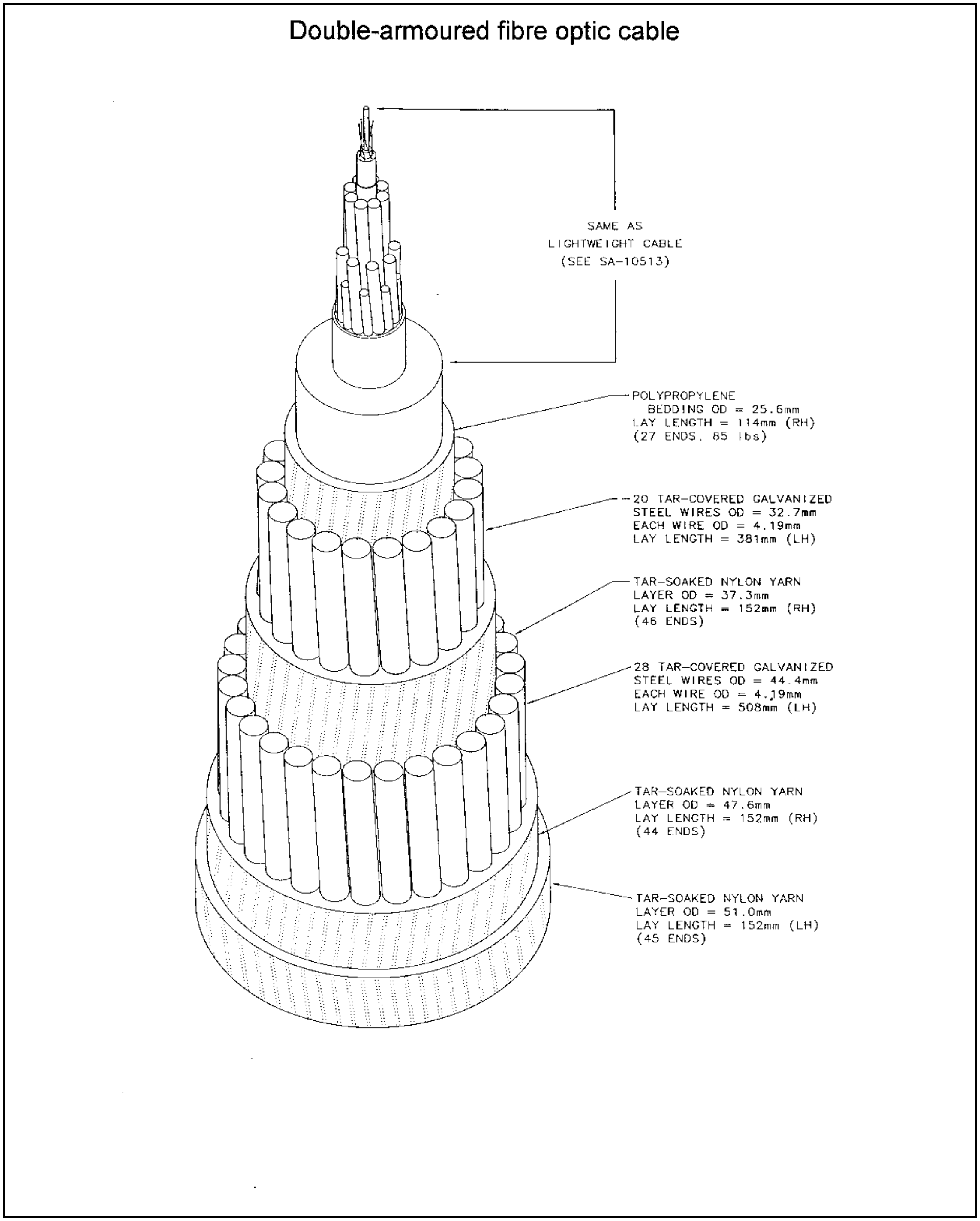


Figure 3. Double Armoured fibre optic cable

Power Cables

The core of the electrical power cable is a metallic conductor (usually of stranded copper). Core(s) are surrounded by an insulating medium, originally oil, but more recently cross linked polyethylene (XLPE). A water barrier is formed around the insulation (usually lead) and steel armouring is applied in one or more layers for protection. These cables carry up to 500,000 volts, and contact with them can be lethal.

A typical power cable may have a diameter of 160 -300 mm (6-12 inches) and weigh 50 kg (110 pounds) per meter. Power cable breaking strengths are extremely high, but it must be remembered that fishing gear and anchors can damage them severely without actually causing a full break.

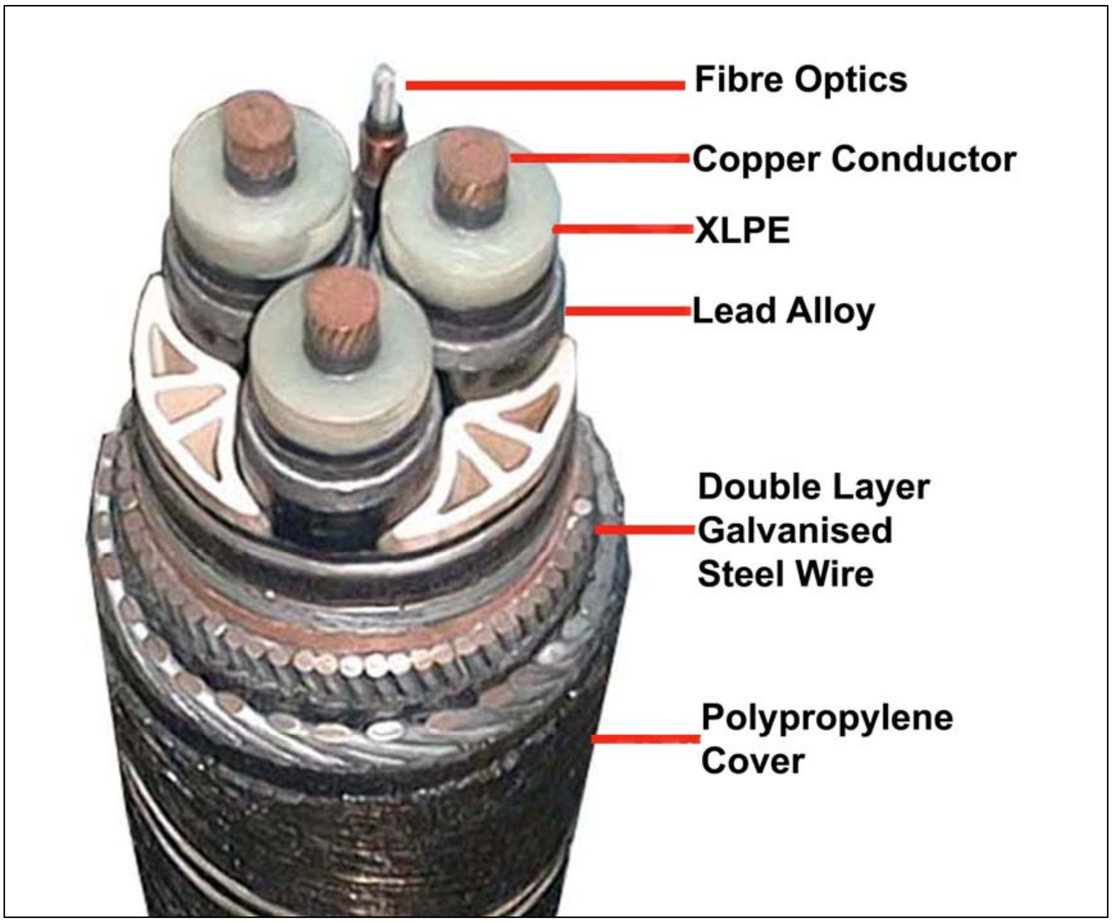


Figure 4. High Voltage (HV) AC Cable, 300 mm (12 inch) diameter

HVDC Cable Systems

High Voltage Direct Current (HVDC) cable systems usually comprise of three separate cables that are bundled together. The following example is based on the Basslink Interconnector running from Australia to Tasmania. Two high voltage DC cables and a fibre optic communications cable are bundled together with twine in the submarine part. The bundle is approximately 65kg (143 pounds) per metre, with the HV cable being 32 kg (71 pounds) per metre.

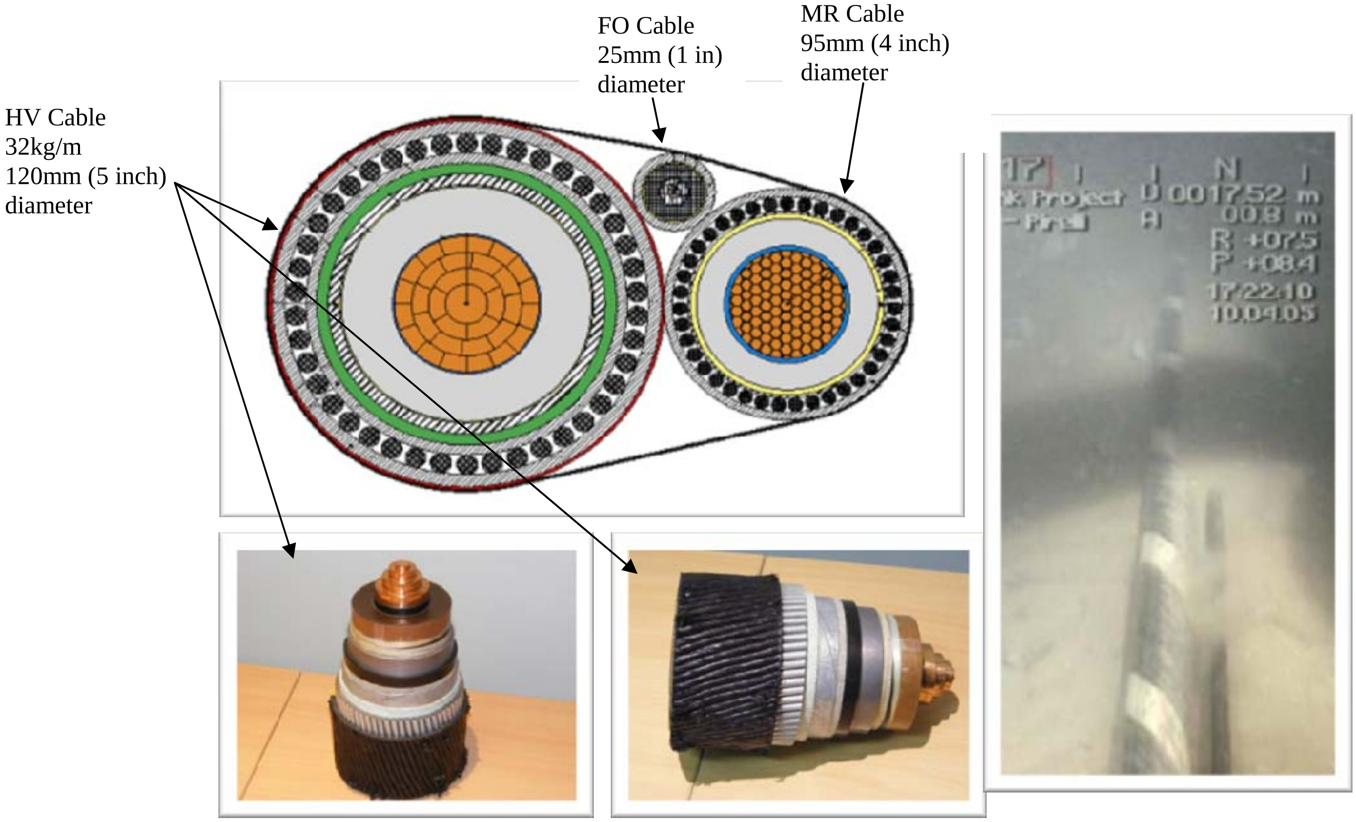


Figure 5. High Voltage DC Cable

The cable is mass impregnated, wood pulp paper tape insulated. The nominal rating is 400kVdc, 1250A and 55°C maximum conductor temperature, the conductor size is 1500mm² in the submarine part.

The metallic return cable is cross link polyethylene (XLPE) insulated with a nominal rating of 12kVdc/20kVac, 1250A and a maximum conductor temperature of 75°C. The fibre optic communications cable has 12 fibres of which 4 fibres are used for interstation communication and the remaining 8 fibres are dark.

Cable installation

Before a cable is laid, a desktop study and careful route survey are conducted, examining water depths, slopes, sediment types, other activities and obstacles. Many cable companies consult with fishermen to identify fishing risks so that potential conflicts may be avoided (or mitigated by cable burial) wherever possible. Pipelines, old cables and material discarded on the bottom must all be located so that the new cable can be laid on the clearest, safest route possible. In cases where a cable must cross a pipeline or existing cable, arrangements are made with the owner of the existing installation to minimise problems.

Specialised cableships lay submarine cables by paying them out over the stern. Differential Global Positioning System (DGPS) navigation keeps the ship as close as possible to the planned route. Cable positions are controlled and recorded as precisely as possible to ensure that the designed system length is maintained, that the cable is laid on known ground, and that it can be recovered easily should maintenance be needed later. However, in areas of extreme depth or current, the cable may touch down on the seabed at a distance from the planned route. For this reason, cable owners often recommend that vessel operators give working cables a 1 nautical mile berth. While a ship is laying cable, its speed may vary from stopped up to seven knots. Its manoeuvrability is restricted, and it displays the day signals and lights for a hampered vessel.

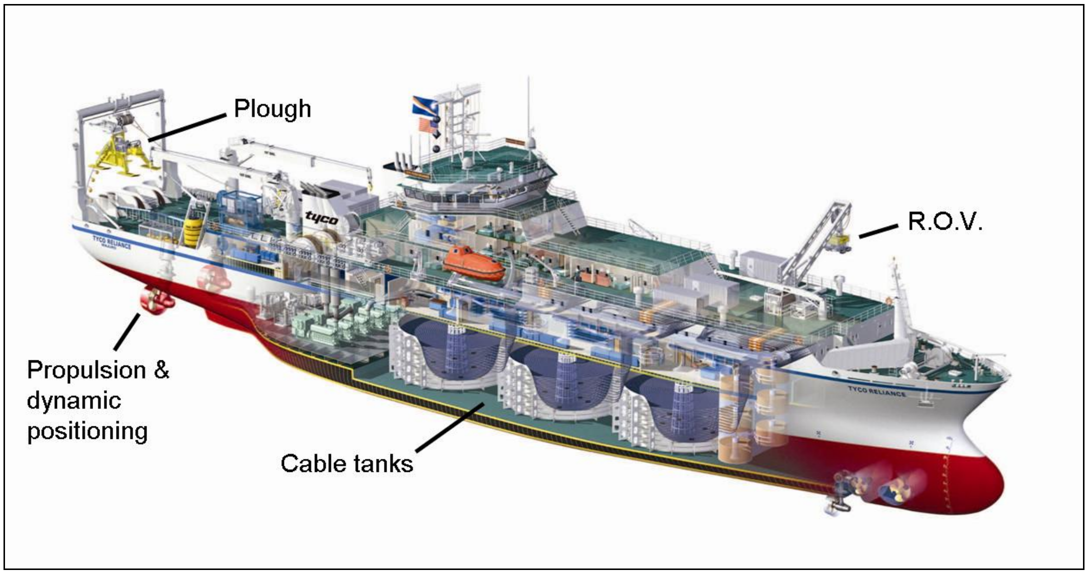
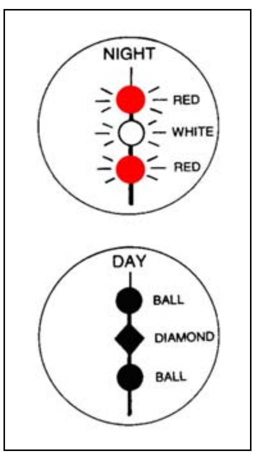


Figure 6. Cableship Cutaway



By night a working cableship displays the lights red – white – red, and by day the shapes ball – diamond – ball.

