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# Submarine Cable Protection and the Environment

*An Update from the ICPC, Written by Marine Environmental Adviser, Dr Mike Clare*

**Climate Change and Subsea Cables: Impacts & Adaptations**

Climate Change: An Issue for Today and Not Just for the Future

**SUBMARINE CABLE PROTECTION AND THE ENVIRONMENT**

**An Update from the ICPC, Written by the Marine Environmental Adviser (MEA)**

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# EDITOR'S CORNER

The International Cable Protection Committee (ICPC) strongly supports continual improvement of the scientific knowledge base relating to submarine cables. Climate change affects everybody, and this includes submarine cables and related infrastructure. A new pioneering study 'Climate change hotspots and the global submarine telecommunications network' has highlighted the complex nature of our changing climate on a global basis with a focus on submarine cables[1]. The study alerts the industry to potential future climate change hazard hotspots to enable the planning of future climate resilient cable routes and landing point infrastructure. This study and ongoing research will help to mitigate any knock on social and economic impacts that could arise if industry is not well-informed and as a result is not well-prepared. This issue of 'Submarine Cable Protection and the Environment' provides a useful synthesis of that broader study and a valuable evidence base that enables the industry to be well prepared to address current and future challenges. It is worth highlighting that this review is particularly timely due to the release of the 'Climate Change 2023 Synthesis Report for the Sixth Assessment Report[2]' this past March by the Intergovernmental Panel on Climate Change (IPCC).

Enjoy this issue focused on Climate Change and Subsea Cables: Impacts and Adaptations.

Sincerely,

Ryan Wopschall

ICPC General Manager

# INTRODUCTION

- The global climate is warming at an alarming rate, primarily due to the emission of greenhouse gases arising from human activities. Global greenhouse gas emissions are continuing to increase, as have unsustainable energy and land use.
- Climate change has led to widespread and rapid changes across the entire Earth System, including unprecedented changes in the atmosphere, ice caps, across ecosystems, and in the ocean. These changes are increasingly affecting both the natural environment and human society, particularly vulnerable communities.
- Impacts on the ocean are also being felt acutely in some settings, which may lead to different or new hazards for subsea cables and their shore-based infrastructure.
- Subsea cables and their landing stations are vulnerable to damage by natural hazards, including storm surges, waves, cyclones, earthquakes, floods, volcanic eruptions, submarine landslides and ice scour.
- The likelihood or recurrence interval of many of these types of events will likely change under future projected climate change scenarios, compounded by sea-level rise; potentially increasing hazard severity, creating previously unanticipated hazards, or hazards may shift to new locations during the 20–30-year operational life of cable systems.
- The following text looks into these climate change-driven hazards and discusses what the subsea cable industry is doing to ensure that the global network of telecommunication cables remain as resilient as possible.

# CLIMATE CHANGE AND SUBSEA CABLES: IMPACTS AND ADAPTATIONS

Natural hazards are changing in their frequency and magnitude as a result of climate change, with their impacts becoming more and more apparent. Just this year, the eastern seaboard of the North Island of New Zealand has faced its third cyclone of the season, with river levels up to 13 m above normal. California has seen catastrophic flooding events, only shortly after widespread forest fires. Climate change is not simply a concern for the future, it is a reality in the present. The peer-reviewed data underpinning the acceleration of climate change were recently brought together in reports published by the [Intergovernmental Panel on Climate Change (IPCC),] that set out the evidence base for past climate change, projections of climate change under different plausible scenarios, and discuss the future impacts and potential adaptation and mitigation measures that may exist.

