About
Submarine Telecommunications Cables

Issue Date: October 2011

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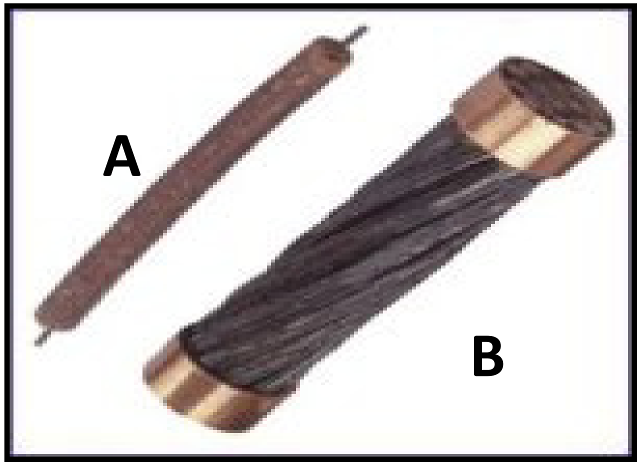
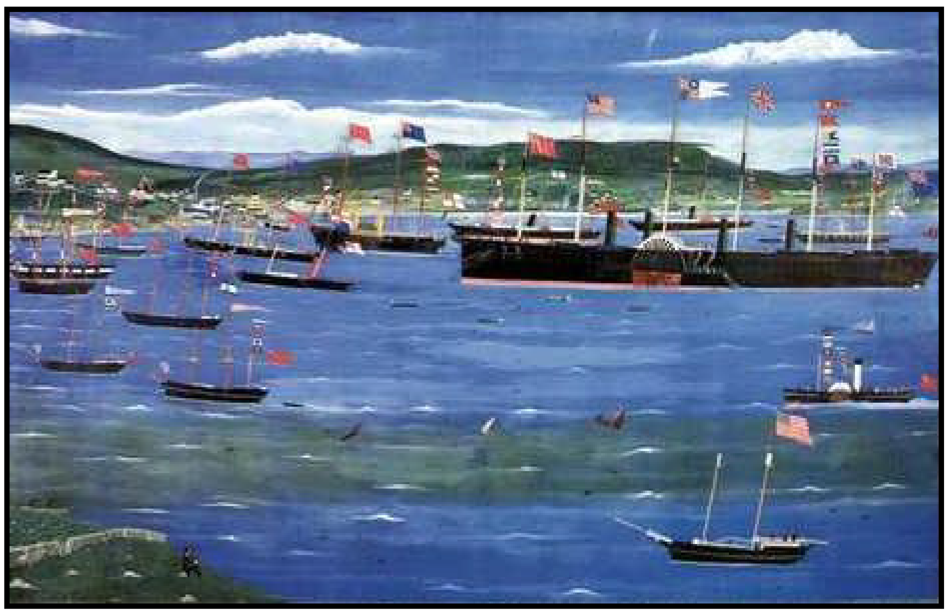


UK-France Cables
A: 1850 B: 1851
Source: BT



Great Eastern off Newfoundland
Source: Cable & Wireless

- **1840: Telegraph cables start to be laid across rivers and harbours, but initially had a limited life**
- **1843-1845: Gutta-percha (a type of gum found in a Malaysian tree) was brought to Britain and starts to replace other materials that were used for electrical insulation, thus extending the life of the cable**
- **1850: 1st international telegraph cable laid between UK and France, followed by a stronger cable in 1851**
- **1858: 1st transatlantic cable laid between Ireland and Newfoundland by *Great Eastern*. This failed after 26 days and another was laid in 1866**

A Brief History – 2

- 1884: 1st underwater telephone cable - San Francisco to Oakland
- 1920s: Short-wave radio superseded cables for voice and telex traffic, but capacity limited and affected by atmosphere
- 1956: Invention of repeaters (1940s) and their use in TAT-1, the first transatlantic telephone cable, began an era of rapid and reliable transoceanic communications
- 1961: Beginning of a high quality global network
- 1986: 1st international fibre-optic cable connects Belgium to the UK
- 1988: TAT-8, the 1st transoceanic fibre-optic cable system, connects the USA to the UK and France

Comparing Old and New

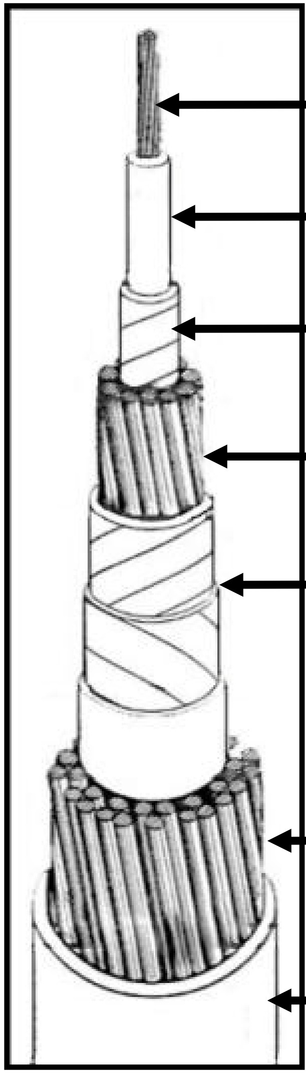
Early Cable Systems:

- **1866: 1st transatlantic cable carried telegraph messages at seven words a minute and cost £20 for 20 words**
- **1948: Telegram cost reduced to 4 pence a word for transmission across the Atlantic**
- **1956: 1st transatlantic telephone cable (TAT-1) initially had capacity of 36 telephone calls at a time. Each call cost US$12 for the first 3 minutes**

Modern Cable Systems:

- **1988: 1st transatlantic fibre-optic cable, TAT-8, carried 40,000 simultaneous phone calls, 10 times that of the last copper-based telephone cable**
- **Today, a single cable can carry millions of telephone calls, together with huge amounts video and internet data**

Submarine Cable – Telegraph Era



conductor - usually copper

insulation - *gutta percha* resin

cushioning - jute yarn

inner protection - wire armour

jute wrap to contain wire

outer protection - wire armour

jute wrap to contain armour

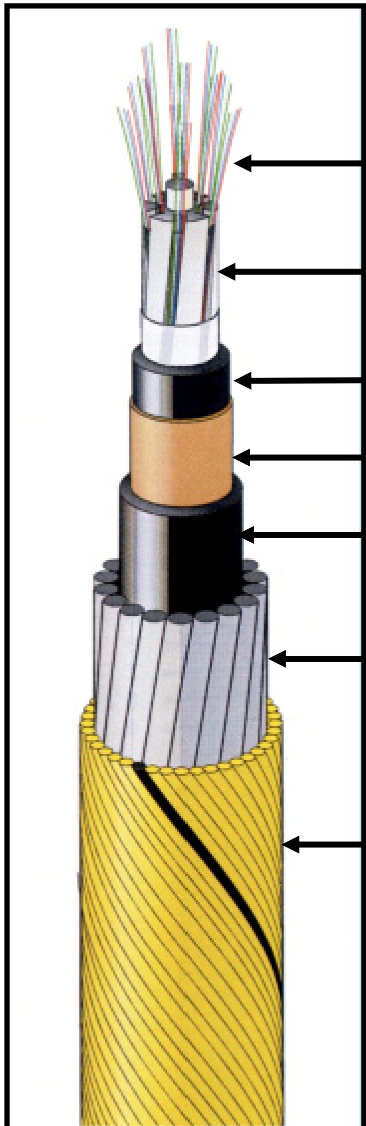
Harvesting *gutta percha* resin

Source: Porthcurno Telegraph Museum

Atlantic cable 1866

Source: Porthcurno Telegraph Museum

Modern Submarine Cable

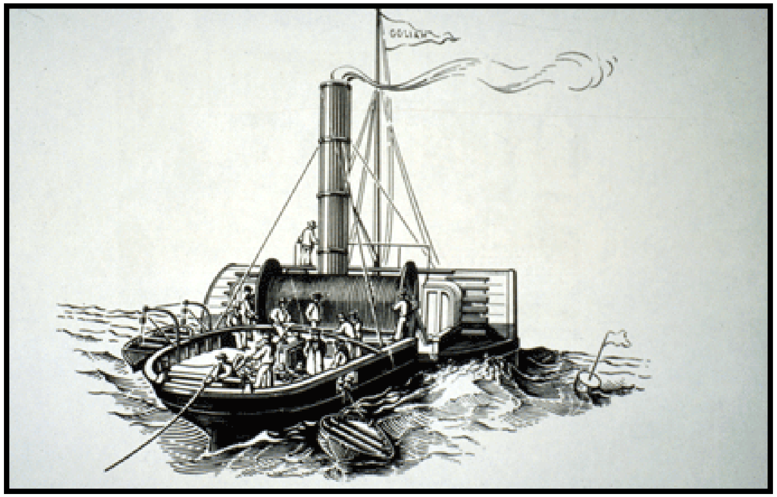


Source: Ericsson

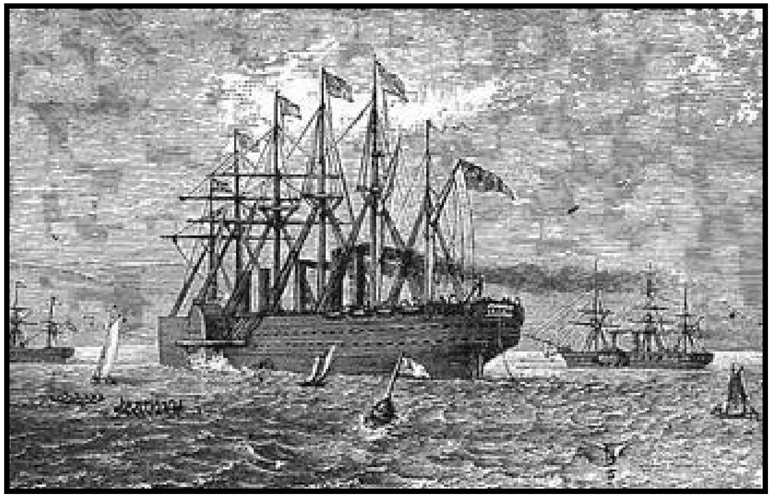
- optical fibres - silica glass
- core for strength and fibre separation - polyethylene/fibreglass
- jacket - polyethylene
- conductor - copper
- jacket - polyethylene
- protective armour - steel wire
- outer protection and wire containment - polypropylene yarn

- Construction varies with manufacturer and seabed conditions
- Cables may have no armour in stable, deep-ocean sites or one or more armour layers for energetic zones, e.g. coastal seas