Figure 7. Signals displayed by a working cableship

During deep water installation, a cable may not reach the seabed until the ship is more than 10 nautical miles away. Fishing vessels should keep at least 1 nautical mile away from a cableship displaying these signals, and should never operate gear astern of such a vessel.

In areas where bottom fishing and other seabed uses occur, cables are usually armoured and buried in the seabed. The burial depth depends on the types of threats present, the hardness of the sediment, the depth of water, and other factors. In many coastal areas, a burial depth of 0.6 to 1.2 m (2 - 4 feet) is preferred. Where more aggressive fishing gear or anchors are used, cableships sometimes attempt burial depths of several meters, although this makes recovery more difficult if maintenance is needed later. Most cables in depths greater than 1,000 m (550 fathoms) have not been buried. However, in recent years special ploughs have been developed that can bury cables in water depths as great as 1500 m (820 fathoms).

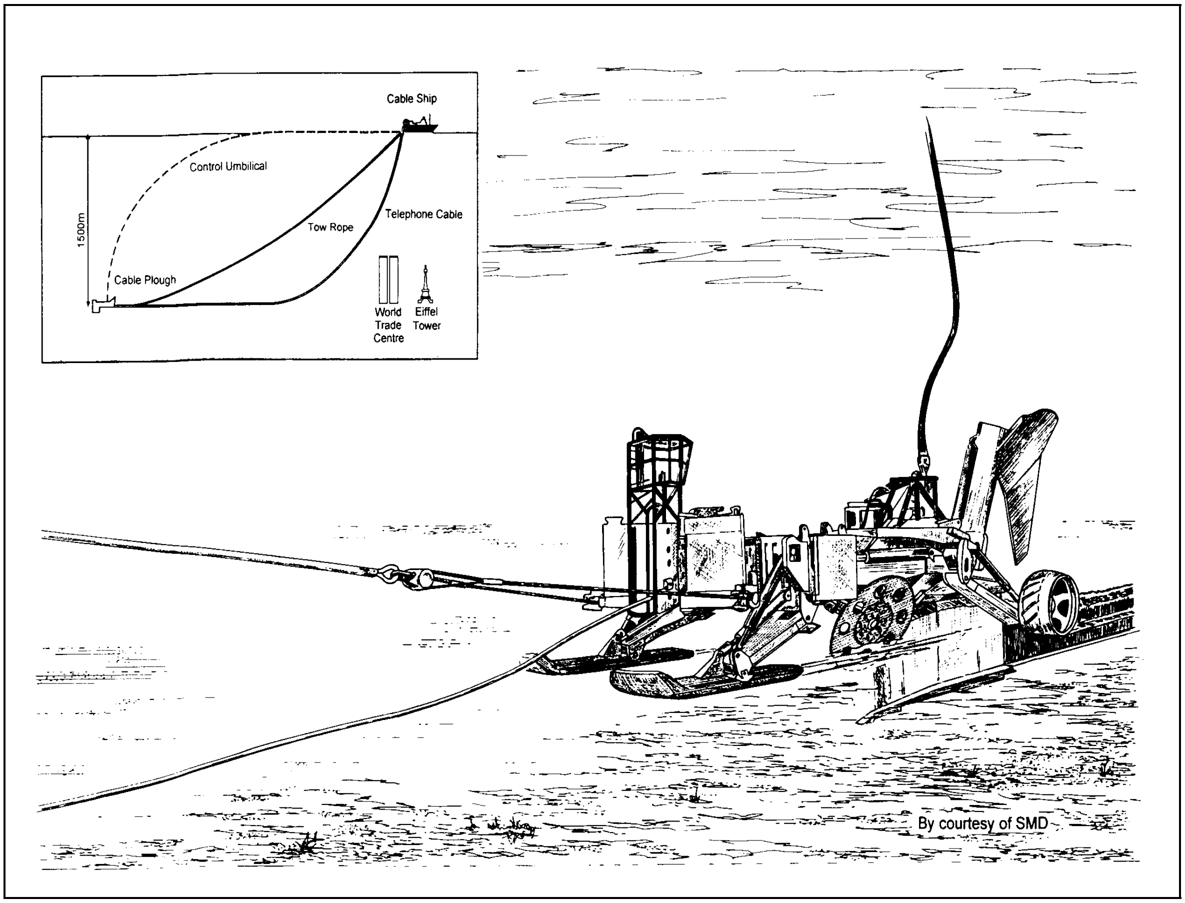


Figure 8. Plough for cable burial, courtesy SMD

Exposed submarine cables

In many situations it is impossible to protect submarine cables by burial because the seabed is too hard, rough, uneven or steep. Cableships equipped with ploughs usually bury cable as it is laid. However, in some cases it is necessary first to lay the cable on top of the seabed, and later return with a Remotely Operated Vehicle (ROV) to bury it. There have been cases where cables were damaged before burial was possible.

In places where two sections of cable have been spliced together during a repair, there is always an extra length of cable (where the cable reaches from the bottom to the ship) which must be equal to at least twice the depth of the water. Every effort is made to lay this flat on the seabed but often parts of the cable curl into one or more loops because of the extra length. There may be some delay before this extra length can be placed in the correct location and buried.

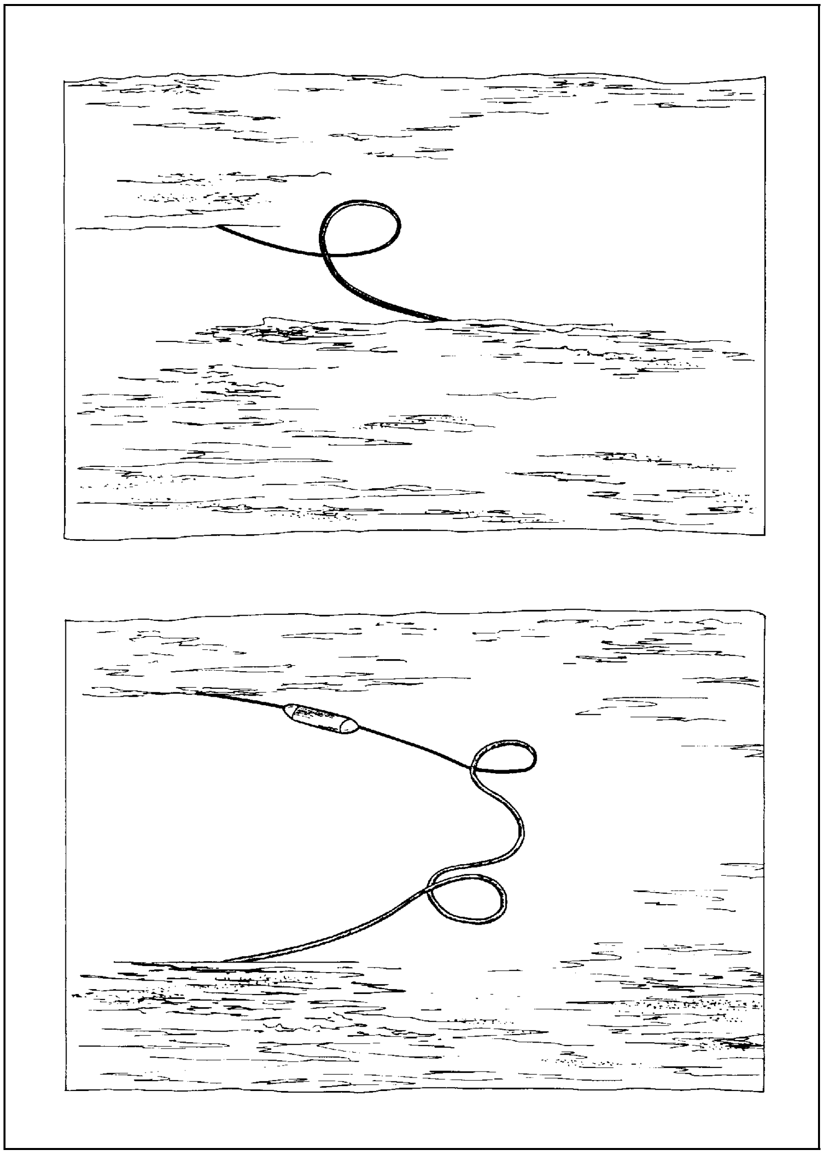


Figure 9. Loop of cable above seabed and final splice

In places where aggressive fishing gear and anchors are used, cable route planners try to avoid rocky areas where burial is not possible. If such places cannot be avoided, some ploughs have the capability to cut through rocky sediment to bury cables. In other rough areas where burial is not feasible, cable sections remain exposed, spanning gaps between rocks.

Although cable installers try to set enough slack in the cable to conform to major seabed features, they are careful not to leave excessive slack, particularly in armoured cable. Armoured cable has inherent torsion that can cause loops or kinks if it is laid with no tension.

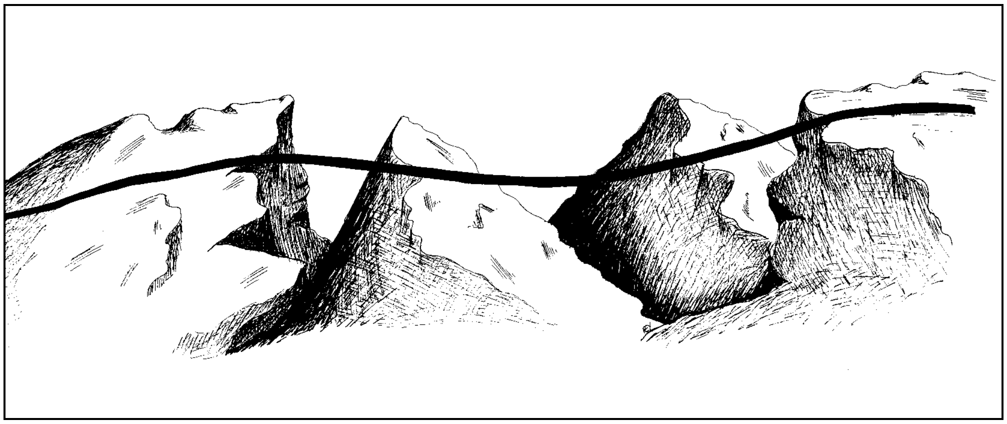


Figure 10. Cable spanning between rocks

In places with steep slopes or strong currents, it may be impossible to operate a plough or ROV, so a cable may remain exposed.

Even when a cable is well buried during installation, shifting sediment may cause it to become exposed later. One area where this has caused problems is the North Sea. Here strong currents create sand waves up to 10 m (33 feet) high which are constantly changing. The result may be sections of cable becoming completely exposed, suspended between the tops of mounds of sand. In areas of shifting sediment where bottom fishing is practised, there is a great risk of cable damage.

Figure 11. Cable spanning between sand waves

4. How fishing can damage cables

Anchoring

Modern cables are very reliable, so equipment failure is rare. Most faults are attributed to anchors and fishing gear. Anchors penetrate the seabed much deeper than most fishing gear. Before anchoring or setting fixed gear with anchors, a skipper should check his charts to be sure that he is not near any submarine cables.

Fishing methods most likely to damage submarine cables

On a global scale, the number one cause of submarine cable faults is believed to be fishing with mobile gear such as bottom trawls, beam trawls and dredges. A few types of static (fixed) gear such as longlines, gillnets, and FADs (Fish Aggregating Devices) have also caused faults. When fishing gear such as stow nets use large anchors, such fishing anchors can present extreme risks to cables. Sometimes it is not the fishing gear itself which causes the problem, but the grapnels which fishermen use to recover lost gear.

Bottom (otter) trawl

The bottom trawl, also referred to as the bottom otter trawl, consists of a cone-shaped net towed across the bottom by a single vessel. It is one of the most common types of commercial fishing gear in the world. On a global scale it is the type which most often catches cables. Included in this group are single or multiple trawls and shrimp trawls.

Bottom trawling speeds range from about two to four knots. The vertical spread of the net is achieved by the weight of the heavy footrope (also called groundrope in some places) along the front bottom edge of the net, and floats or other lifting devices attached to the headrope on the forward top section of the net. The horizontal spread of the net is achieved by trawl doors, also called otterboards, attached to the ends of the footrope and headrope by bridles of varying lengths. The most common towing rig involves two warps of steel wire rope extending from the vessel, one to each trawl door.