Early Cable Ships

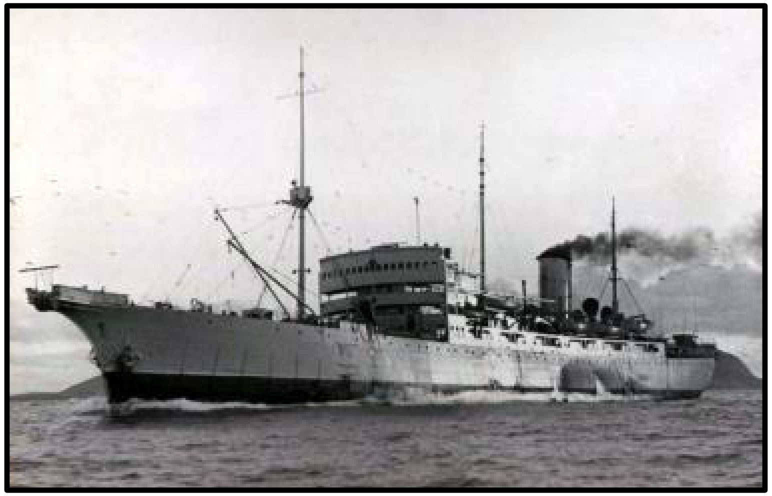


Goliath: lays 1st international cable, UK-France, 1850-1
Source: Illustrated London News



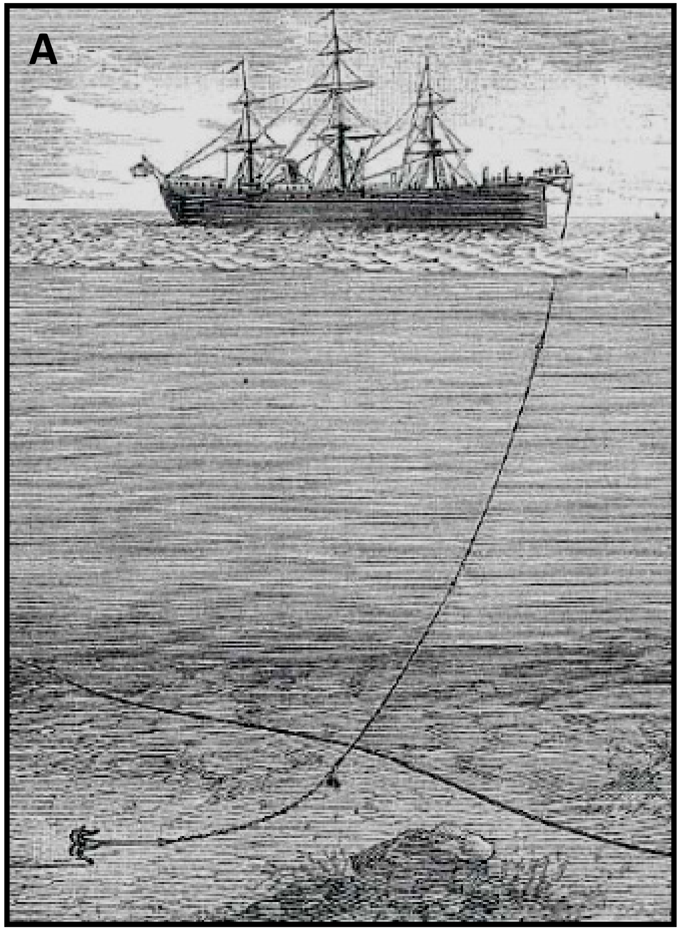
Great Eastern: laying cable off Newfoundland, 1866
Source: Canadian Government

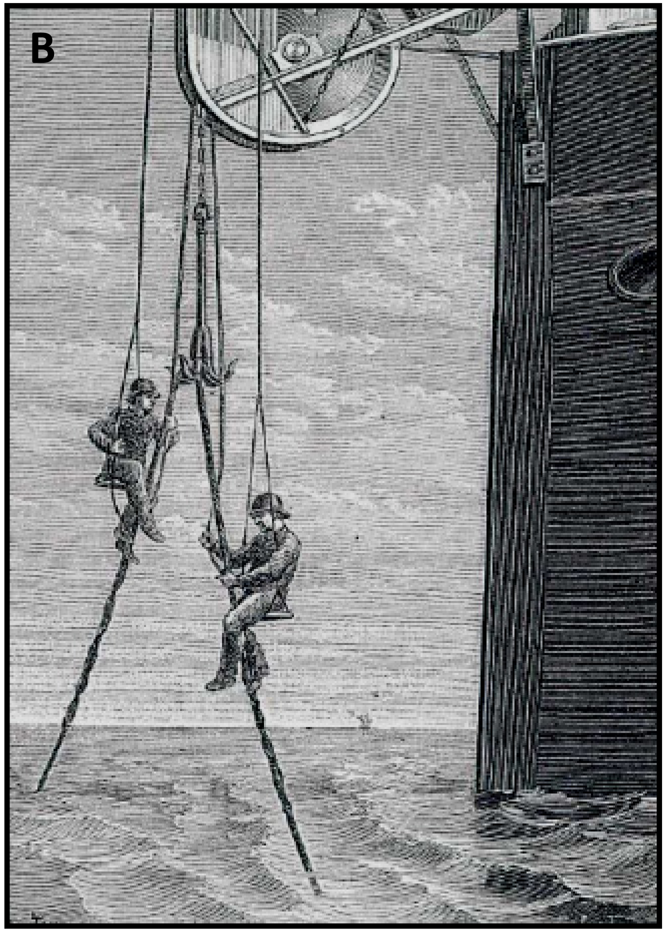
John Pender, named after pioneer cable maker, 1900
Source: Cable & Wireless



Monarch: laid 1st transatlantic telephone cable, 1955/6
Source: www.atlantic-cable.com

Cable Repair in 1888





[A] Cable ship trailing grapnel to retrieve cable followed by [B] securing of the cable ready for repair

Source: Traité de Télégraphie Sous-Marine by E. Wüschendorff, 1888

Modern Cable Handling Methods

Bringing the cable ashore
Source: Global Marine Systems

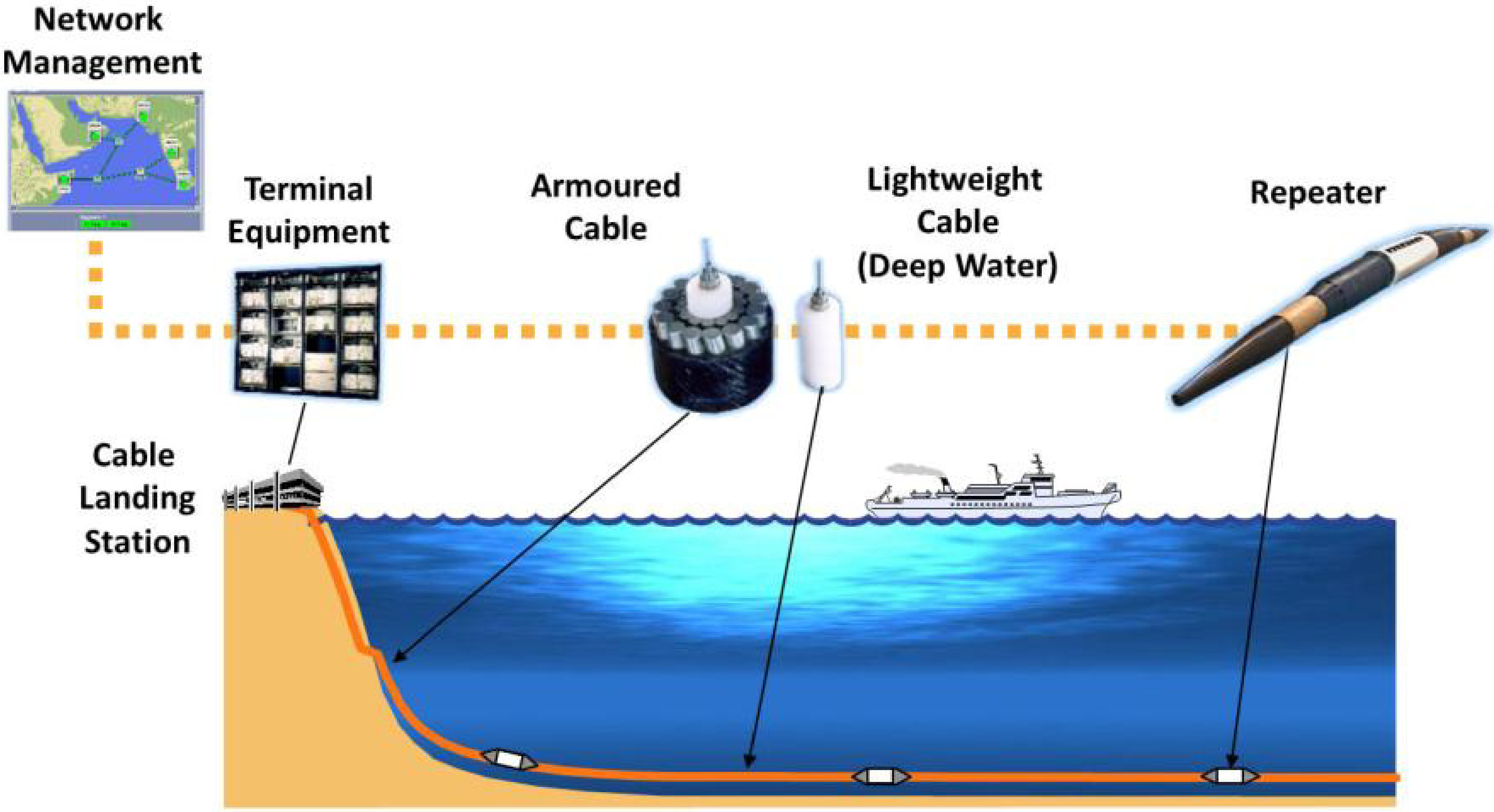
Cable and repeaters inside a cable ship
Source: TE SubCom

ROV used for cable inspection, recovery and burial
Source: TE SubCom

How Submarine Cables Work

- Fibre-optic submarine cables rely on a property of pure glass fibres whereby light is guided by internal reflection
- Because the light signal loses strength en route, repeaters are required at regular intervals to restore it
- Repeaters are now based on optical amplifying technology, which requires short lengths of erbium-doped optical fibre to be spliced into the cable system. These are then energized by lasers that cause them to ‘lase’, thus boosting the incoming light signal

Typical Submarine Cable System



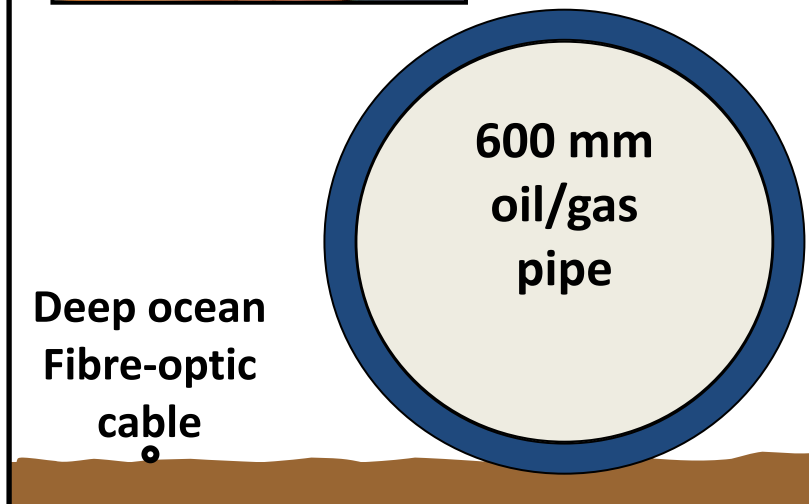
NOT TO SCALE

Source: UK Cable Protection Committee and Alcatel-Lucent Submarine Networks

Cable Size

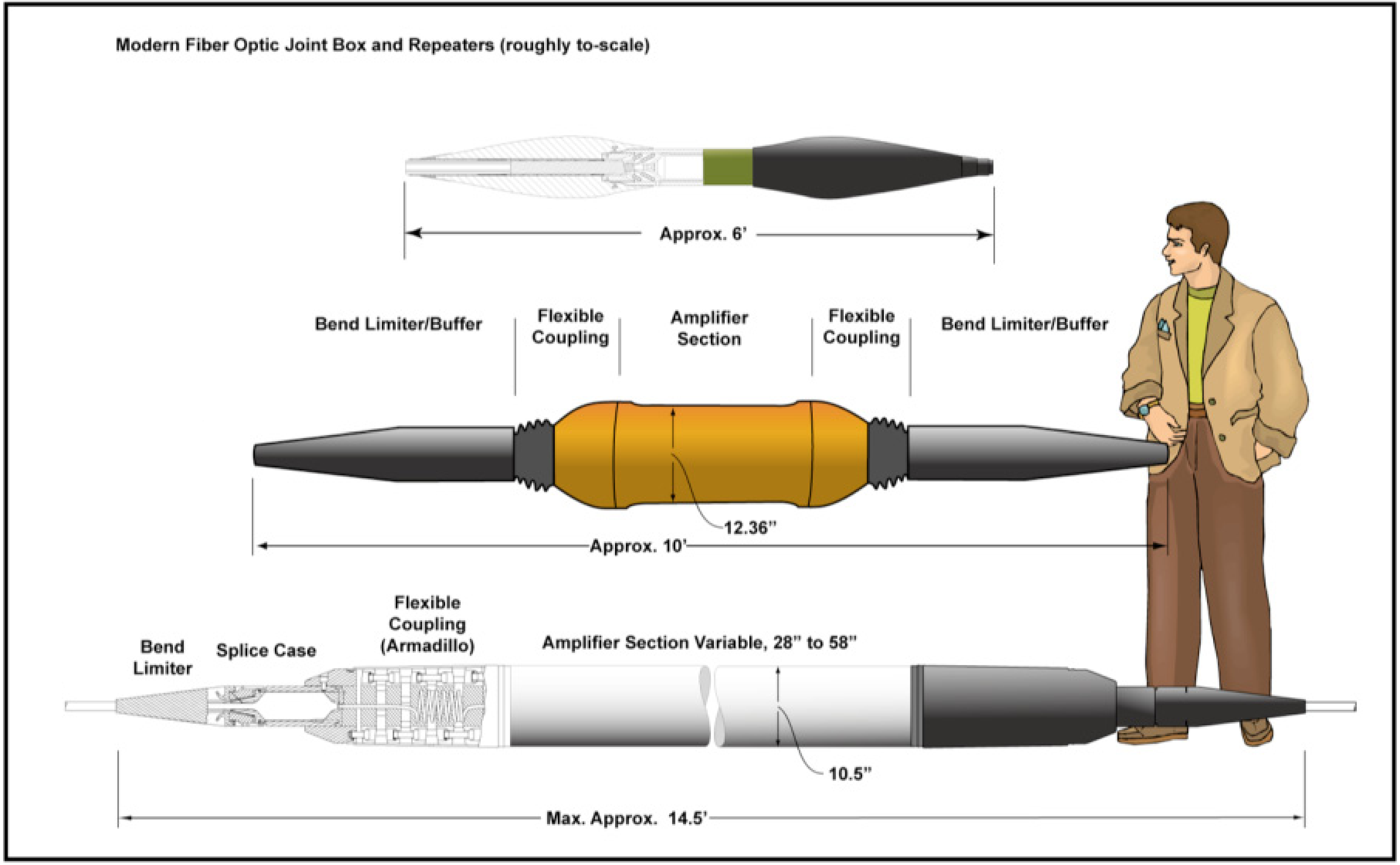
- Cables are small: deep-ocean types, without protective armour, are typically 17-20 mm diameter – the size of a garden hose or beer bottle cap
- Armoured fibre-optic cables may reach 50 mm diameter
- In contrast, submarine oil/gas pipes can reach 900 mm diameter, and fishing trawls typically range over 5,000 – 50,000 mm wide
- One of the longest cable systems is the South East Asia - Middle East - West Europe 3 system (SE-ME-WE-3), with a total installed length (including branches) of almost 40,000 km

Deep-sea cable, (black) sectioned to show internal construction; fine strands at top are optical fibres used to transmit data



Modern fibre-optic cable in hand (for scale) and relative to 600 mm diameter subsea pipe

Joint Boxes and Repeaters



Source: Lonnie Hagadorn

Submarine Cables and Satellites

Advantages of cables

- High reliability, capacity and security
- Insignificant delay compared to satellite
- Most cost-effective on major routes, hence rates cheaper than satellites

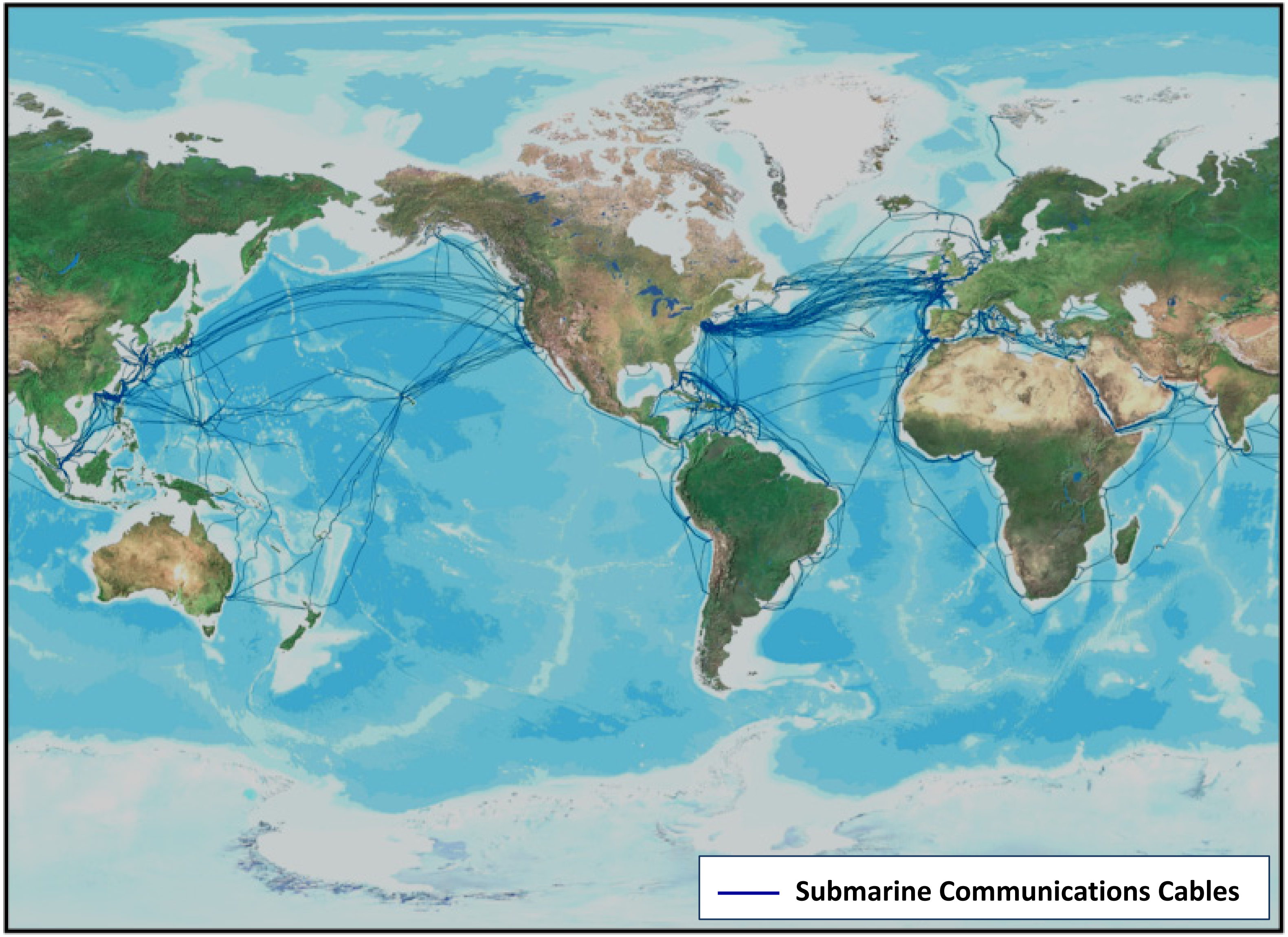
Carry >95% of transoceanic voice and data traffic

Advantages of satellites

- Suitable for regions that are vulnerable to disasters
- Provide wide broadcast coverage, e.g. for TV
- Suitable for minor routes such as links between small island nations

Carry <5% of transoceanic voice and data traffic

Main International Cable Routes



Source: TE SubCom

Coastal Cable Routes

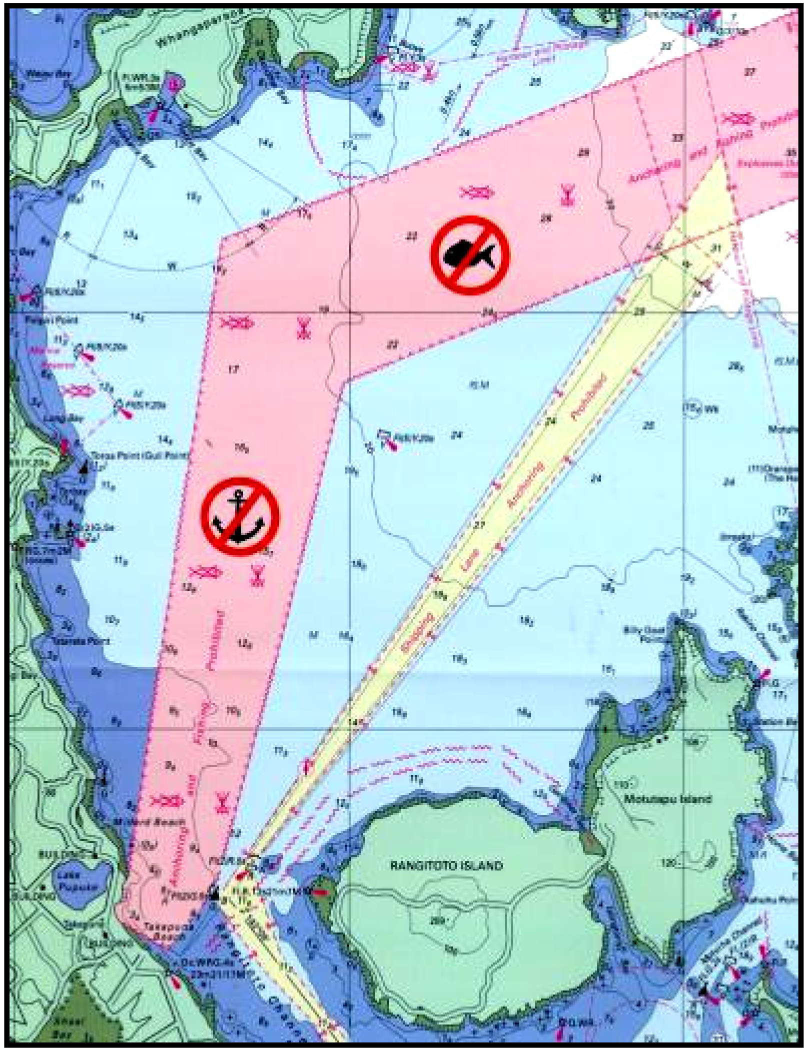


Chart with protection zone for Southern Cross cable terminal in New Zealand
Source: Telecom NZ