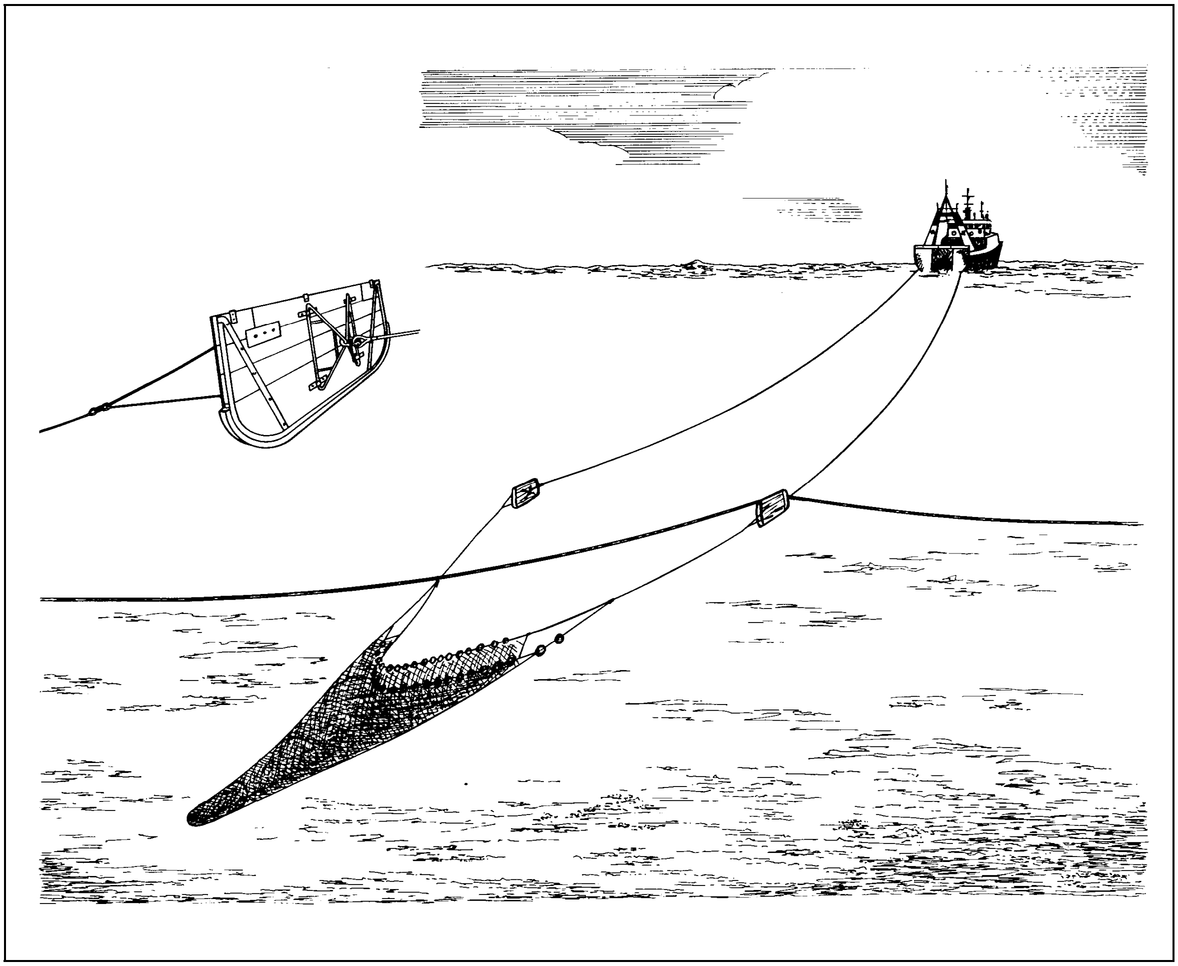


Figure 12. Bottom (otter) trawl catching cable

In recent years various types of twin or triple trawls have been used in some areas. The theory is that a much wider area of sea bed is swept by the trawl for the same amount of engine power but less drag than a huge single trawl. Figure 13 shows a type that has become common with European vessels.

A feature of these trawls is the centre weight between adjacent trawls, sometimes called the clump weight that is used to keep the ground rope hard down and to maintain the geometric shape of the multiple trawl configuration. This may vary in type from a simple bundle of heavy chain to a purpose designed roller type of sledge. They are not designed to penetrate the sea bed but could entangle with a surface laid cable

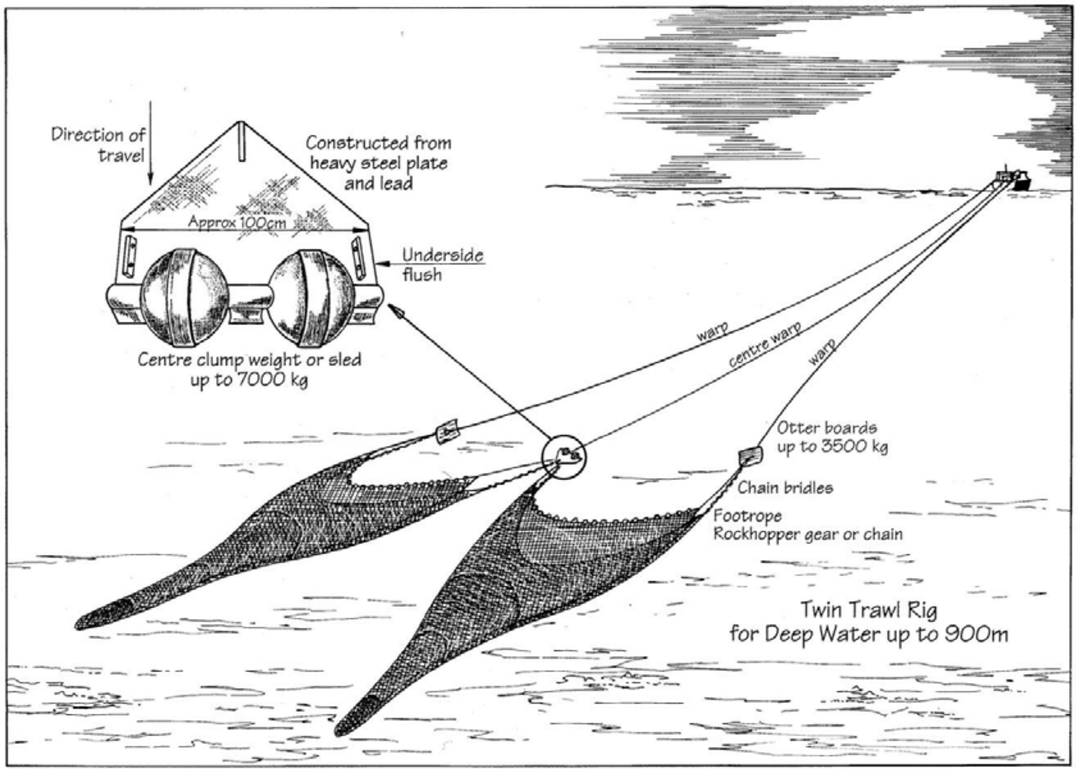


Figure 13. Twin trawl rig.
Drawing by Lillian Harris

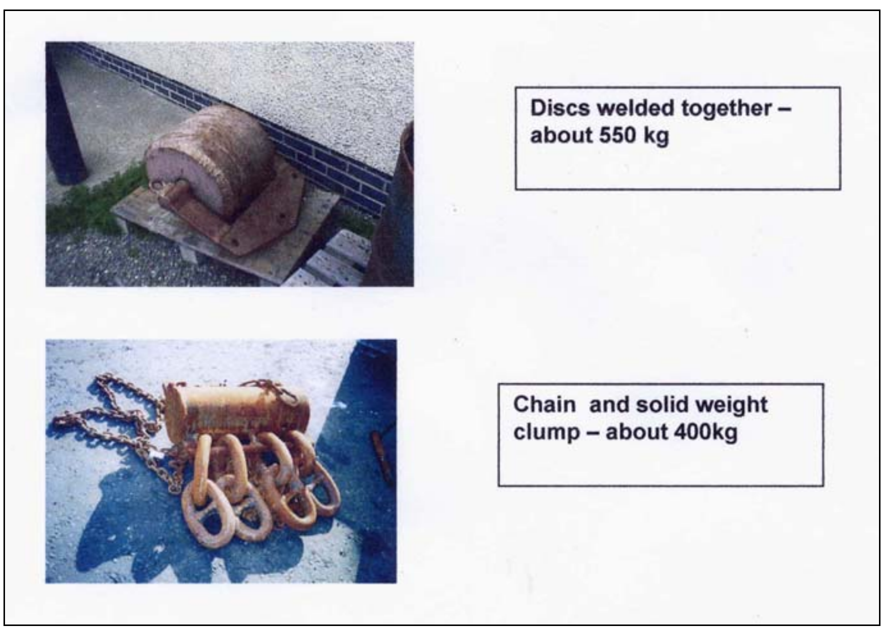


Figure 14. Examples of clumps used in twin/triple trawls

Shrimp Trawling

In shrimp trawling, a typical double rigged shrimper pulls a single warp from each outrigger. This warp splits to a bridle of two wires, each attached to a door. Thus two doors and a net are towed from each outrigger. A smaller try-net which is hauled in more frequently to check the catch is towed from the side of the vessel. Increasing numbers of shrimpers are now towing "twin trawls", with two nets towed from the end of each outrigger.

With these rigs, if one net or door gets stuck on an obstacle on the bottom, the risk of capsize may be greater than the risk for a conventional stern trawler or side trawler. This is because a downward force at a towing point on the end of an outrigger has a greater capsizing effect than a downward force exerted right at the side of the vessel.

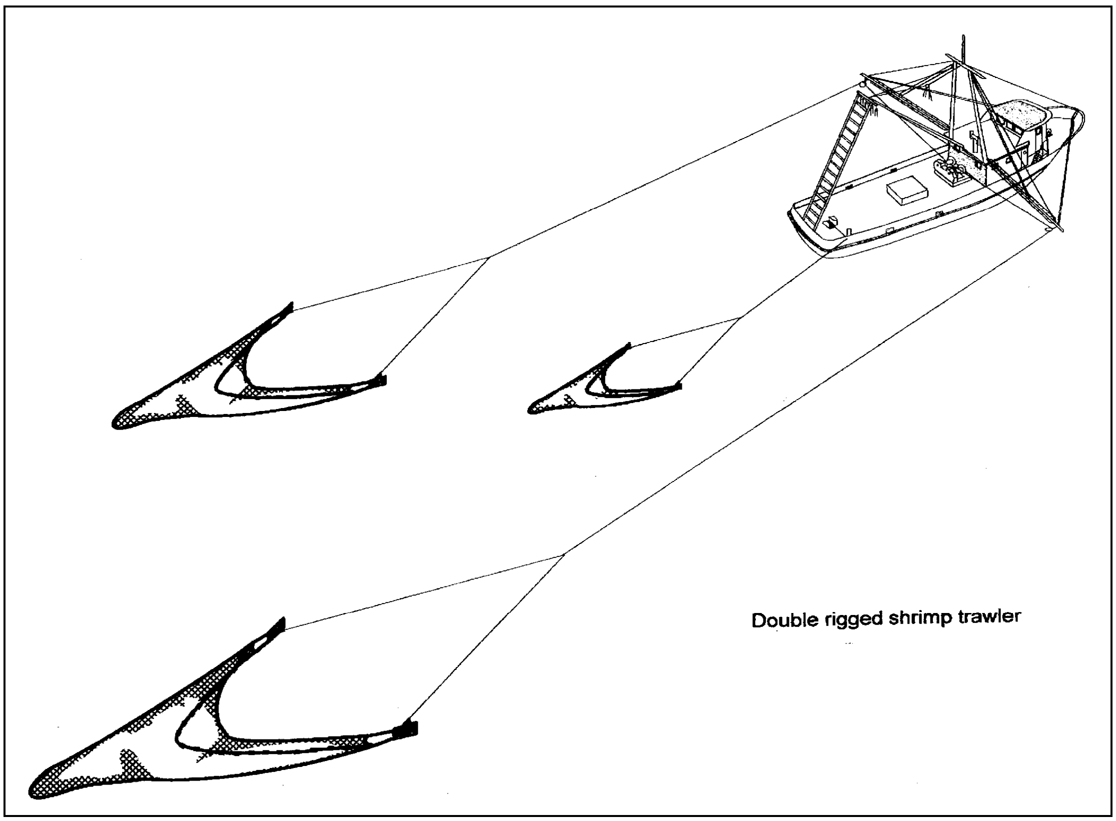


Figure 15. Shrimp trawler

(Courtesy Marco Marine)

Trawl doors (Otter boards)

Trawl doors keep the gear on or near the bottom and provide horizontal spread for the net. In most bottom fisheries the intention is to have the door and the footrope skim along in contact with the seabed without digging into it.

Studies of trawl interactions with cables have shown varying results. If a trawl passes over a cable that is buried or laid flat on the seabed, some studies indicate that in most cases no cable damage will occur. However, many factors affect this interaction. For example, some trawl doors have smooth, curved front edges designed to ride easily over obstacles. Other doors have sharp corners or gaps between a sacrificial wear shoe and the bottom of the door. Cable contact with a door over muddy seabed may simply result in the cable being pressed into the seabed with no damage, but a door strike to a cable lying on rock may crush or bend it. Finally the bottom edges of the doors inevitably become damaged in use and this can provide snag points that will snag a cable.

When a cable is struck hard by a large trawl door, damage to the cable is likely. The damage is more severe if the door snags the cable and exerts a pulling or lifting force. Doors with curved front edges and doors designed to ride with the front corner off the bottom are less likely to snag on cables and other seabed obstacles. In the 1970's the International Cable Protection Committee funded research to develop and spread the use of doors with curved forward edges. Some fishermen weld an additional plate or “shoe” on the bottom of each door to increase its weight or protect against wear. Unless the front edge of the shoe blends smoothly with the door, this can cause it to snag more on objects such as cables.

In some deepwater fisheries, doors are rigged to stay slightly off the bottom. Bottom contact is made by the footrope and by long cables and bridles between the doors and the footrope.

Trawl ground gear

Behind the trawl doors are bridles connecting the doors to the wings of the net (to the ends of the footrope and headrope). Bridles vary in length from 1 m (3 feet) to several hundred metres, depending on target species and net configuration.

Along the bottom front edge of the trawl is the footrope, also called the groundrope or sweep. A great variety of footropes are used today. On soft mud bottom, synthetic rope, steel cable and chain may be used. For use on rougher bottom various rubber discs and bobbins are more common. Rockhopper gear made from heavy rubber discs sometimes cut from old tractor tyres is designed to work on very hard seabed.

Vessels towing on smooth bottom for shrimp, flatfish and other species which live in contact with the seabed often use tickler chains ahead of the footrope which cause bottom dwellers to jump or swim up and be captured by the net.

On smooth bottom, fishermen often keep their ground gear in close, continuous contact with the bottom. Some degree of seabed penetration is likely and this may increase the chances of fouling a cable. However, the risk is offset by the fact that cable burial is often deeper on smooth sand and mud. On rocky bottom, trawl gear is often rigged to keep light contact, with little or no seabed penetration. Unfortunately, light contact in such areas might not decrease the chances of fouling a cable, since cables are more likely to be exposed on top of the seabed or spanning between rocks. There is also the risk of a door bouncing over a rock, landing hard and penetrating the seabed to strike a cable. Although some footropes have rollers, the rubber discs of rockhopper gear are not designed to roll. They may become cut or torn and this increases the risk of snagging on a cable. If a cable is suspended above the bottom because of uneven or rocky seabed, there is a greater chance that fishing gear will snag it, especially if the first point of contact between a door and a cable is above the vertical midpoint of the door.

Trawling in deep water - special concerns for cables

If a trawler skipper fishes near a cable in deep water (800 to 1800 m, 440 – 900 fathoms), the risk of losing the gear or endangering the vessel may be greater than the risk in shallow water. There are several reasons for this. For one thing, a cable is less likely to be buried in deep water. An unburied cable is much more likely to be caught by a trawl than a buried cable.

Cables in deep water may remain unburied for several reasons. First, until recently, the ploughs used to bury cables would not work in depths greater than 1,000 m (550 fathoms). Now some ploughs can bury cables down to 1500 m (820 fathoms). However, the majority of cables below 1,000 m (550 fathoms) have not been buried.

Second, some deep water fisheries are conducted on steep slopes. Most ploughs and ROV's will not bury cables on steep slopes.

Third, some deepwater fisheries are conducted over rocky bottom where cable burial is much more difficult.

When a trawl catches a cable in deep water, if the skipper chooses the mistaken course of trying to lift the cable, he will probably be unable to do so. The load on the vessel trying to lift the cable would be tremendous for two reasons. First, the great length of cable needed to reach from the bottom to the surface would be extremely heavy. Second, if the cable is laid fairly straight, the lift would be like drawing a bowstring and the cable would exert a strong tensile force to return to a straight line. This situation is more acute if the cable is partly buried. Furthermore, although some deepwater fisheries use very heavy warps and ground gear, others are conducted with thinner, lighter towing warps. In case of a snag on something as heavy as a cable, the risk of parting these warps and losing the gear is substantial.

Deepwater cables are often not armoured with steel wires. This makes them more vulnerable than shallow water cables. Trawl fisheries in deep water are expanding in some areas. Faults caused by fishing at 1300 m (700 fathoms) and deeper have been reported from the North Atlantic, South Atlantic, South Pacific and Mediterranean regions.

Unusual trawling conditions

Under abnormal conditions, trawls may dig into the bottom much deeper than usual. This greatly increases the risk of fouling a cable. For example if a new door/net combination is rigged badly, the door may dig very deep and bury itself in the sediment until the vessel stops or the warp breaks. The parting of a chain or bridle aft of the door could also cause such a situation.

After a door jumps over a large obstacle it may dive deep into the bottom and become stuck. In addition, if a vessel stops its forward motion or turns too sharply, a door may lay down flat on the bottom. In this case, a door with a solid bracket may penetrate the substrate much deeper than usual.

Beam trawling

With the beam trawl, horizontal spread is maintained by a rigid beam across the front of the net, attached to the top panel of netting. The vertical opening, usually less than 1 m, is maintained by the height of the trawl heads which support the ends of the beam. Beam trawls were used before trawl doors were developed in the late nineteenth century. Although otter trawling is now more common on a worldwide scale, the beam trawl is still a very effective gear which is widely used for bottom-dwelling species, especially flat fish.

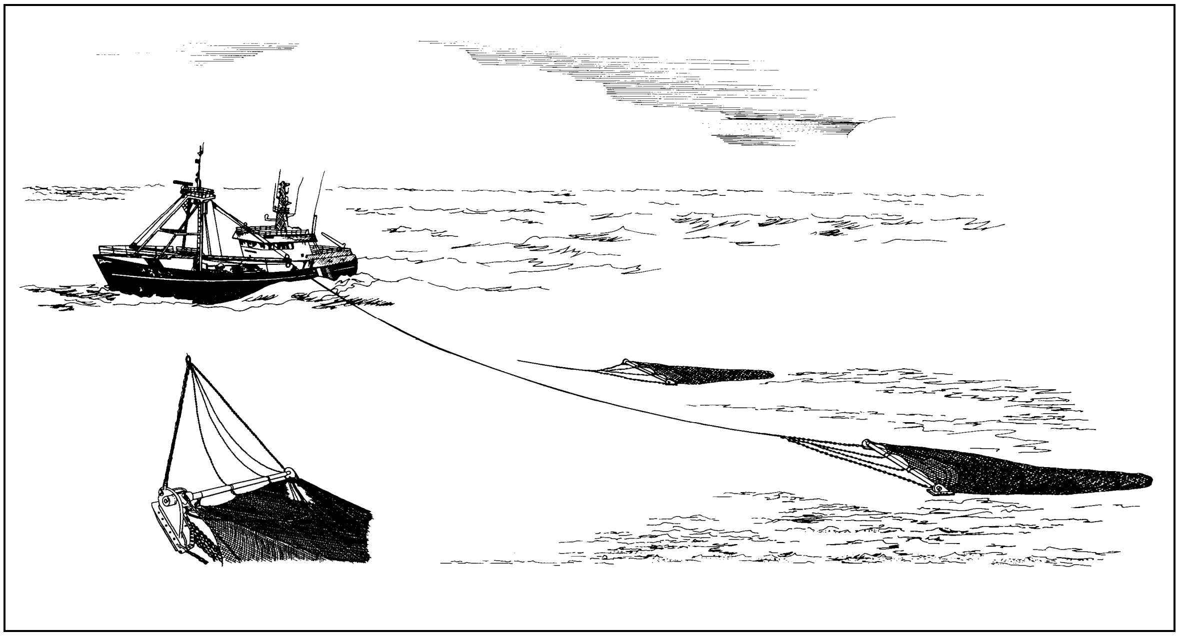


Figure 16. Beam trawl.
Drawing by Lillian Harris

In many areas it is common for a vessel to tow two beam trawls at a time, one from each outrigger. Catching a cable with a single one of these trawls is especially dangerous because all the downward pull is concentrated at the end of the outrigger which may be high and far from the centre of the vessel. One recommended safety system moves the towing block from the end of the outrigger to the side of the vessel if a trawl gets stuck on an unknown seabed obstruction. If a skipper thinks the obstruction may be a cable, extreme caution should be used.

Small scale beam trawls are used in many coastal areas by small vessels. Target species include shrimp and small bottom-dwelling fish. Some industrial scale beam trawls towed by mid-sized vessels also target shrimp. The largest, heaviest beam trawls generally target flatfish living in contact with the bottom. This gear can be rigged with up to a dozen heavy tickler chains or a chain mat which dig the fish out of the sediment.

Beam trawls are used extensively in parts of Asia and Europe. Conflicts between beam trawls and cables have occurred most intensively in the North Sea, English Channel and Irish Sea. The heaviest beam trawls may weigh up to 10 tonnes. Towing speeds of 4 knots are common and the fastest ones may move at 7 knots. Heavy bottom contact is maintained by the sole plates on the bottom of the trawl heads. In some conditions such as areas of sand waves, these trawls, when rigged with multiple tickler chains, may remove layers of sediment as they pass. On productive fishing grounds trawlers may make multiple tows over the same spot. Even buried cables may become exposed and damaged under such conditions.

During the 1970's the problems of beam trawl interactions with cables and pipelines were studied in depth. One development that emerged was the rounding of the shoes on the leading edge of the sole plate as well as the distribution of the bridle attachment points on the trawl heads. The rounded shoes and attachment array aid the trawl in passing over obstacles rather than towing through them, but not all beam trawls are equipped with such rounded surfaces.

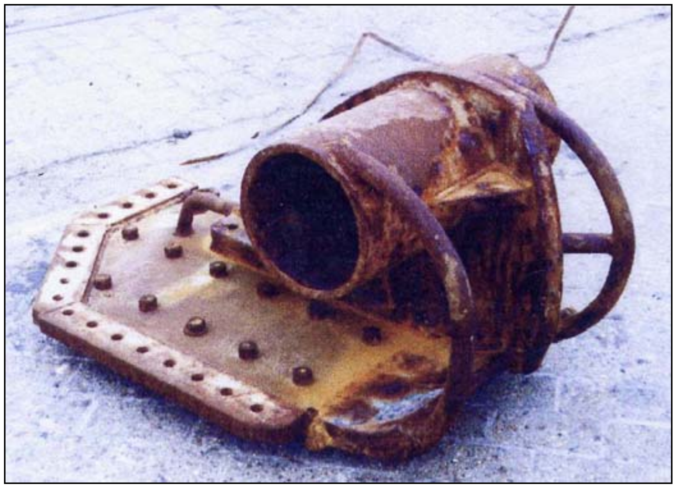


Figure 17. Shoe of beam trawl
(Photo courtesy A. Hopper)

Moreover, a beam trawl towed by a 2,000 hp vessel at 4 knots could well generate forces of impact in excess of 20 tonnes. This would cut through a lightweight cable. Although it would probably not part an armoured cable, the impact or any attempt to lift the cable could damage and put it out of service.

How trawl gear can damage cables

Submarine cables will break if they are pulled too hard. However failure of the communication through a cable will occur at lower levels of tension or if the cable is pulled or bent beyond acceptable limits.

Trawling is the fishing method which causes the greatest risk of damage to submarine cables. Damage can occur as a result of the impact of trawl doors and ground gear. Moreover, any attempt to free a trawl caught on a cable is almost certain to cause serious damage, and could also endanger the vessel and crew. Some ways by which trawls can damage cables are as follows.

Impact of a trawl door, beam trawl or dredge

When a trawl door strikes a fibre optic cable, damage is likely to occur. The weight of one door may range from 50 to over 4,000 kg (110 - 8,800 pounds). The force of impact in a horizontal direction (parallel to the seabed) of a trawl door weighing 1,900 kg (4,200 pounds) in water, when towed by a 4,000 hp trawler at 2.9 knots is calculated to be about 11 tonnes. Any hard object with this mass travelling at speeds up to four knots is likely to damage the glass fibres of a cable.

Although this force could inflict damage to the sheathing of the lightweight and lightweight screened cable it is unlikely to cause a break on the initial impact. The elasticity in the trawl and cable system will absorb much of this force and in all probability the trawl door will ride over the cable. However, this impact could damage the glass fibres and render them unable to carry signals. In power cables the water barrier maybe breached and electricity will cease to flow as the protection systems shut them off.

Cutting or tearing action from sharp or jagged edges

Should a trawl door or ground gear have sharp or jagged edges, the force of impact and the snagging of these edges could tear the sheathing of cables or damage the armour and insulation.

If the gear does not pull clear then the maximum force could build up again. This strain, and bending the cable through a tight radius, could cause serious damage.

Abrasion to the submarine cable caused by passage of the trawl bridles is another potential problem. The abrasive action on the cable from the trawl bridles could damage lightweight cables by removing the polythene insulation.

As the ground gear passes over the cable there are a number of components such as bobbins, shackles and rockhopper discs and also the centre weights in a multiple trawl which could catch the cable with sufficient momentum to bend it more sharply than the glass fibres can withstand.

The greatest risk from a trawl/cable encounter would occur during efforts made by the crew to recover the gear. Mention has been made elsewhere of the risks of capsize but there is also the likelihood of severe cable damage from crushing and bending of the cable. This is especially true of fibre optic cables. In the recovery process it is possible to apply the full power of the trawl winch to the warp and this can be further increased by applying engine power. The largest trawlers have a line pull of 28 tonnes. This could damage armoured as well as lightweight cable.

Bottom pair trawling

Pair trawlers do not use doors. A bottom pair trawl is similar in concept to an otter trawl. However, rather than achieving horizontal spread by the force of doors, spread is achieved by two vessels, with one towing each side of the net. Pair trawls can have more catching efficiency than otter trawls because eliminating the drag of doors allows the same horsepower to tow a larger net or tow faster, and because their herding effect on many species is greater. The bottom penetration of this gear is a result of the footrope and the heavy weights attached to the bridles forward of the net. Depending on the type and shape of weight, it may cause more risk for cables than a trawl door, since many trawl doors are designed to skim lightly along the seabed. In some fisheries the weights on the sides of the pair trawl rig may penetrate the seabed enough to damage cables laid on or near the surface of the sediment.

Dredging

A dredge is a type of gear towed across the bottom with a solid metal frame in front to collect the catch. It is most often used for molluscs such as clams and scallops, but some types of dredge also target crabs and flatfish. Most dredge fishing is done in water depths less than 150 m (80 fathoms). This gear type is not nearly so widespread as the trawl. However, where dredges and cables exist together, the risk of interaction may be substantial.

Vessels using hydraulic dredges (also called mechanised dredges) generally tow only one, although in recent years there are exceptions in the north eastern USA. With other types of dredges it is common to tow multiple gears from both sides of the vessel. As with beam trawlers, the risk of capsize may be increased when the gear on one side of the vessel is snagged and the other side is free.

The scallop dredge

In the industrialised fleets, boat (dry) dredges targeting scallops are the most common type. Most types have a chain bag which drags along the bottom collecting the catch. Some also use steel teeth which penetrate the seabed a few centimetres (1 cm = 0.4 inches). As with other gear types, greater bottom penetration can occur under unusual conditions, such as when a dredge pushes a rock ahead of it. A dredge 4.5 m (15 feet) wide with tickler chains can weigh in excess of 2200 kg (4,800 pounds) when empty. With towing speeds ranging up to five knots, this type of gear can easily ruin a submarine cable. In some fisheries, deflecting bars and wheels have been added to help the gear pass over seabed obstacles. Such devices may also help prevent entanglement with cables.

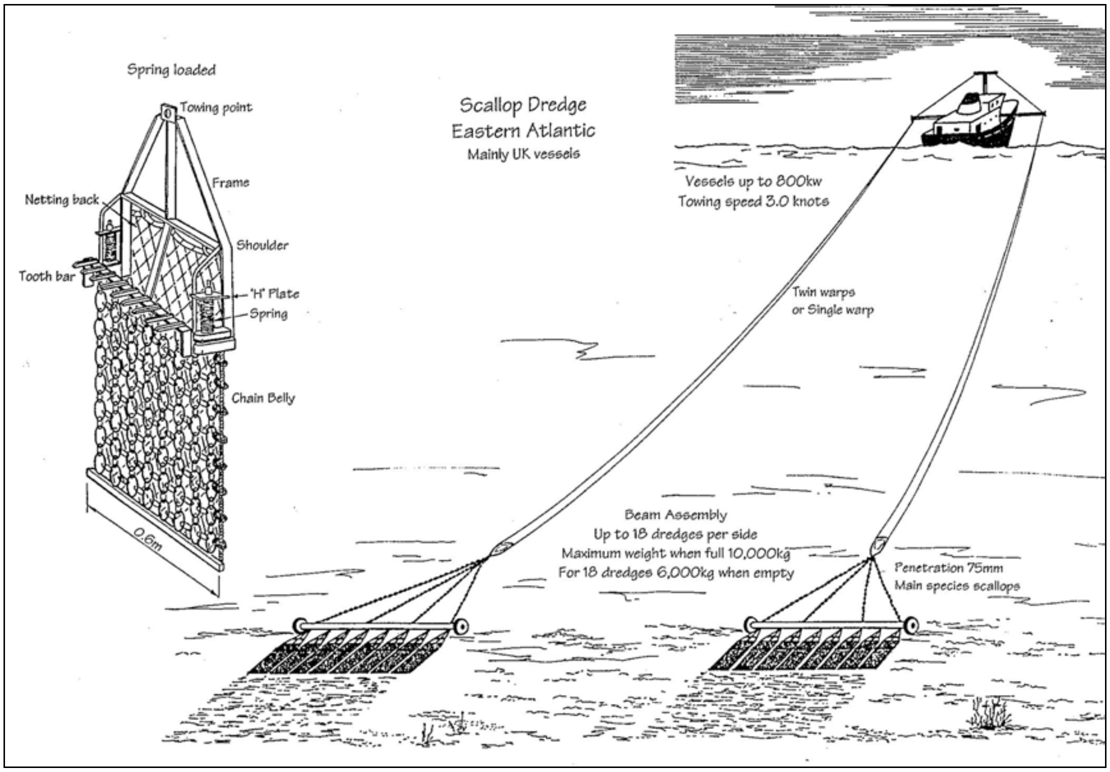


Figure 18. Scallop dredge, European type.