- Near the shore, cables need protection from shipping, fishing and other activities
- To reduce risk, cables and protection zones are identified on nautical charts
- A cable protection zone is a legal entity where activities harmful to cables are banned
- Cable burial in water depths up to 2000 m is also a key protective measure

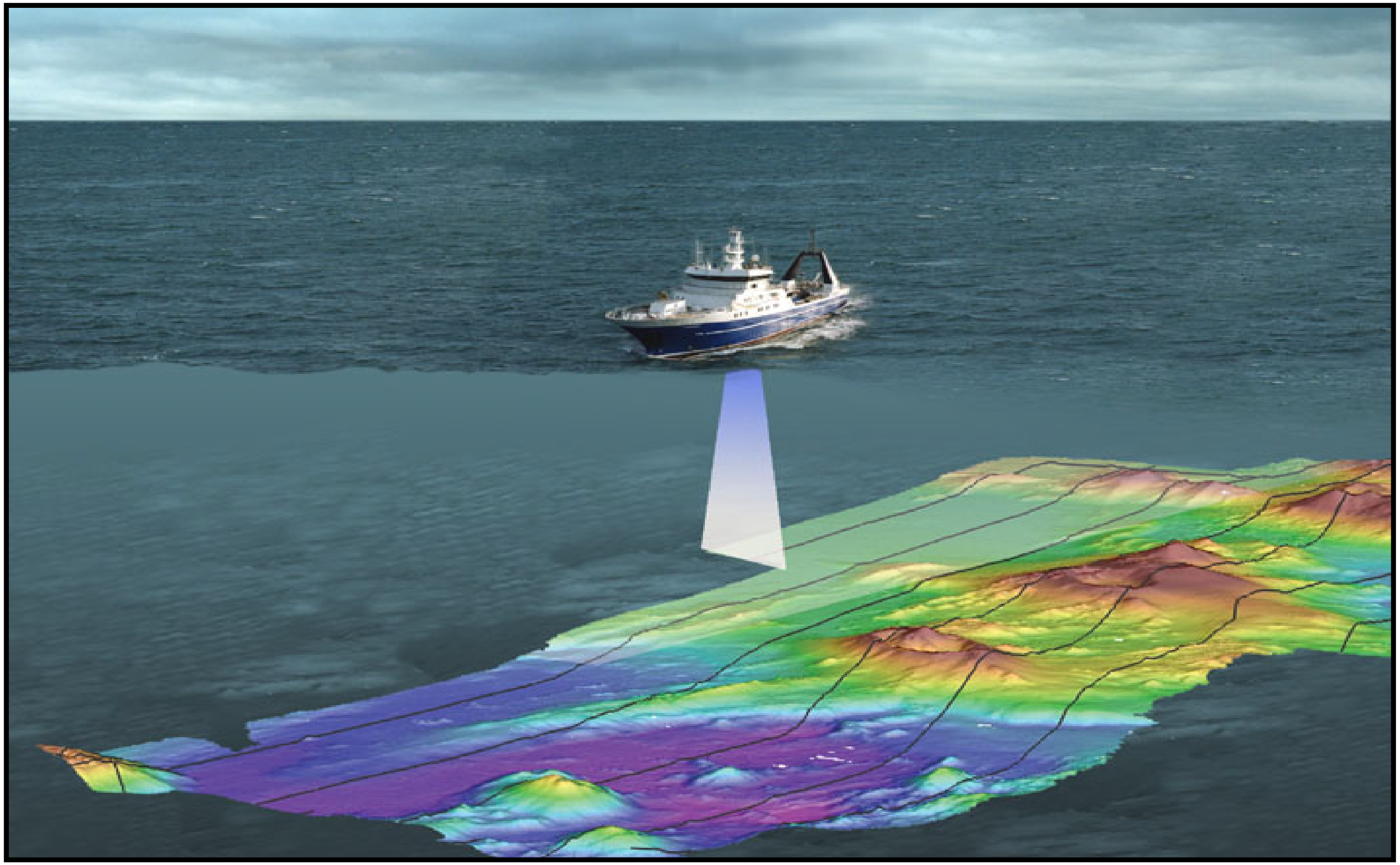
Installing a Submarine Cable

Installing a submarine cable typically involves:

- Selection of provisional route
- Obtaining permission from the relevant authorities
- Full survey of route and its final selection
- Design cable system to meet conditions of selected route
- Laying the cable, including burial in appropriate areas
- In some cases, a post-lay inspection may be necessary
- Notification of cable position to other marine users

Cable Route Survey

Cable routes are carefully surveyed and selected to minimize environmental impacts and maximize cable protection

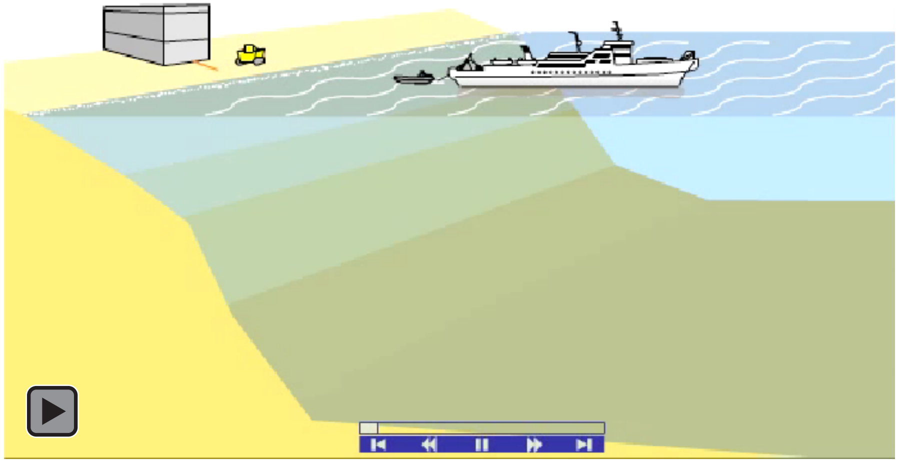


Seabed mapping systems accurately chart depth, topography, slope angles and seabed type

Source: NIWA

Cable Laying

- **Guided by the route survey, specially designed ships are used to accurately place cables on or beneath the seabed**
- **Shallow water laying may be aided by divers ; Deep water laying may involve remotely operated vehicles**



Source: Alcatel-Lucent Submarine Networks

Cable Burial - 1

- Cables may be buried in a narrow (<1 m wide) trench cut by water jet or plough
- The plough lifts a wedge of sediment so that the cable can be inserted below
- Burial speed depends on cable type and seabed conditions
- For an armoured cable, the burial speed is about 0.2 km/hr

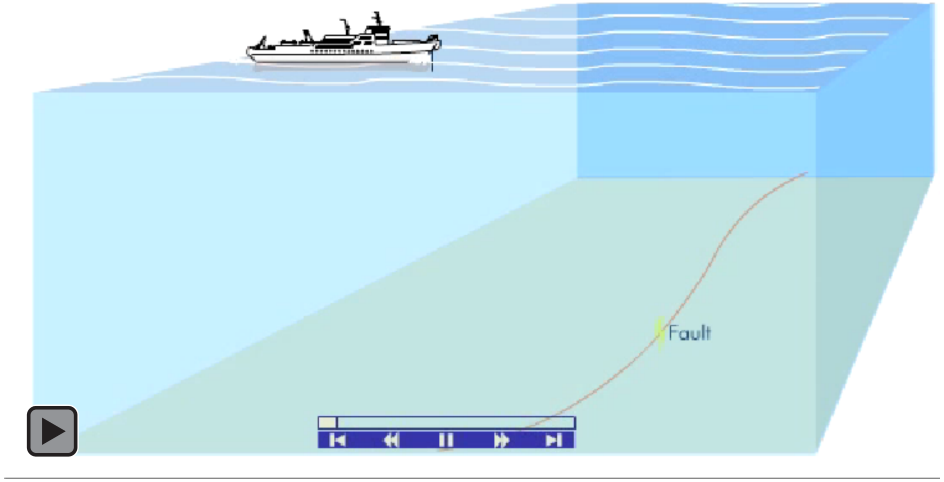
A plough being prepared to start the burial of a cable
Source: Seaworks, NZ

Cable Burial - 2

- Cables are typically buried 1 m and exceptionally up to 10 m beneath the seabed to protect against trawl fishing, ships anchoring and other activities
- Burial may extend from the shore to about 2000 m water depth, which is the present limit of trawl fisheries
- Burial may locally disrupt the seabed along a narrow path and form turbid water. The extent of this is dependent upon burial technique, seabed type and wave/current action
- In the absence of cable-based studies, analysis of seabed disturbance from fishing and other activities suggests that impacts are short-lived (months) where waves/currents are active, but possibly longer-lived in deeper, less turbulent water

Cable Repair

In the event of a fault, the cable has to be recovered from the seabed so that a replacement section can be spliced in:



Source: Alcatel-Lucent Submarine Networks

Cables and the Law - 1

Recognizing the value to humanity of international communications, cables are protected by international treaties:

- **1884: The International Convention for the Protection of Submarine Cables**
- **1958: The Geneva Conventions of the Continental Shelf and High Seas**
- **1982: United Nations Convention on Law of the Sea (UNCLOS)**

Cables and the Law - 2

Modern international law extends the special status of international cables to all uses:

- Telecommunications
- Power
- Scientific
- Military

Cables and the Law - 3

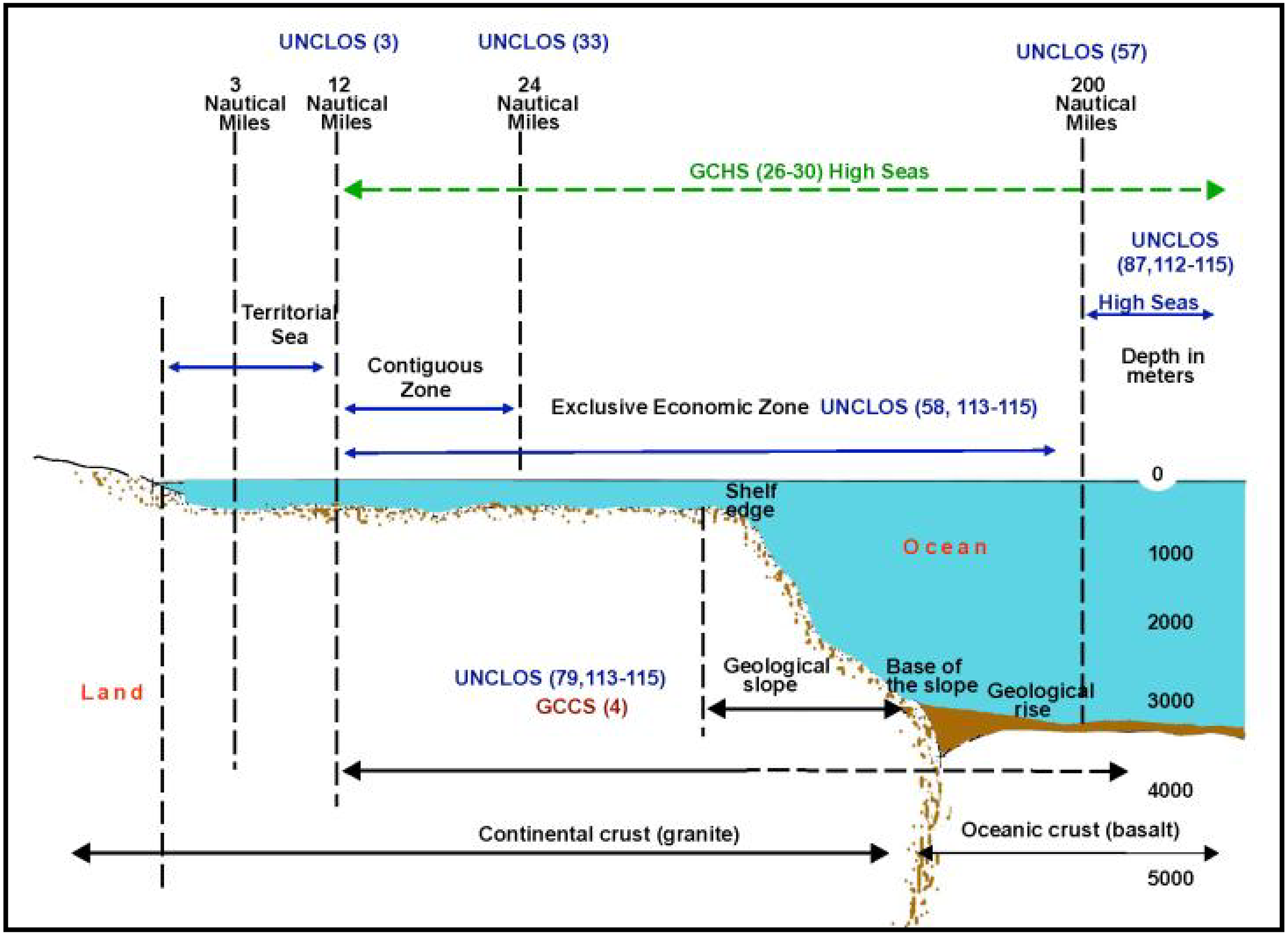
The international treaties establish universal norms:

- **Freedom to lay, maintain and repair cables outside of a nation's 12 nautical mile territorial sea**
- **National obligations to impose criminal and civil penalties for intentional or negligent injury to cables**
- **Special status for ships laying and repairing cables**
- **Indemnification for vessels that sacrifice anchors or fishing gear to avoid injury to cables**
- **Obligations of cables crossing earlier laid cables and pipelines to indemnify repair costs for crossing damage**
- **Universal access to national courts to enforce treaty obligations**

Cables and the Law - 4

The International Tribunal for the Law of the Sea, Hamburg, Germany
Source: Stephan Wallocha

Cables and the Law - 5



Legal boundaries of the ocean from Territorial Seas to Exclusive Economic Zone and onto the High Seas
Note: The numbers in (brackets) refer to treaty articles
Source: Doug Burnett

Cables and the Environment - 1

ATOC/Pioneer Seamount scientific cable with attached anemones (*Metridium farcimen*) located in 140 m water depth off California

Source: Monterey Bay Aquarium Research Institute

Cables and the Environment - 2

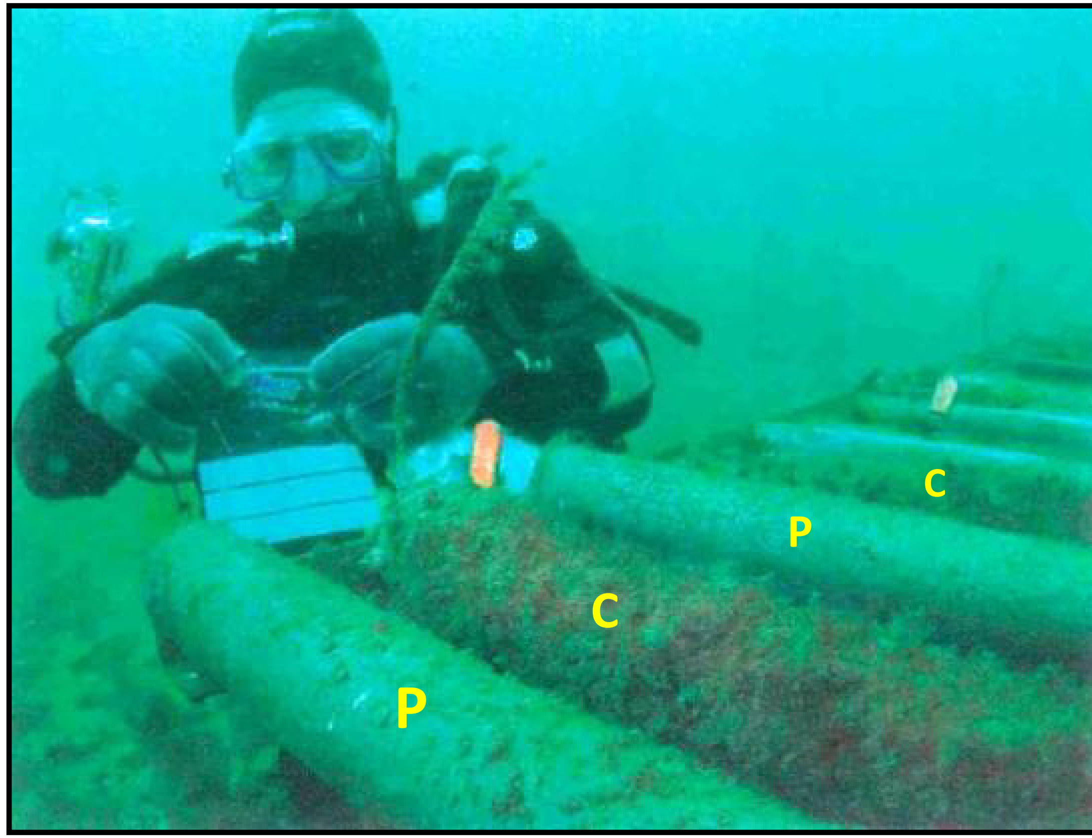
- Properly laid, fibre-optic cables have a neutral to benign impact on marine environment
- A cable's small size means its "footprint" is small, especially compared to submarine pipelines or trawl dredge
- Cables are substrates for marine organisms with recovered cables yielding key specimens for scientific collections

Telecommunications cable with encrusting marine organisms
Source: Glauco Rivera

Cables as Artificial Reefs - 1

Scientific tests undertaken in the UK show that:

- **Cables are fully colonised by marine organisms in 1-2 months depending on conditions**
- **Cables are essentially non-polluting**



Diver checks lengths of fibre-optic cable (C) and plastic pipes (P) that act as controls to check rates of colonisation by marine organisms
Source: Dr K. Collins, Southampton University

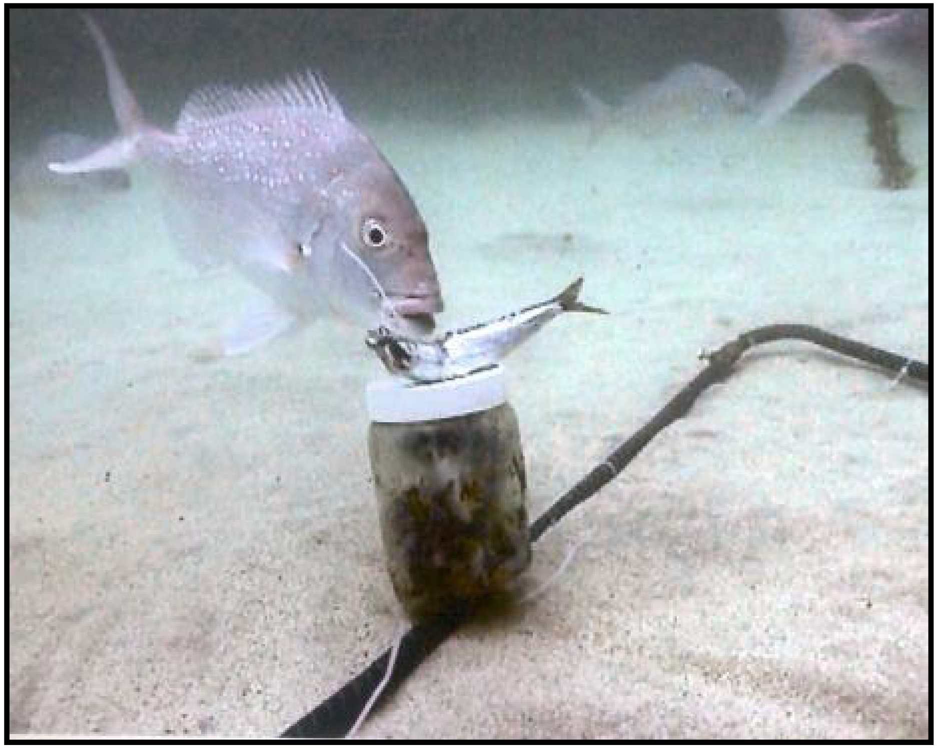
Cables as Artificial Reefs - 2

- Coils of cable have been placed off Maryland and New Jersey to form artificial reefs
- These reefs have attracted many marine organisms that range from algae to fish
- To be successful, reefs must be stable, non-toxic, last for 20-30 years and provide habitats

Submarine cable coiled to form an artificial reef on the continental shelf off the US state of Maryland.
This picture shows colonisation by starfish, mussels and other organisms that may help biodiversity & fish stocks
Source: © Compass Light