Drawing by Lillian Harris

The box dredge

Box dredges are rigid structures used to catch scallops, mussels and clams. They are generally fished in shallower waters than the scallop dredges described above. Some types have a toothed cutting bar which scrapes the bottom and which can damage cables.

Mechanised (hydraulic) dredges

Mechanised hydraulic dredges shoot high pressure streams of water into the seabed to dig out clams and other molluscs. These water jets liquefy the seabed and turn it into a slurry of sediment and benthic sea life.

This type of gear causes particular concern for cables because it may remove a layer of sediment with each pass. Where fishing is good, a vessel will often make multiple passes over the same spot. In this way it can eventually dig deeply into the seabed and damage even buried cables.

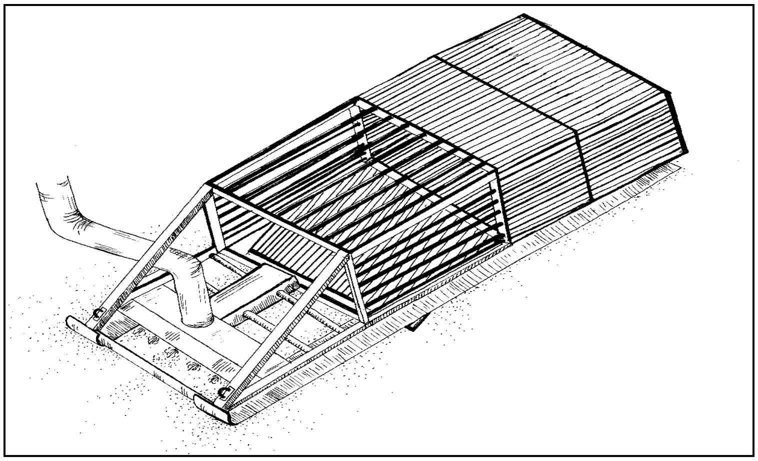


Figure 19. Mechanised (hydraulic) clam dredge.

Drawing by Riley Young

Towing speeds range from 0.6 knots up to about 3.0 knots. Industrial scale hydraulic dredges are made of steel and can weigh more than 10,000 kg (22,000 pounds).

In some shallow water mechanised dredge fisheries, the vessel drops the anchor off the stern, steams ahead to drop the dredge off the bow, then tows the dredge by hauling the anchor line with a winch. In oceanic fisheries the gear is usually towed from the stern.

Bottom longlines

A bottom longline consists of a main line laid on the seabed with a number of branch lines (sometimes called gangions or snoods) attached. At the end of each branch line is a baited hook. Bottom longlines are usually set with an anchor at each end and they do not move across the bottom much except during retrieval. A vessel sets the gear, lets it soak for a few hours, and then returns to pick it up. Variations of this gear are used to target species ranging from cod to bream to sharks. Main lines may be of fibre rope, monofilament nylon, or light steel cable. Branch lines vary in length from less than one-half metre to at least 5 m (1.5 - 16 feet).

A small longliner may fish fewer than 1,000 hooks, but a large automated longline vessel may fish more than 15,000 hooks per day. Branch lines are spaced at intervals from 1.8 to 6 m (6 - 20 feet) apart.

The use of longlines for deepwater fisheries is on the increase in some areas because of the high energy costs of deepwater trawling and because longlining may offer greater selectivity of target fish

A number of cable faults caused by longlines have been reported. The force generated in trying to clear a snagged longline has been estimated at up to 4 tonnes. With lightweight cable, a substantial force applied by the point of a fish hook can penetrate the outer covering and reach the electrical conductor or damage the glass fibres. If longlining increases in deeper waters (currently 2,000-3,000 m or 1100 - 1600 fathoms maximum in a few areas) there will be growing concern over the potential for damage to the exposed lightweight cables found at these depths.

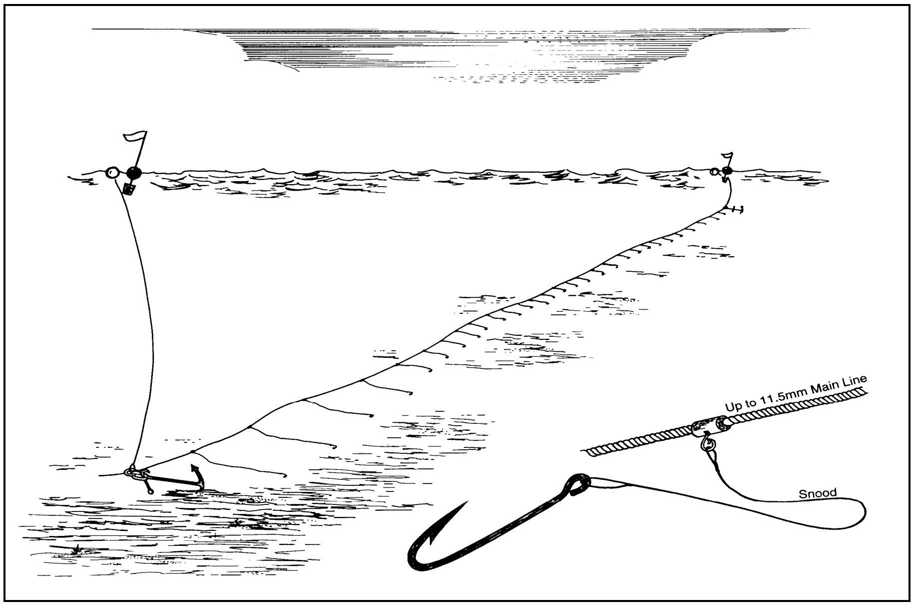


Figure 20. Bottom longline.

Drawing by Lillian Harris

Fishing Anchors and Grapnels

A great variety of anchors and weights are used on static fishing gear. These range from stones and steel bars weighing a few kilograms, to anchors three meters long, weighing over a tonne, on the wing nets and stow nets of East Asia. These anchors sometimes penetrate the seabed much more deeply than trawl gear. They may drag across the seabed a long way, when a vessel is retrieving them in deep water or when they are used in areas of soft bottom and strong currents. Fishermen using these types of gear should use great caution to stay away from cable routes. Figure 21 shows an anchor from fishing gear (believed to be a large stow net) that snagged a cable end.

Figure 21. Fishing gear anchor recovered with end of cable

When longlines or strings of traps and pots are lost, it is common practice for a fishing vessel to tow a grapnel (a hook-like anchor or length of chain with several prongs) across the bottom to find and lift the gear. In some areas with strong currents which pull marker buoys underwater, no buoys are used - the normal way to recover the gear is by using a grapnel. Many problems between cables and stationary fishing gear may occur because grapnels can catch cables, too. (Indeed the major method used by cable companies to recover lost or damaged cables is with a grapnel similar to those used by fishing vessels.)

Fishing methods less likely to damage cables

Midwater trawling

Midwater trawls are used to catch pelagic species living higher in the water column. Both single-boat trawls and pair trawls are used in midwater. Most midwater trawlers are relatively large vessels, and their nets are usually larger than bottom trawls. They generally pose no threat to submarine cables. However in some fisheries the gear is fished close to the seabed with occasional bottom contact. Such practices raise the possibility of trawl doors or heavy chain weights damaging cables.

Boat seining

A boat seine is a net similar to a trawl which is hauled by two very long ropes. Trawl doors are not used with boat seines. Horizontal spread is usually achieved by the vessel laying out the towing ropes far apart.

There are several different ways of operating a boat seine. It may be fished by a single boat either at anchor or towing. It may also be towed by a pair of vessels. In cases where a large anchor is used by the vessel, the risk of cable damage is greater.

Midwater longlines

Midwater longlines are used in many areas to catch pelagic species such as tuna, swordfish and sharks. These are used most often in open ocean with neither anchors nor bottom contact. They may carry hundreds of hooks on long branch lines spread farther apart than the branch lines of bottom longlines. A total length of forty miles is not unusual for the main line.

Midwater longlines are unlikely to have any interaction with cables on the seabed. However, problems have occurred during cable installation. A cable ship may unknowingly lay a cable over a longline which is soaking whilst the vessel which owns the fishing gear is out of sight. If a lightweight cable sinks over a longline, the buoyant force and drag of the longline may chafe through the cable insulation. The longline may also cause a sharp bend, loop or kink that damages the cable. Both the cable and the fishing gear are likely to be damaged. Caution and communication are required to avoid such problems.

Stationary gear types fixed on stakes

In very shallow coastal areas, some types of longlines, gillnets and fish traps are attached to stakes driven into the sediment. Although these fisheries are generally considered small scale, they are not to be disregarded. There have been cases of cable damage by such stakes.

Entangling nets

There are many different types of entangling net. Most entangling nets are made of thin twine which fish cannot detect easily. Vessels set these nets like mesh fences on the bottom or in mid-water. Fish and shellfish become entangled when they swim into a net. When the vessel hauls the net aboard, the entangled fish come with it.

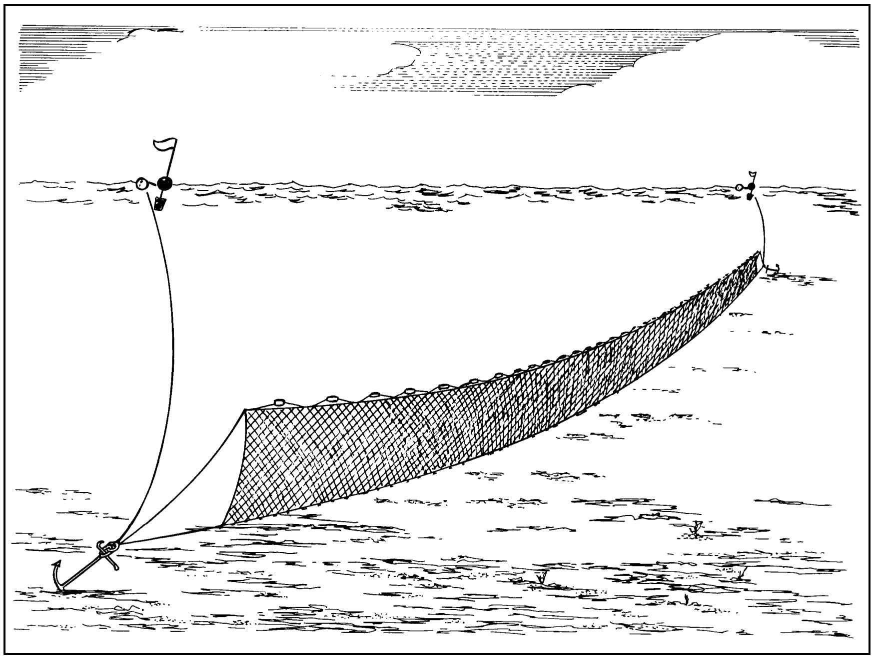


Figure 22. Bottom gillnet.

Drawing by Lillian Harris

Bottom gillnets range in length from a few hundred metres to over two miles. Most bottom gillnets are fished with anchors to hold them in place. However, on some areas of smooth bottom, gillnets are rigged to drift across the seabed, pulled by the force of the current. This method has become widespread in some coastal, tropical shrimp fisheries.

A driftnet is basically an entangling net without anchors, rigged to drift with the current. Many types of driftnet float near the surface or in midwater, with no bottom contact. International agreements have reduced the use of large scale oceanic driftnets which were often fished in mid-water to target squid and other species. However, small driftnets less than two miles in length are still used. Small scale driftnets are sometimes fished on smooth bottom for species such as shrimp.

Entangling nets do not penetrate the bottom to any significant extent. However, there is some potential for such a net to catch a cable laid on top of the seabed.

<u>Fish traps</u>

Fish traps are stationary structures into which fish swim, but from which they cannot escape. There are hundreds of types throughout the world made of netting, bamboo, wood or wire mesh. They are usually fixed to the bottom with anchors or stakes. Fish traps are coastal gears usually set in shallow water. The major concerns for cable interaction are the anchors or stakes. Fish traps should not be set in cable areas.

Pots

Many different types of pots are used to catch fish and shellfish. The distinction between a pot and a trap is not always clear, and some would say that all pots are traps as well. However, pots are generally small enough and solid enough for a number of them to be loaded on board a vessel. Pots may be made of netting fastened to a frame, of wood, wire mesh, plastic, or other materials. This gear type ranges from the small ceramic octopus pot resembling a vase weighing 2 kg (4 pounds), to a metal mesh king crab pot measuring 2.5 m (8 feet) on a side and weighing over 300 kg (660 pounds).

Vessels generally set their pots on the bottom and return to haul them after a few hours or a few days. Each pot may be marked by a line and buoy, or the fisherman may set them in series, attached to branch lines along a main line. They do not penetrate the bottom, but they could snag a cable on top of the seabed.

Pots, traps and longlines laid in deep water may cause more risk for cables than these gear types in shallow water. The deepwater gear often carries much heavier anchors and lines. At the same time, cables in deep water are less likely to be heavily armoured and well buried. In deep water, a combination of heavier fishing gear and lighter, exposed cables would clearly result in higher risk of damage.

FADs

FADs, or Fish Aggregating Devices, are gears set to attract fish, not catch them. For reasons not fully understood, fish tend to congregate near objects which are floating or suspended in open water. FADs take advantage of this tendency.

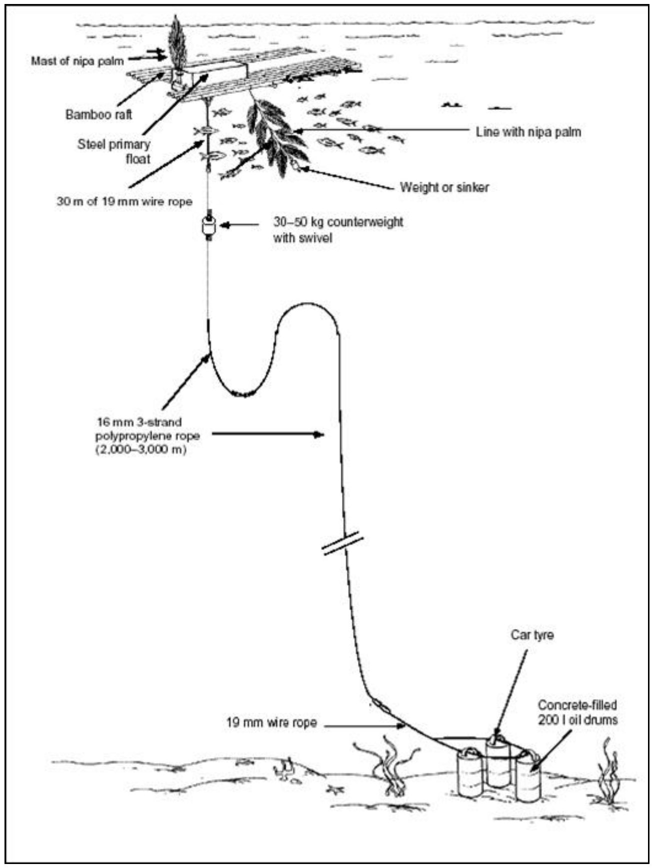


Figure 23. **Traditional style FAD**.

Drawing courtesy Secretariat Pacific Commission

The simplest type of FAD is an anchored buoy. A FAD buoy may be a large metal ball, several floating objects tied together such as plastic floats, foam blocks, tyres, or pieces of bamboo. Sometimes flags, lights or radar reflectors are added to make the FAD easier to find. Some fishermen believe that a FAD is more effective if it has other objects attached, such as a raft, extra ropes tied to the buoy line, or palm branches suspended in the water.

FADs are sometimes set in shallow water, but some are also set in water as deep as 4,500 m (2400 fathoms). Most are considered expendable because they are often lost due to storms and other causes. FAD anchors may be very heavy. Concrete blocks, old engine blocks and oil drums filled with cement are among the commonly used anchor materials. In deep waters or on rough bottom, a length of heavy chain often comes between the buoy line and the anchor. Most FADs have buoys visible on the surface, but in some areas midwater FADs are used with buoys set 10-30 m (5-16 fathoms) below the surface. Midwater FADs may present less hazard to navigation, withstand rough seas better, and avoid making their locations knows to other fishermen who would not be welcome.

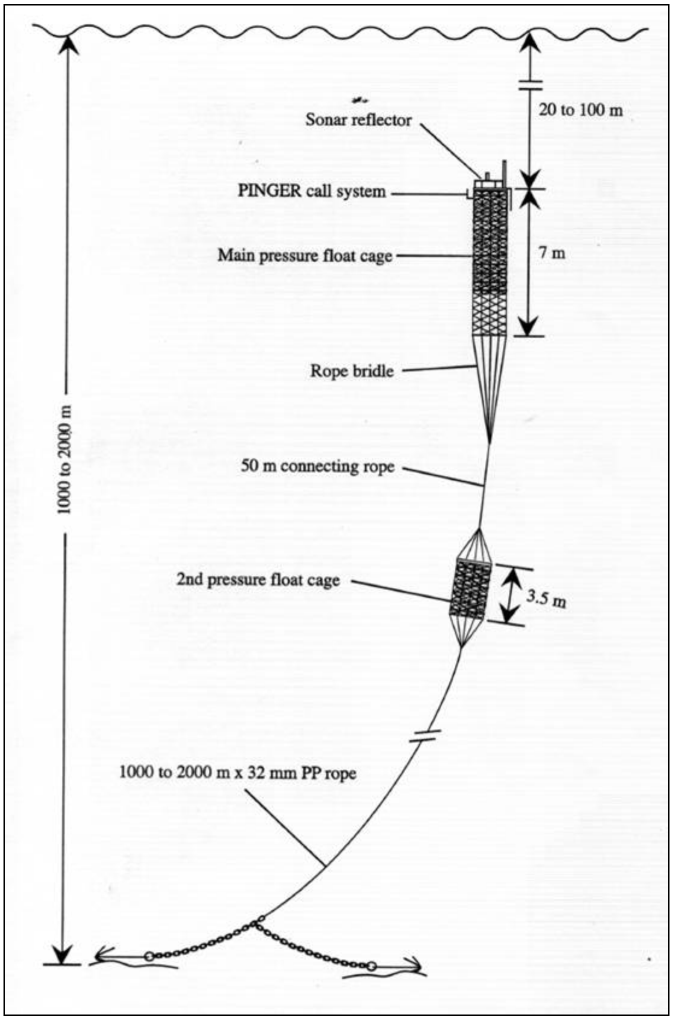


Figure 24. **Midwater FAD.**

Drawing courtesy Secretariat of the Pacific Commission

Fishermen use FADs because they help to increase catches and reduce the time and fuel spent looking for fish. A fisherman or group of fishermen may set a FAD and leave it for a few days in order to allow time for fish to gather. They make a trip to the FAD, catch all they can, then leave it alone for a few days while fish gather again. After a deep-water FAD is set, it is usually left in place until it is lost to storms or other causes. Some species commonly found around FADs include tuna, mackerel and sharks.

Several different fishing methods are used around FADs. The simplest is the handline or hook and line with the vessel either still or trolling. Pole and line fishing is sometimes practised. Driftnets or encircling gillnets may be used. Some FADs are designed so that the buoy and branches suspended from it may be detached from the anchor line and allowed to drift away, while the anchor line stays on the surface suspended from a smaller, temporary float. The fish stay with the larger FAD buoy as the vessel surrounds it with a purse seine or other encircling net. After the fish have been caught, the vessel can tow the FAD buoy back to the anchor line and attach it again.

A FAD can pose a threat during cable installation if the cableship is not aware of the FAD and the cable is set over it. A FAD may also cause damage if the anchor or its chain strikes or chafes the cable. When a FAD line breaks, the buoy is usually lost. The line and anchors are left on the seabed, since deep water recovery is very hard. If the break occurs near the surface, the line is left to drift around its anchor in a circle that may have a diameter of twice the water depth. Many FAD lines are buoyant so they will stay off the bottom , and lines left in this condition may present a hazard of tangling or chafing on cables. The use of FADs has spread a great deal in recent years, and several such conflicts have been reported. FADs should not be set near cables.

5. The dangers of catching cables and how to reduce them

The most effective way to avoid the dangers of catching cables is to avoid using anchors, grapnels, and any gear that penetrates the seabed near a cable, and to keep fishing gear away from cables. However, if a vessel is fishing near cables and the gear becomes fouled, it is extremely dangerous to try to recover it. Instead, the skipper should contact the Coast Guard or the cable company and seek more information to determine if he is in fact fast to a cable. The company owning the cable will know if, and where, an in-service cable has been damaged from monitoring equipment at the terminal. Their advice may be to attach a buoy to the warp and let the gear go. In many cases, cable companies have reimbursed vessels for gear sacrificed in order to avoid damaging cables.

When a trawler encounters an unidentified seabed obstruction, the skipper should watch for signs that the obstruction could be a cable. These include the difficulty experienced in trying to pull clear and a progressive weight increase from the cable as it lifts clear of the seabed. If in the course of trying to free the gear from an unknown obstacle it becomes apparent that it may be fouled on a cable, the skipper should lower the gear back to the seabed and call the Coast Guard or cable company.

Trying to lift a trawl entangled with a submarine cable can be much more dangerous than pulling free from other seabed obstructions. When the winch is engaged, at first it may appear that the trawl is coming free but the tension in the trawl warp increases as more cable is lifted from the seabed. This is partly because of the increased weight of cable coming off the bottom and hanging from the trawl. In addition, if the resting cable were stretched fairly straight before the incident, it would also resist being pulled from a straight line, as would an archer's bowstring. The problem is worse if the cable is partly buried, because the vessel is trying to pull the cable out of the sediment. If the cable is partly buried it will be impossible to lift it more than a few metres and the tension in the warps could build up rapidly to a point which could capsize the vessel and especially if the warp tension was very high

Capsizing as a result of cable entanglement - one risk too many

A capsize is the most serious outcome of an encounter between a fishing vessel and a submarine cable. There are many reasons why a ship may capsize such as wind, waves, collision, flooding movement of cargo, and for fishing vessels and tugs, the external loads on the towing lines or warps.

A well built vessel is designed to return to the upright when heeled by forces of wind and waves. In normal conditions there are two equal and opposite forces acting on the ship. Firstly there is gravity created by the weight of the ship and its contents acting through the centre of gravity G. Secondly there is the buoyancy created by the water pressure on the submerged hull, acting through the centre of buoyancy B (see Figure 25).

When the ship is heeled by wind or waves the centre of buoyancy moves to a new position as the underwater shape of the hull changes. Gravity remains unchanged and a restoring couple is created which brings the vessel back to the upright.
The art of good design is to keep the centre of gravity low in the ship by putting weights such as fuel and ballast low down in the ship. This maximises the length of the righting lever GZ in the figure. If the position of G is too high it can, at small angles of heel go over centre of B and create a capsizing couple.