Cable Protection Zones as Sanctuaries

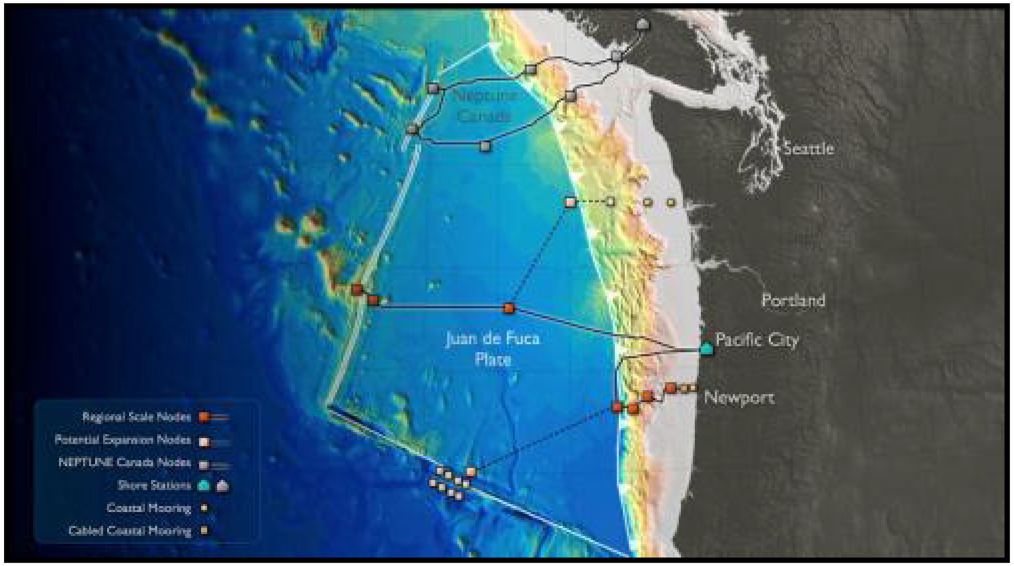
- **Zones that are created to protect submarine cables could act as marine sanctuaries, thus improving biodiversity and fish stocks**
- **An effective zone must contain habitats that are suitable for fish and other marine life, exist long enough for ecosystems to develop and be policed to prevent illegal fishing**

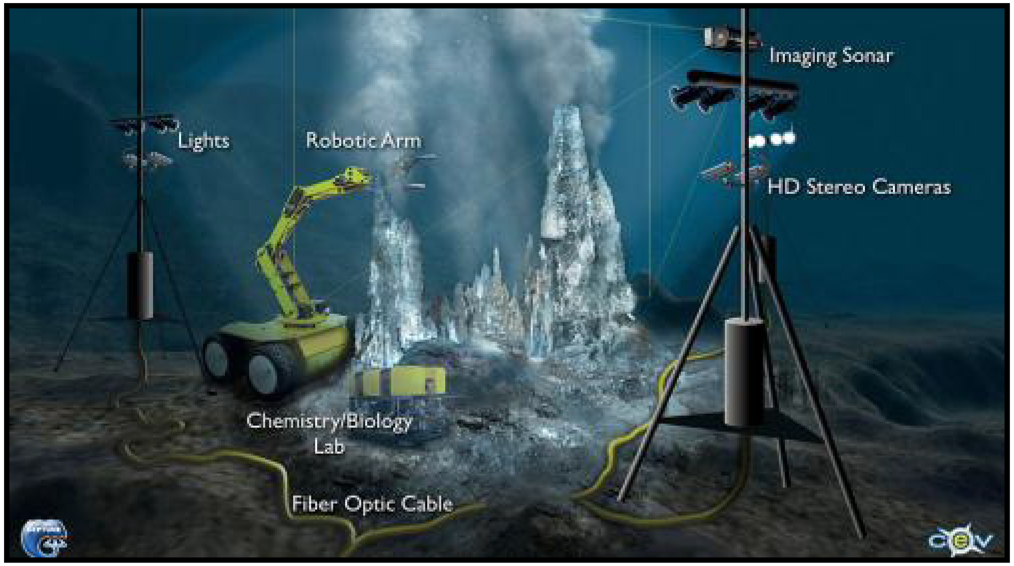


Experiment to count fish to test if a cable protection zone acts as a marine sanctuary
Source: Leigh Laboratory, University of Auckland

Observing the Ocean

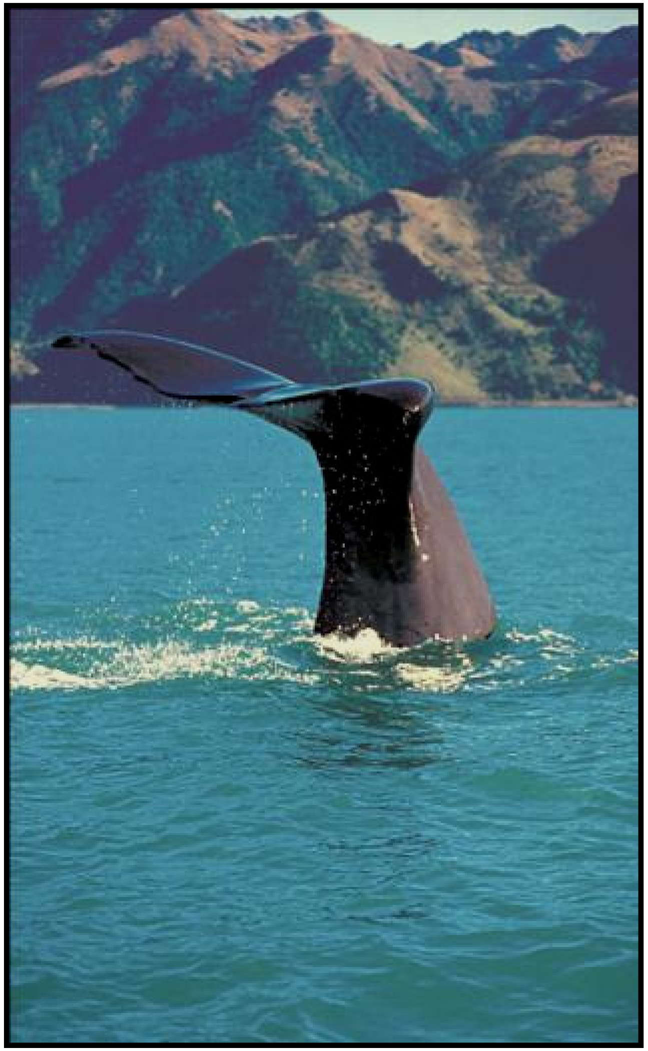
- Ocean observatories are being developed for the long-term monitoring of the marine environment
- Observation sites will be linked via submarine cables that will provide power for equipment and data transfer to shore
- Covering many parts of the world, observatories will help detect and warn of natural hazards, measure ocean response to climate change, undertake research and develop technologies





Observatories off Canada and USA [top] with artist's depiction of proposed activities [bottom] ***Source: Neptune Canada and OOI***

Marine Mammals



Sperm whale begins dive off New Zealand
Source: NIWA

- Published cable fault data show that from 1877 to around 1960, 16 whale entanglements were noted – mainly involving sperm whales
- Since that period there have been no reported incidents of marine mammal entanglements
- This change in part reflects improved materials and laying techniques
- Compared to telegraph cables, modern cables are stronger, laid under tension with less slack, and are often buried below the seabed in water depths down to 2000 m

Fish (including Sharks)

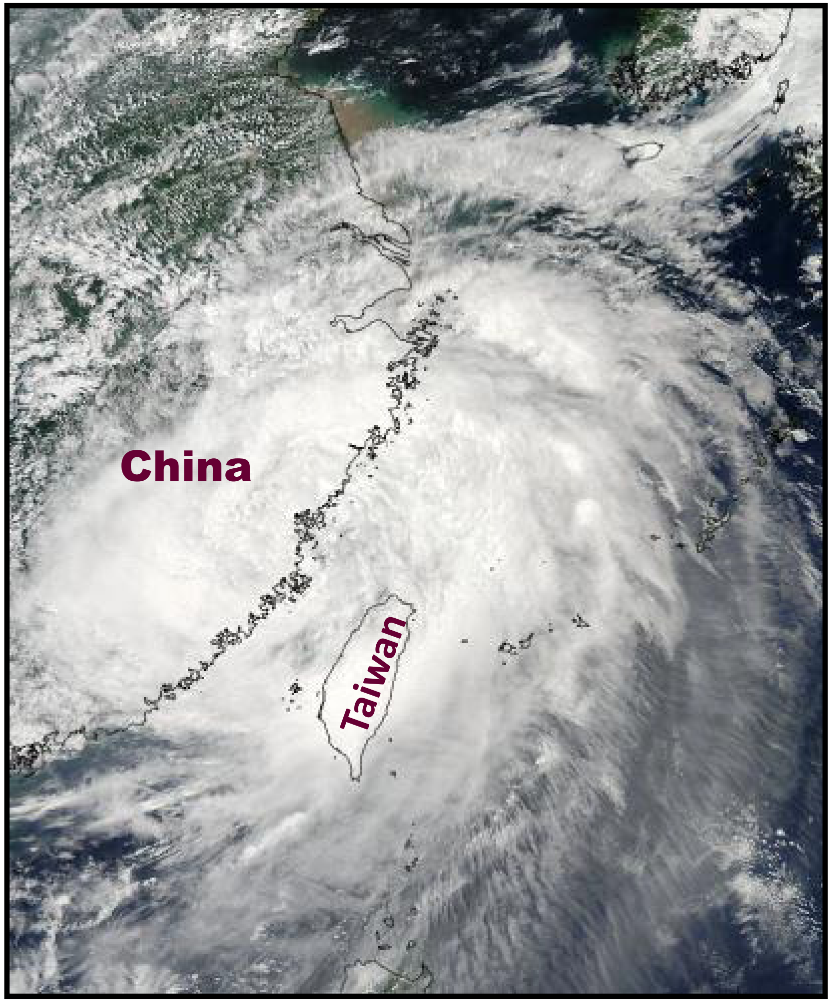
- Faults caused by fish restricted mainly to telegraph cables (pre-1964)
- Attacks could be due to cable smell, colour, motion or electro-magnetic field
- In 1985-1987, a domestic fibre-optic cable installed in the Canary Islands was damaged by sharks in 1-2 km water depth
- These attacks were verified by the presence of shark teeth that were found embedded in the cable
- The cable design was subsequently improved with the inclusion of metal tape sheathing in 1988
- There is no evidence of faults caused by fish (including sharks) on systems that use this improved cable design

Effects of Natural Hazards - 1

- Submarine cables are exposed to natural hazards in all water depths
- In depths to around 1000 m, the main hazards are human activities with natural effects causing under 10% of cable damage incidents
- Natural hazards dominate in water depths greater than 1000 m. These include:
  - Submarine earthquakes, fault lines and related landslides - break or bury cables
  - Density currents - break or bury
  - Currents and waves - abrasion, stress and fatigue
  - Tsunami, storm surge and sea level rise - damage coastal installations
  - Extreme weather (e.g. hurricanes) - break or bury
  - Rarely, icebergs or volcanic activity

Effects of Natural Hazards - 2

- Typhoon Morakot struck Taiwan from 7-11 August 2009, when almost 3 m of rain fell in the central mountains
- This caused rivers to flood and carry vast amounts of sediment to the ocean
- So much sediment was discharged that dense sediment-laden currents formed and flowed across the seabed, breaking several cables en route
- While records of such events are too short to identify trends, the enhanced precipitation of Typhoon Morakot is consistent with warmer air and ocean temperatures