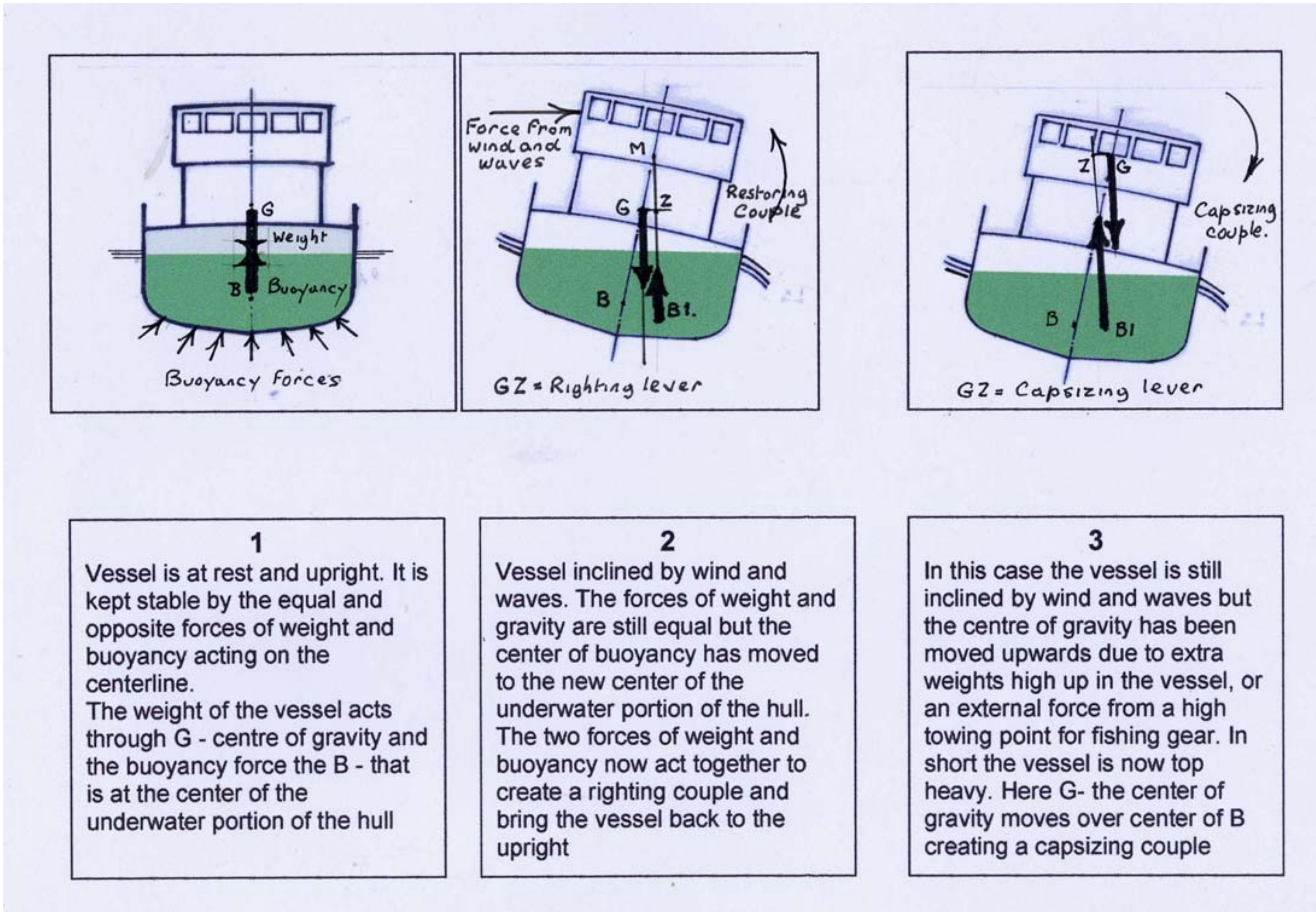


Figure 25. **Basics of Stability of Fishing Vessels**

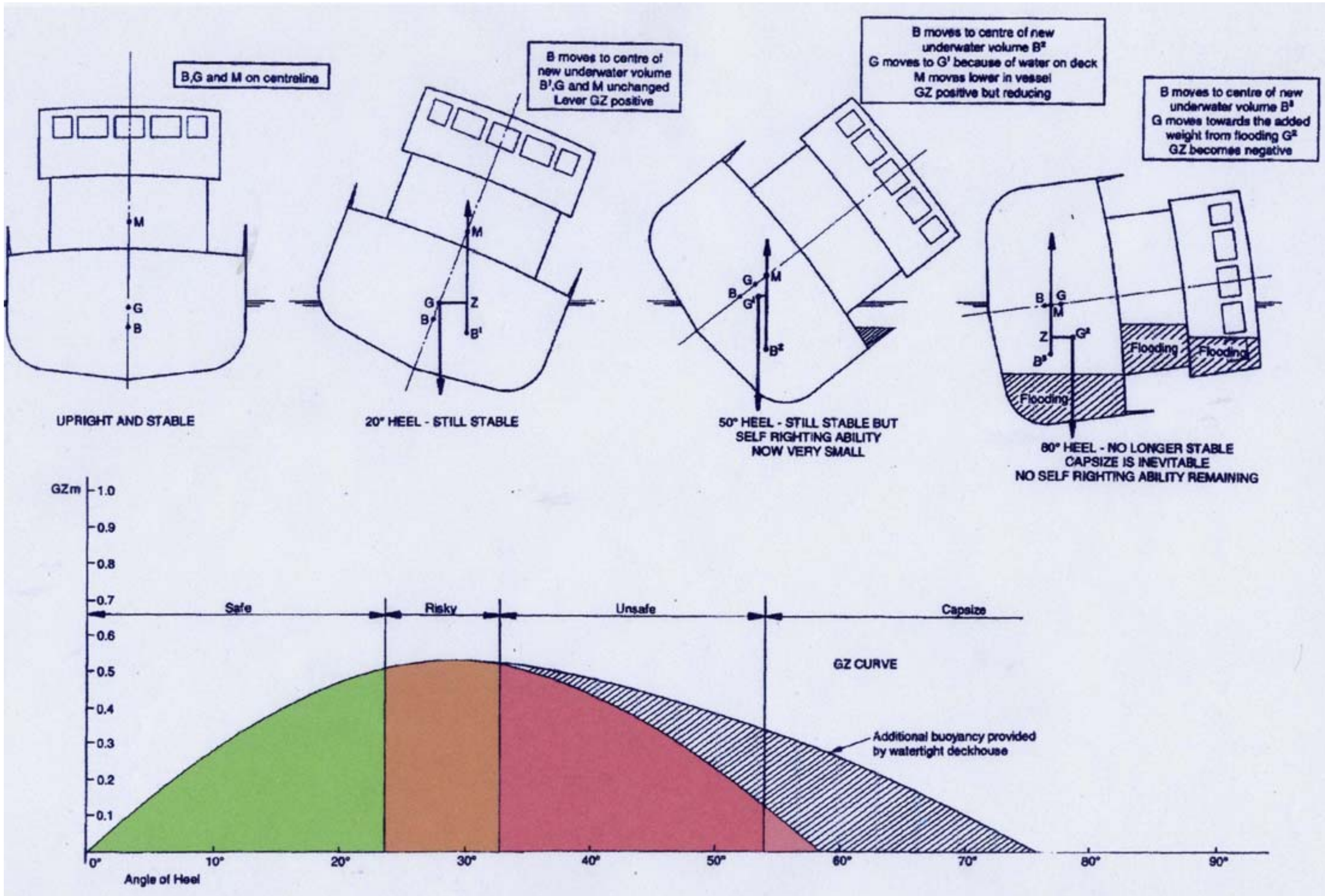


Figure 26. **The physics of capsize**

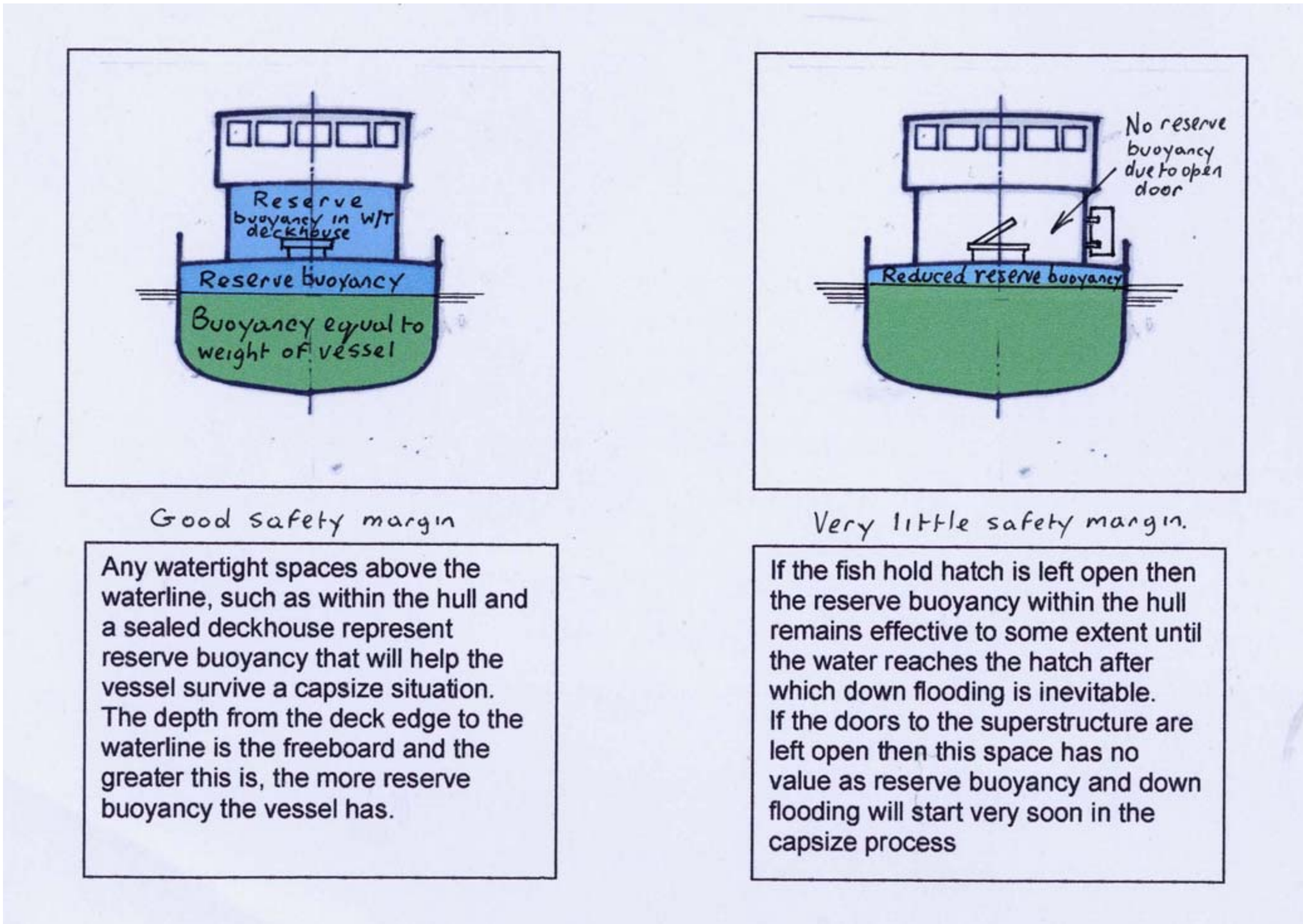


Figure 27. Effects of freeboard & reserve buoyancy on safety of fishing vessels

When a vessel is towing a trawl or dredge the ship carries additional loads which become forces equal to adding weights on to the basic ship. Depending where they are they affect both the force of gravity and the position G. The forces too will change if the vessel snags a seabed obstruction and increase dramatically if the vessel tries to pull free by using winch and engine power.

Let us now examine what might happen in a case of cable entanglement.

6. The Royal Resolution - a case study of capsize

The Royal Resolution is not a real vessel. This is a fictional account of a capsize. Nonetheless, it is typical of several accidents in which well built and apparently stable fishing vessels have capsized when trying to pull clear of obstructions such as seabed cables.

Being involved in capsize is one of the most frightening things to befall a fisherman. The capsize is usually very quick so there is no time to take preventive action or send a Mayday call. The capsize results in the violent movement of heavy gear, loose tackle and derrick booms all of which can kill or seriously injure people. Orderly evacuation of the vessel is rarely possible. Anyone trapped below decks becomes disoriented and may find it impossible to get out especially if there is a power failure and the lighting suddenly fails. Those surviving such an event are often traumatised for many years and their sea-going career is affected.

On a cold but clear morning in February at 0700 hours the 28 m, 500 hp beam trawler Royal Resolution was fishing in 50m of water in the southern North Sea. There were several other beam trawlers in the area. The sea state was force 2 and there was a strong easterly spring tide running at about 2 knots. There was a full moon low on the horizon. The vessel was towing in a southwesterly direction. The hatches were closed and secured but the watertight door to the deckhouse had been left open for ventilation.

The skipper had gone below at 0600 hours at the start of the last tow, leaving the mate with the watch. He had been on the bridge continuously for 20 hours due to fog and unusually heavy traffic. At 0715 the port trawl came fast to an obstruction on the seabed. The mate immediately stopped power to the propeller. He activated the safety mechanism which brought the towing point on the port warp from the end of the outrigger derrick to the forward towing position nearer to the centreline. The skipper returned to the bridge immediately and resumed command. He decided to haul the starboard gear to the surface and then reverse back over the obstruction to see if the port trawl pulled clear. At 0740 it was clear that this tactic was not working so he first brought the starboard trawl inboard and then engaged the winch to pull the vessel as close as possible to the obstruction. At this time he had no idea what was causing the problem. As winch power was applied it was obvious that, although the gear was now clear of the bottom, the tension was still increasing rapidly and the list to port was increasing. At 0750 he ordered the winchman to secure the winch brake and he engaged the propeller in reverse to once again attempt to pull free. The vessel quickly *took on an alarming list in excess of 30 degrees. He stopped the engine but by then the sea flooded in over the ship's rail and into the accommodation. He realised she was going to capsize and shouted a warning to the crew.*

The Royal Resolution capsized at 0752. The crew of five, all of whom were on deck, escaped in spite of being entangled with falling gear and ropes. One had the presence of mind to release some lifejackets. A liferaft floated clear and automatically inflated. This together with the lifejackets clearly saved lives. The crew were picked up 20 minutes later by the Belgian trawler Verdun which had observed the incident from about 1 mile away whilst hauling her own gear. The Royal Resolution sank at 0812. In this case there were no serious physical injuries to any of the crew. However, most suffered some hypothermia. Two suffered long term trauma and have not returned to fishing.

Subsequently divers inspected the wreck to see if it could be recovered. They found the port gear fouled by a heavily armoured submarine cable which would have been unlikely to be pulled clear by any of the methods used by the skipper. There are many cables shown on the charts in this area. Although all are buried it is an area in which the sea bed is constantly changing shape due to strong tides and currents and scouring by beam trawlers.

<u>The Royal Resolution: what happened?</u>

The mate's decision to stop the main engine, engage the safety mechanism was entirely correct and may have prevented the vessel from towing herself into an immediate capsize situation through considerable external forces. The leverage provided by the length of the outrigger derrick and the tension in the warp would have been very dangerous for the vessel.

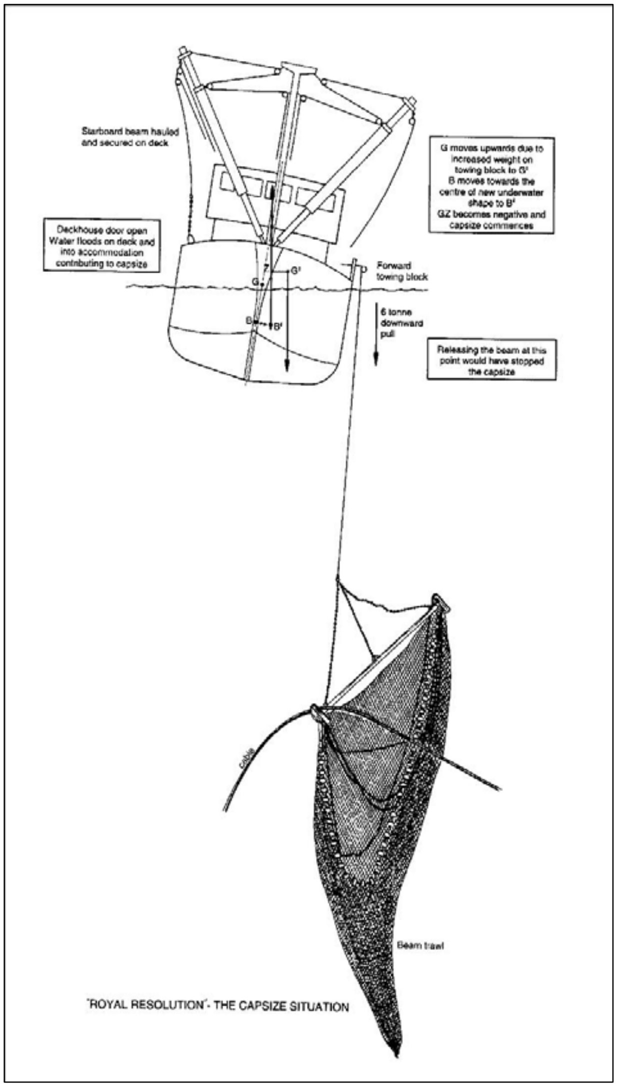


Figure 28. Capsize situation

The lifting of the starboard beam trawl was normal practice since the number of crewmen only allowed them to handle one beam at one time. It was also common-sense since the starboard beam could have easily fouled the obstruction or the port beam leaving the vessel in a situation in which the only solution may have been to release and lose both sets of trawl gear. This is not an acceptable option for most skippers. Nevertheless it may have been wise to leave the starboard beam outboard and use it to provide some balance to the large forces which were to build up on the port side.

When the vessel was hauled back to the obstruction the beam was probably starting to lift the submarine cable as it had obviously not pulled clear in the horizontal direction. By securing the winch brake and using the engine, the skipper was able to apply a load of about 6 tonnes at the towing point which was about 3.5 m (11 feet) off centre and about 4.0 m (13 feet) above the waterline. This had the effect of moving the vessel's centre of gravity towards the load and thus reducing the righting lever (GZ) and creating an external capsizing force. The sudden inflow of water over the ship’s rail added a new weight to the starboard side which further increased the angle of heel allowing more water to flow inboard and flood the accommodation through the open door. A strong tide was pushing on the port side. The fact that the vessel was anchored to the seabed through its gear and the cable contributed to the capsizing forces. Capsize became inevitable.

A crucial factor is that the skipper did not know he was fast to a cable. It could have been anything from a piece of wreckage, lost fishing gear or a heavy boulder. The obstruction was apparently pulling free but in reality he was lifting the cable and there was a progressive increase in weight. This makes the process of disengagement from a cable an especially dangerous situation for all fishing vessels. The problem lies in the enormous forces generated by the engine and winch which can exceed the vessel's natural ability to right itself.

Had the deckhouse watertight door been closed it may have saved the vessel. At a late stage it would have been possible to release the winch brake and remove the capsizing forces very quickly. Since the deckhouse was open it allowed rapid flooding of the engine room. This hastened the capsize and eventual sinking, giving little time for corrective action.

Two very important factors in resisting capsize are adequate freeboard and adequate reserve buoyancy above deck in the form of watertight deckhouses (see Figure 27). Both can be built into the vessel in the design stage but in practice maintaining the watertight integrity of a deckhouse is difficult. Doors are left open to allow the free access of crew into and out of the spaces.

The figures above show how a vessel can heel to about 20 degrees before it starts to move into the risky zone, and beyond 30 degrees or so the risk of capsize becomes inevitable unless the capsizing load can be released. They also show the benefit of any reserve buoyancy in partially reducing the risks. Most fishing captains will intuitively know when the vessel reaches the unsafe point but it has to be said that once this point is passed then capsize can take place in seconds.

Special consideration of small vessels less than 24m length

Small vessels of under 24m or so are at greater risk than the larger vessels when entangled with a cable. Firstly many of these vessels are not built to the International Maritime Organization (IMO) criteria, because it is largely irrelevant to their size. This does not mean that they are unsafe in normal operations. However some carry a very high engine power to the hull size and therefore can generate a disproportionate capsizing force when coming fast. They do not have the reserves of buoyancy of the lager vessel or righting forces from the weight of the ship to resist capsize. A comparison may be the comparison between a high powered motor cycle and a 4X4 road vehicle. It would be much easier to knock the first one down.

Figure 29. Beam trawler snagged on out-of-use cable.