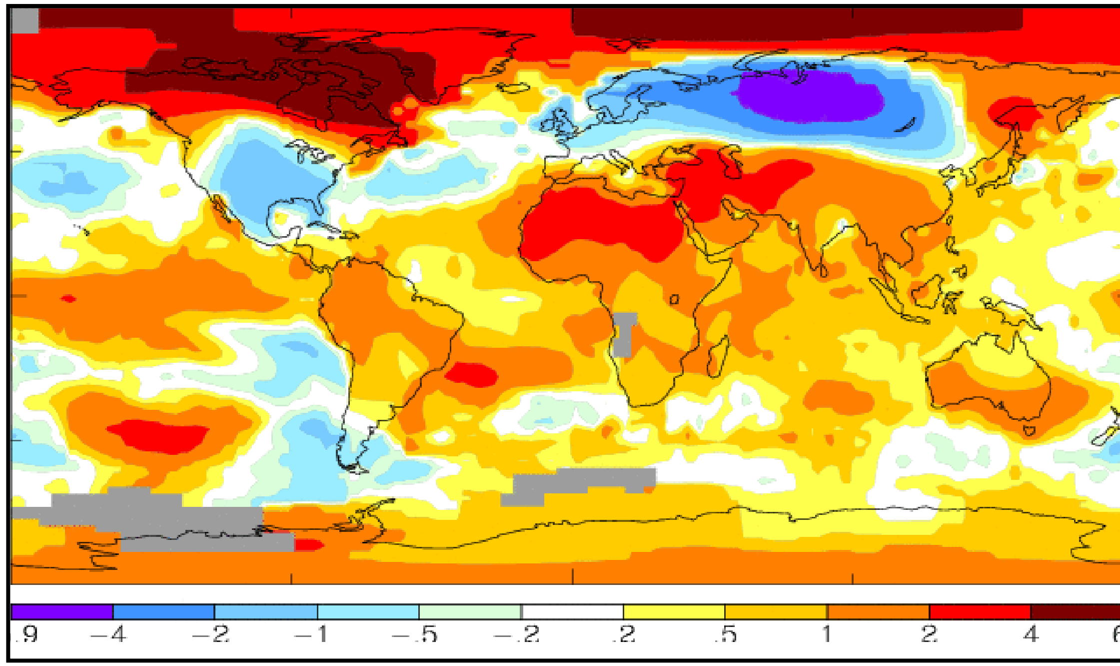


Typhoon Morakot masks Taiwan as it releases a deluge to set off submarine mud flows that broke cables
Source: MODIS Rapid Response, NOAA

Effects of Climate Change

Cables may be exposed to risks arising from global warming via:

- Rising sea level due to thermal expansion of ocean and melting ice
- Increased windiness and wave/current activity
- More intense storms, rainfall and floods
- Changes in offshore activities, e.g. growth of renewable energy schemes

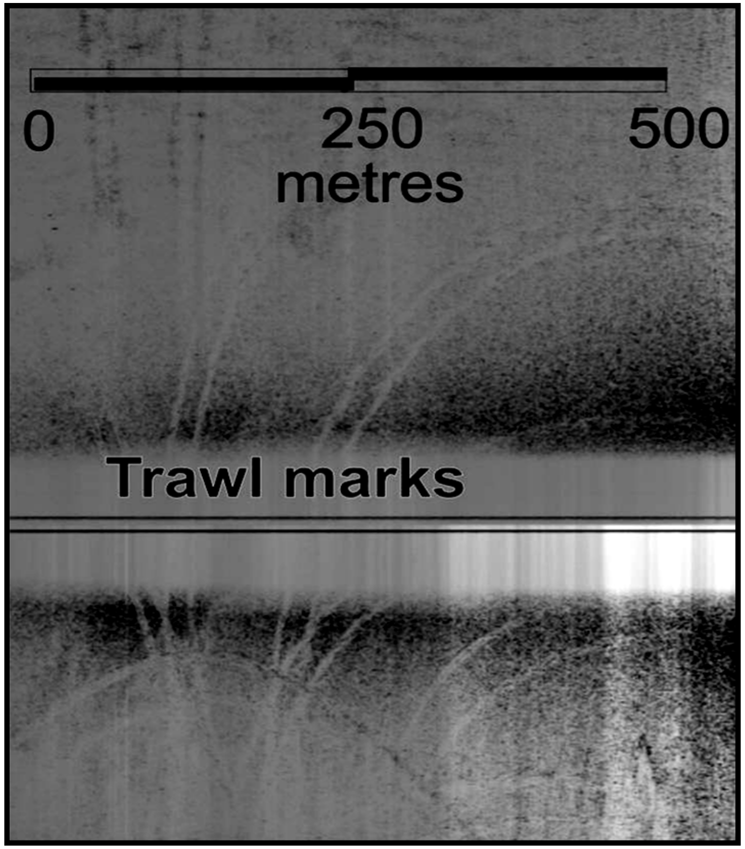


The global distribution of temperature anomalies for winter 2010. The colder than normal winter in the USA, Europe and Russia is clear, but so is the warmer than average Arctic and much of the Southern Hemisphere. This helped make 2010 the joint warmest year on record. The scale is degrees cooler/warmer than the 1951-1980 average temperature.

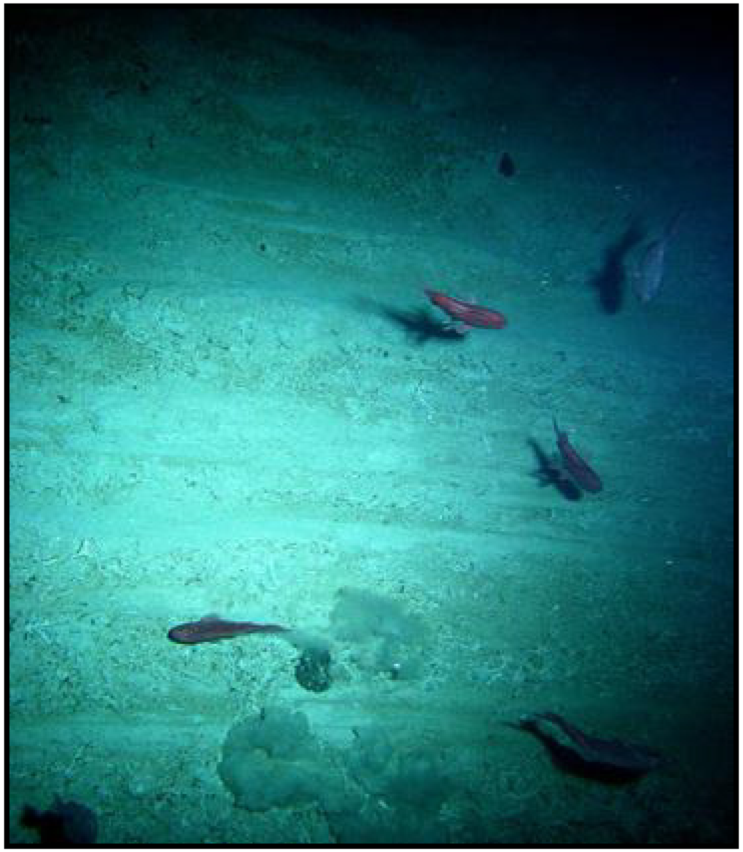
Source: Goddard Institute of Space Studies, NASA

Effects of Human Activities

Submarine cables are coming into increasing contact with other seabed users, especially fishing and shipping industries

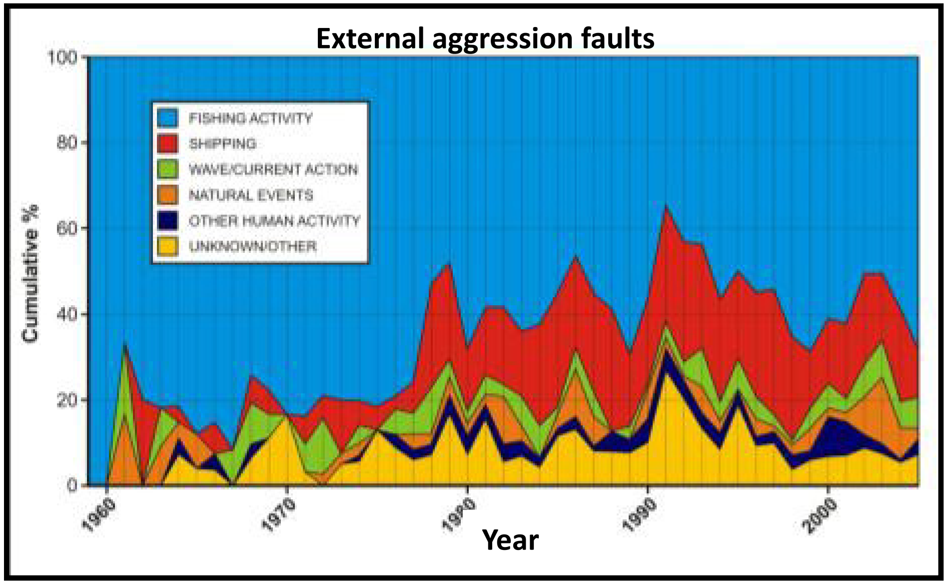


Sonar image of 25m wide trawl scars, Nova Scotian shelf
Source: A. Orpin, NIWA



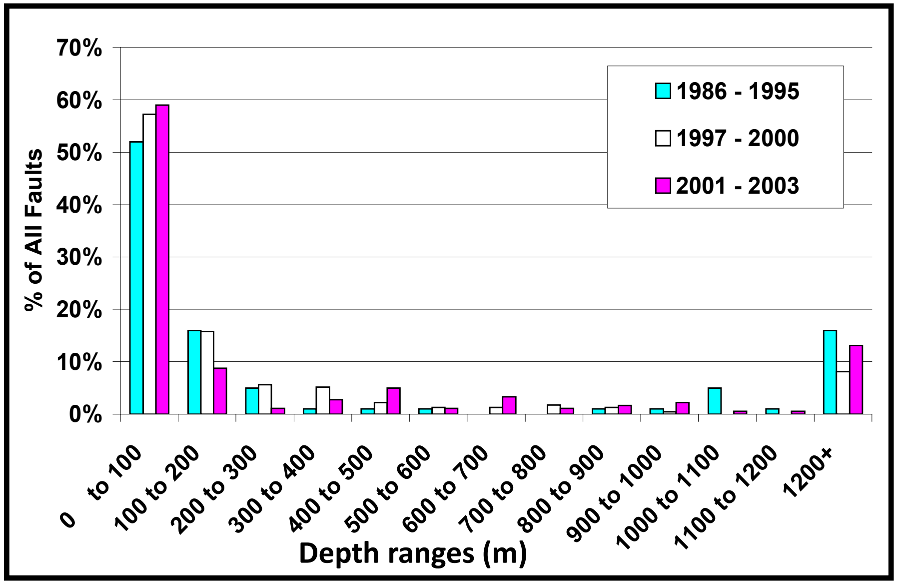
Trawl scars, Chatham Rise
Source: M. Clark, NIWA

Fault Causes



Analysis of faults by type of aggression

Source: M. Wood and L. Carter, IEEE, 2008



Analysis of faults by water depth

Source: Submarine Cable Improvement Group

- **Around 70% of all cable faults are caused by fishing and anchoring activities**
- **Around 12% are caused by natural hazards, e.g. current abrasion or earthquakes**
- **Most faults are caused by human activities in less than 200 m water depth**
- **Faults in more than 1000 m water depth are mostly caused by natural events**

Cable Damage From Fishing

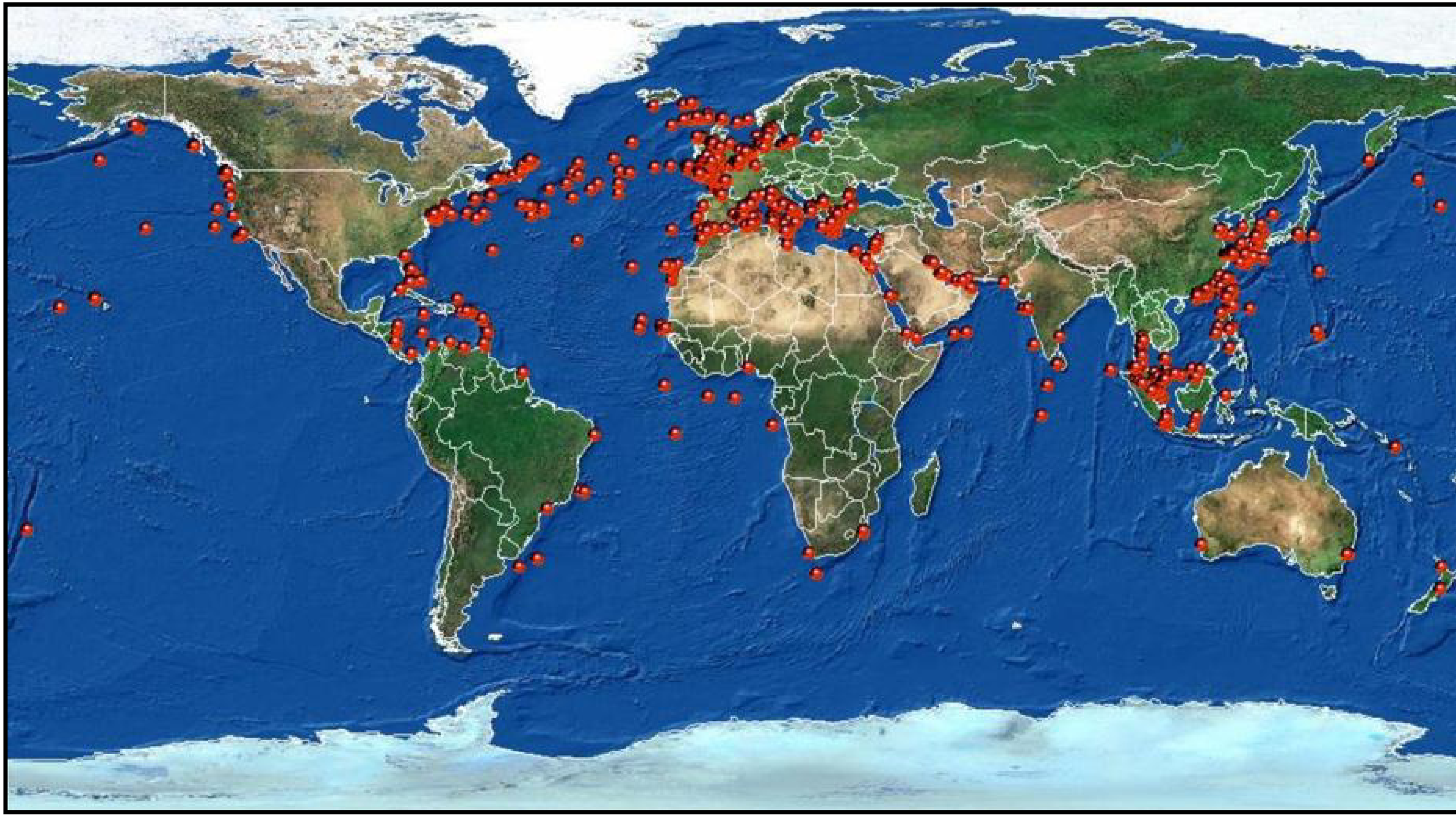
Illegal fishing in cable protection zone

Cable snagged and moved by trawl gear

Cable damaged by trawl gear

Sources: Seaworks and Transpower NZ

Cable Faults Worldwide



Global pattern of external aggression cable faults, 1959-2006

Source: TE SubCom

Other Seabed Users

- **Coastal seas are increasingly used for energy projects (wind, tide and wave power), resource extraction and environmental protection (marine sanctuaries, marine protected areas, etc.)**
- **ICPC strongly supports constructive interaction with other seabed users to ensure harmonious access to the coastal seas and ocean**

Offshore wind farm, Middelgrunden, Denmark
Source: © LM Glasfiber

Cables and the Future - 1

"Prediction is very difficult, especially about the future" **- Niels Bohr**

TECHNOLOGY

- **Cable design and operations are constantly evolving. New systems are smaller with greater capacity and reliability**
- **Further development of ocean observatories will rely on new cable technology. This is likely to include integrated environmental sensors and docking modules to enable submarine survey vehicles to download data and recharge**
- **Submarine cables, with sensors to detect chemical and physical changes, are planned for maritime and coastal defenses**

Cables and the Future - 2

ENVIRONMENT

- In some regions of the world, submarine cables are likely to be exposed to more natural hazards related to changing climate
- Climate change may also affect other marine activities such as fishing, with potential impacts on cables
- Measures to preserve biodiversity, ecosystems and resources via various protection zones in national waters and the high seas, may impinge upon cable passage
- The ocean, especially the coastal seas, will be subject to increased human activities due to expansion of renewable energy schemes

Cables and the Future - 3

LEGAL

The ICPC is very concerned about:

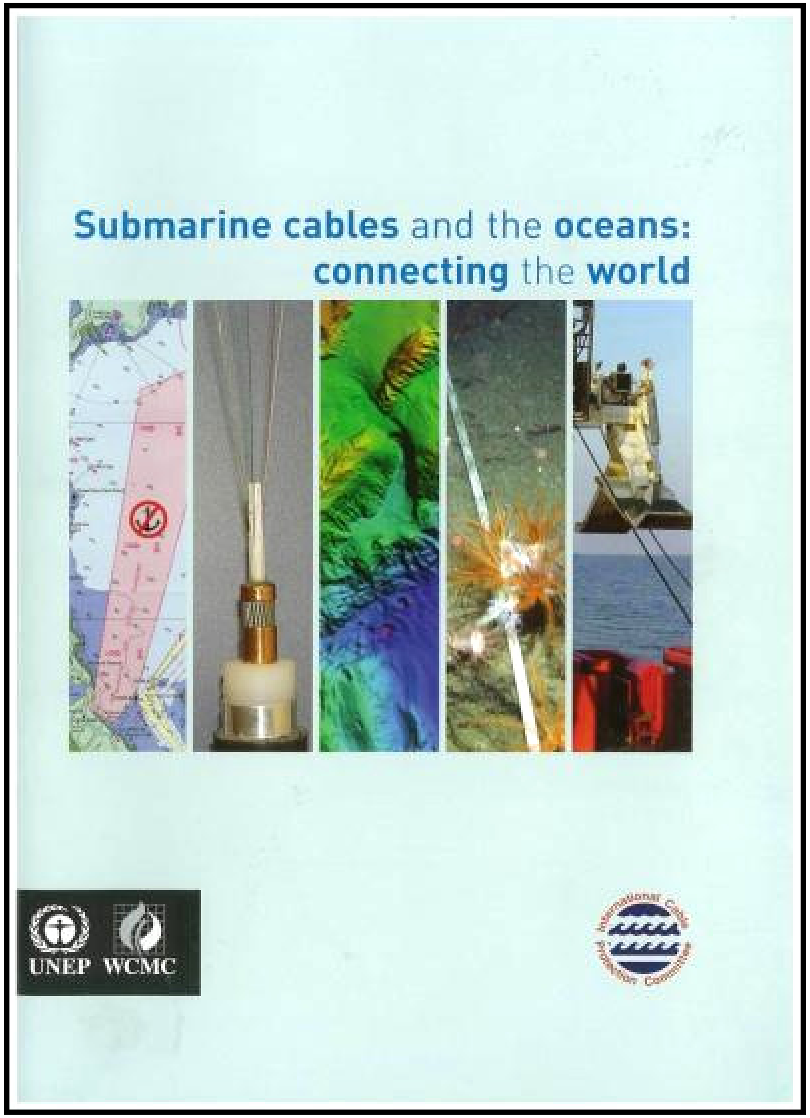
- **Coastal State encroachment on traditional freedoms under UNCLOS to lay, maintain and repair international cables**
- **Resolution of Continental Shelf boundaries under UNCLOS**
- **Lack of national legislation to implement UNCLOS obligations to protect international cable infrastructure beyond territorial waters**
- **Restrictions on international cables that are imposed without any scientific basis to appease local constituencies, some of which regard submarine cables as an alternative revenue source**

More Information

This booklet was prepared in collaboration with UNEP (United Nations Environmental Programme) and was published in 2009.

It provides an objective, factual description of the submarine cable industry and the interaction of submarine cables with the marine environment.

A copy can be downloaded by clicking here



Glossary

- **Armour:** steel wires placed around cable for strength and protection
- **Coaxial cable:** two concentric conductors separated by an insulator; enabled telephone calls over long distances using analogue technology
- **Fibre-optic cable:** Optical fibres encased in protective tube that is also a power conductor for repeaters. Enables telephone, video and data communications over long distances using light; has much greater capacity, reliability and signal quality
- **Repeater:** Submersible housing containing equipment that is needed to boost the signal at regular intervals on long submarine cable systems; powered from the cable terminal
- **ROV:** Remotely Operated Vehicle – a submersible tool that works on the seabed to inspect, bury or recover the cable
- **Telegraph cable:** Copper wires insulated with gutta-percha, wrapped in India rubber and steel wire

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Acknowledgements

Alcatel-Lucent Submarine Networks

British Telecom

Cable & Wireless

Compass Light

Ericsson

Global Marine Systems

Government of Canada

IFREMER

KDDI

LM Glasfiber

Lonnie Hagadorn

Monterey Bay Aquarium Research Institute

Neptune Canada

NASA

NIWA

NOAA

Porthcurno Telegraph Museum

Seaworks NZ

Southampton University

Submarine Cable Improvement Group

Telecom NZ

TE SubCom

Transpower NZ

UK Cable Protection Committee

UN Environmental Programme

University of Auckland

University of Massachusetts

ICPC - Sharing the seabed in harmony