Other factors affecting stability of fishing vessels

Other factors which can contribute to the capsize of a vessel include:

a) Weight accumulation. Most vessels accumulate as much as 20% weight increase after 20 years with most gains occurring during the first 5 years. This is due to paint, corrosion, water absorption by wood work, additional equipment, loose gear carried on deck and the accumulation of ship's stores. Since most of this lies high in the vessel its net affect is to raise the centre of gravity (G) and thereby reduce GM.

b) Engine power relative to vessel size. There has been a tendency to cut building costs by installing the maximum engine size in a small hull. Sometimes regulations force the size of vessels to an upper length limit, and installing a high powered engine into the vessel, theoretically, gives it the capability of a larger boat. Since much of the engine power can be transmitted through the trawl warps the possibility of generating a capsizing force clearly exists.

c) Winch power. This is not regulated in any way. For the purpose of towing heavy trawls in deep water winches with line pulls of up to 40 tonnes are now coming into use on relatively small vessels. When recovering gear from an obstruction the full power of these winches can be brought to bear on one side of the vessel creating a capsizing force as described earlier. The warp diameter is selected to have a tensile strength of 2 or 3 times the winch pull, so the warp is not likely to break before the capsizing forces are reached.

d) Wave height and length. The initial static stability is calculated for still water conditions. As has already been indicated the centre of buoyancy depends on the underwater volume and shape. In wave action these are constantly varying. Thus the righting levers will also vary and with a fixed external load from a fastener on one side there is a strong probability that the GZ value may diminish or even become negative. During stormy weather, a vessel which is heeled sharply to one side as a result of an external load, can take on board a lot of water from waves. This will immediately increase the probability of capsize. Quartering seas are especially dangerous when a vessel is trying to pull a heavy load on board.

e) Tide and current flow. Normally a vessel will lie bow up to the tide or current flow when fast to the bottom by either an anchor or when fast to the seabed by fouled gear. However in the various manoeuvres to clear the gear the vessel may be brought broadside on to the flow. Circumstances could arise in which this provides an additional force contributing to capsize.

IMO Stability Criteria

The minimum criteria for fishing vessels over 24 m (80 feet) in length are laid down by the International Maritime Organisation (IMO). These are now adopted by many National Organisations in a modified form for vessels of 12 to 24 m (40-80 feet) in length. It is also recommended that beam trawlers, because of their high risk to capsizing, carry 20% margin on the criteria.

These criteria show that if a vessel is loaded within the permissible range of loading conditions it will operate safely and resist capsize from most wind and weather conditions. However, it should be remembered that trawling in particular can result in excessive loads which can take the vessel beyond the safe limits provided by the criteria.

But is this enough to equip the skipper to make decisions when faced with an unexpected capsize situation? Probably not, since most skippers of fishing vessels have limited opportunity to put their knowledge of stability into practice. Moreover, many may have only superficial or even no knowledge of the subject. This can result in complacency that if the vessel meets the criteria there is little risk of capsize. Casualties and deaths from capsize are too frequent. However, with good design, careful ship management with regard to loading and sound seamanship these accidents can be reduced.

It would be wrong to assume that a competent skipper is not aware of these dangers to his vessel. Much of his experience tells him that his vessel is in danger and that certain factors increase the risks. Nonetheless the capsize situation can develop rapidly and in circumstances largely outside the experience of most seafarers. The enormous increase in power of small vessels and their winches provide the means of generating external forces far beyond the original expectations of the IMO stability criteria.

7. How to avoid catching cables

The best way for fishermen to avoid catching cables is to know where they are and stay away from them when using anchors, grapnels, and any other gear that penetrates the seabed or snags cables. The legal requirements for avoiding cable damage vary from place to place, but in all areas it is good fishing practice to avoid risks that can be costly, dangerous and disruptive to essential communication services. The locations of most submarine cables are marked on nautical charts, and increasingly on electronic navigation software.

Submarine cable awareness charts and electronic data services

Cable awareness charts enable fishermen and other seabed users to know the locations of cables and avoid possible conflict before it happens. Cable companies in many areas now give skippers free charts showing cable locations, and mount campaigns to spread the word when new cables are laid.

The United Kingdom Cable Protection Committee (UKPC – http://www.ukcpc.org.uk/) and Kingfisher Charts develop cable awareness charts that can be downloaded from the internet or ordered from Kingfisher. Coverage includes most submarine cables landing in the UK. Route Position Lists compatible with most fishermen's navigation software can also be ordered or downloaded from this site.

On the other side of the Atlantic, the North American Submarine Cable Association (NASCA) has developed a set of electronic cable awareness charts compatible with the navigation software used by most fishermen in the region. These can be ordered on CD by contacting http://www.n-a-s-c-a.org/.

Many other companies and fishermen's organizations distribute cable awareness materials for local waters. Since the International Cable Protection Committee includes all the major telecom cable companies of the world, and many power cable companies, the ICPC can usually direct inquirers to the appropriate source for cable awareness materials in local waters.

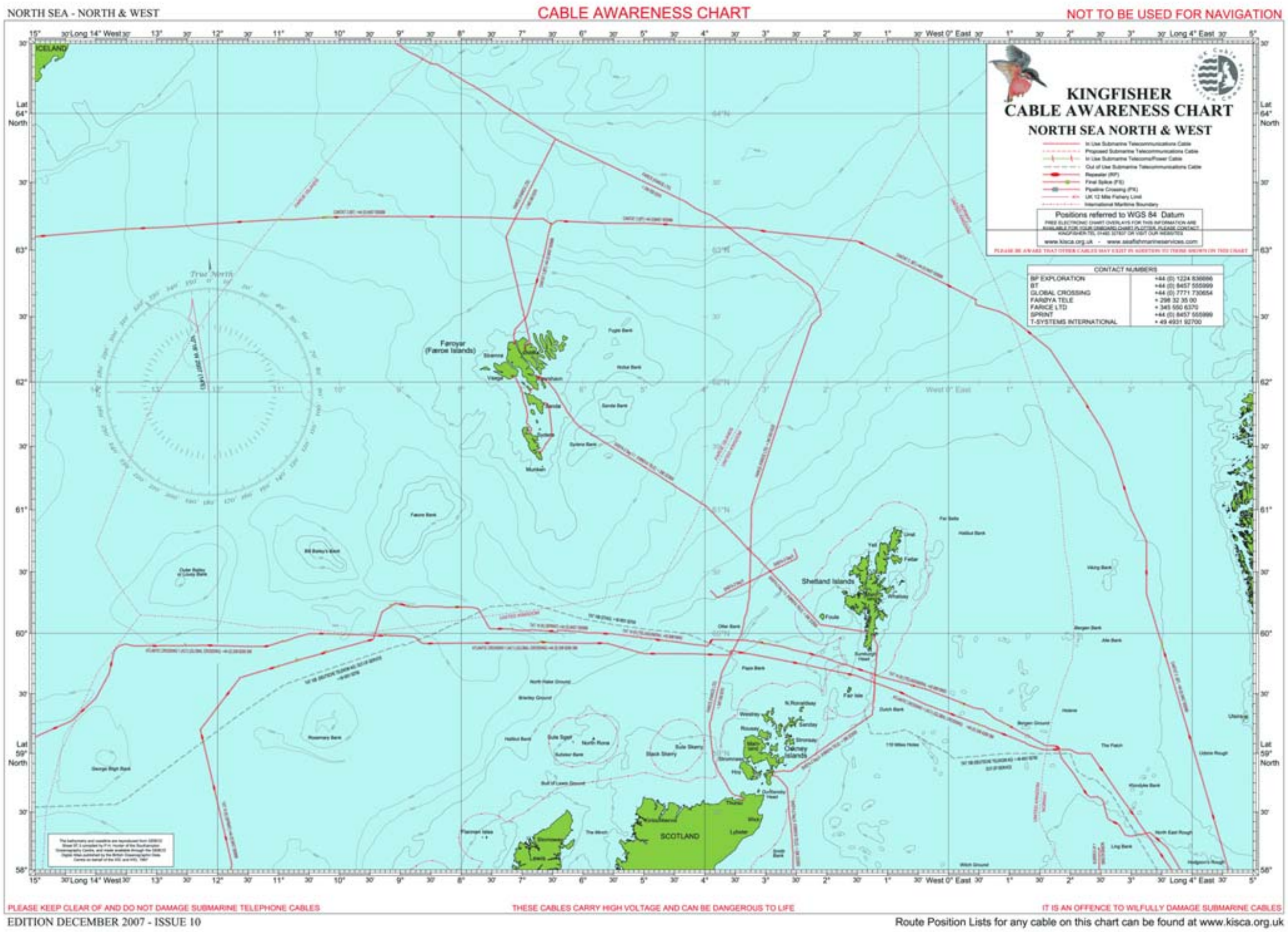


Figure 30. Cable awareness chart

Electronic chart plotters, and navigation by computer software linked to positioning systems such as GPS, are now being used by many skippers. These represent an opportunity to not only inform a fisherman about cables in his area but also to provide a warning if he is coming too close to the cable route. In Iceland the cable coordinates are sent electronically to all local fishing vessels for the submarine cables around the island. Similar systems are in use in other countries, with cable routes available from disc or download. These can reduce the risks both to vessels and cables. As electronic charts have become more common on board vessels, it is essential that information on cable locations be transferred to these charts.

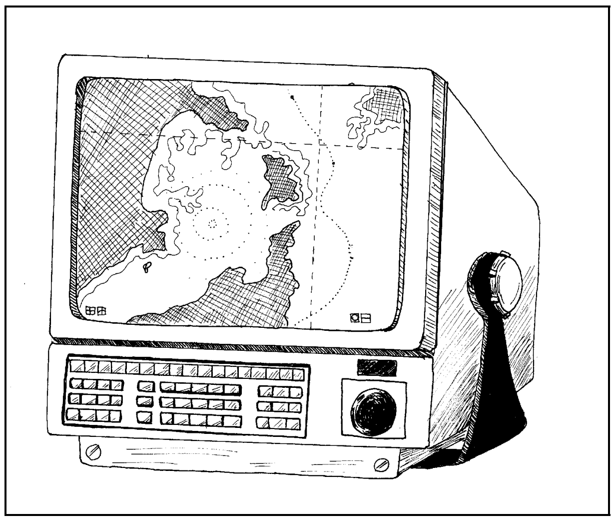


Figure 31. Electronic navigation chart

Out-of-service cables

A major cause for concern are the out-of-service cables whose exact locations may not be shown on navigation charts. Many of these were laid over 50 years ago. Precision in navigation was far less than it is today so there are uncertainties about the locations of these cables. Although some are buried, many are not. With the growth of the offshore oil and gas industries it has been necessary to cut these old cables where they cross pipeline routes. The cut ends are sometimes secured with concrete blocks. Although these cut cables at present may lie in exclusion zones of oil or gas fields, the concrete blocks represent another hazard to fishermen in the future especially when trawling.

8. Legal aspects

National laws governing damage to cables vary somewhat from one area to the next. But the overriding international legal requirements originated in 1884 and are set out in the United Nations Convention on the Law of the Sea (1982) ("UNCLOS") to which 157 nations are parties. UNCLOS is considered binding customary international law. Fishermen are required to exercise prudent seamanship to avoid damaging submarine cables. This means in practice not fishing near known cable locations. In many areas, charts and notices to mariners are available showing the locations of cables on the seabed. Such charts should be kept up to date on the vessel.

Under UNCLOS and the earlier 1884 International Convention for the Protection of Submarine Cables, if a mariner damages a cable and the damage could be avoided by taking reasonable care as a prudent seaman, then the person causing the damage is liable. If a mariner damages a cable with fishing gear or an anchor, when he could have seen that cable on a chart and avoided it, he may be liable for the damage. In addition to civil liability for damages, the mariner may face criminal sanctions for culpable negligence or wilful injury to a cable.

But international law recognizes an exception. If the mariner's damage to the cable is caused by taking necessary actions to save the vessel or crew, there is no liability. An example would be a ship without power being set upon a shoal that is saved by anchoring and in the process a cable is damaged.

International law also requires that a vessel that has gear or an anchor caught on a cable is required to sacrifice the gear or anchor to avoid injury to the cable. Provided the mariner was not negligent in contacting the cable in the first place, the mariner is entitled to indemnity for the cost of the sacrificed gear or anchor by the owners of the cable. To claim indemnity for the sacrifice, the mariner should file within 24 hours of arrival in port a declaration setting forth the circumstances of the sacrifice with the cable owner, if known, or the local government maritime authorities like the coast guard. In the case of a valid sacrifice, the cable owner may be required to pay the indemnity for the sacrificed gear or anchor.

In practice, different laws apply to these cases, depending on where the incidents occur. Many countries have their own laws governing such issues, and there are international agreements covering the high seas. Cable companies have reimbursed many fishermen for trawls they sacrificed in order to avoid damaging cables by trying to recover entangled gear. On the other hand, in cases where fishermen have broken cables after towing repeatedly over them and disregarding warnings, fishermen have been forced to pay heavy damages or fines. In some cases their vessels have been seized and impounded.

9. Improving communication among cable companies and fishermen

There are many fishermen who question why they need to know about submarine cables. "The cables are buried so why not fish over them?" is the widely held view. Whilst most cables on the continental shelf are buried, there are areas where this is impractical. Below 1,000 m (550 fathoms) cables are for the most part laid on the seabed. Moreover, in some cases it is virtually impossible to avoid having lengths of cable exposed on top of the seabed because of steep, hard, or uneven bottom. Fishermen throughout the world need to understand the dangers of coming foul of a cable.

These days the seabed is used more intensively, and by more diverse groups, than ever before. Fishermen, cable companies, offshore oil and gas companies, environmentalists and other groups all have an interest in seabed installations. For many years cable companies have taken steps to contact fishermen and inform them about the locations of their cables. They have distributed charts, booklets and other items. In some areas a two-way dialogue has grown, with fishermen telling companies where the most heavily fished areas lie, so that these areas may be avoided when cable routes are planned, and so that routes affording better cable burial can be found. In most areas such dialogue is informal, but in some places more formal cable/fishing committees have been established. Seabed users may have their differences, but there is general agreement that the seabed will be better managed if there are good communications among interested parties.

10. The International Cable Protection Committee

In 1958, six cable owners met in London and formed the Cable Damage Committee. Nine years later the group changed its name to the International Cable Protection Committee to reflect more accurately its purpose - to promote the protection of submarine cables against natural and man-made hazards. Now this Committee has over 90 members from more than 45 different nations, including the owners of electrical power cables. It promotes information exchange and dialogue among seabed users. Working through its members, it fosters the development and distribution of cable awareness charts, and recommended procedures for activities such as cable routing and cable/pipeline crossing. The ICPC also produces educational materials as part of an ongoing program to foster cable awareness in the fishing and offshore industries.

The ICPC welcomes inquiries and suggestions from individual fishermen and their organisations. The Committee will continue to develop ways for cable owners and fishermen to share the seabed for the benefit of all.