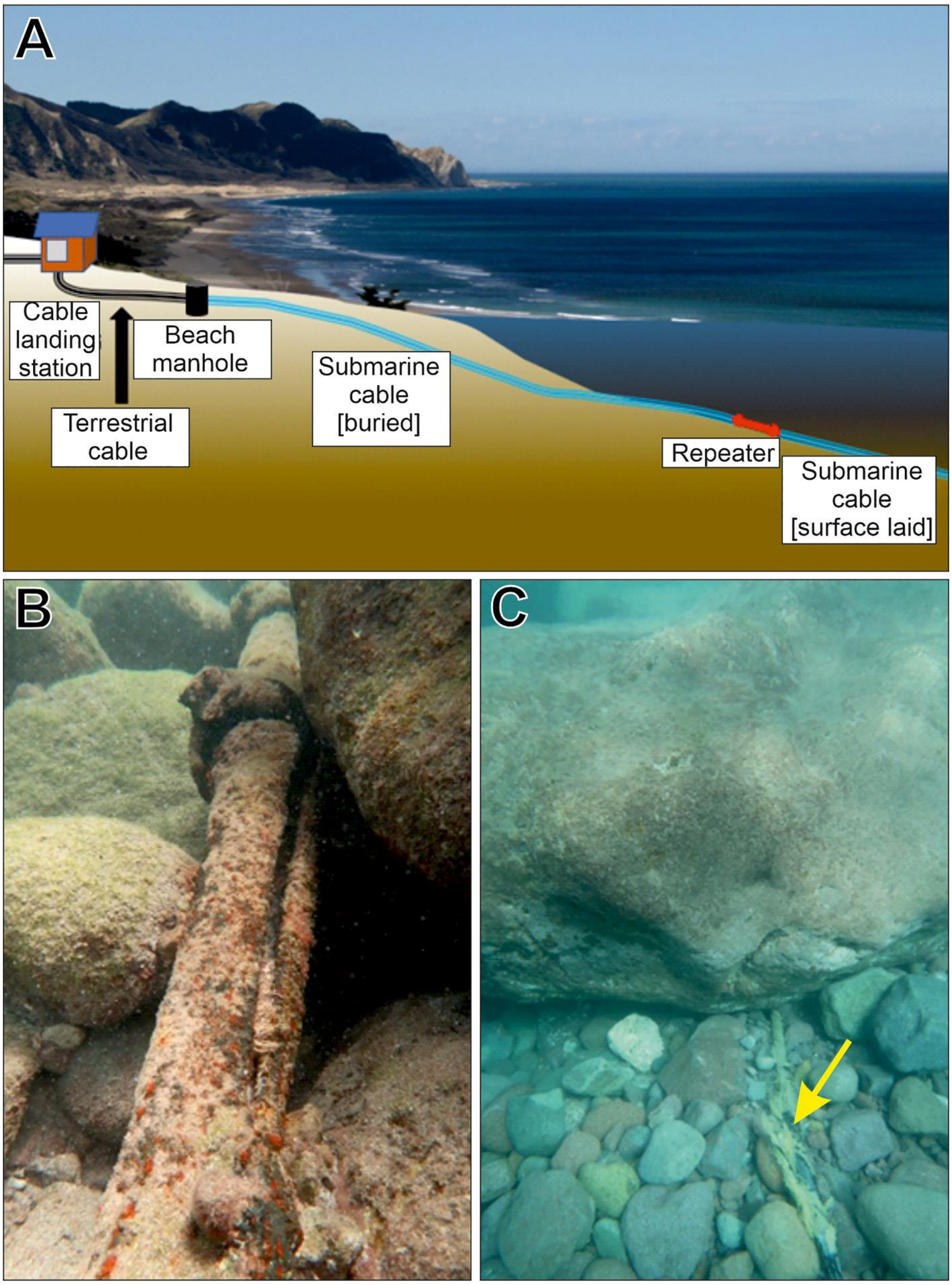
## THE IMPORTANCE OF THE OCEAN

The ocean plays a critical role in protecting our planet from the effects of climate change, absorbing >90% of the excess heat that has been created and around a quarter of $CO_2$ emissions from the past decades[3]. At the same time, the effects of climate change are being felt globally across the ocean, causing loss of sea ice, modifying ocean currents, changing weather patterns, and resulting in a range of impacts from coastal regions to its deepest parts. These changes have potentially wide-reaching impacts for ocean health, fish stocks, shipping and critical infrastructure such as the network of subsea cables that carries >99% of all intercontinental digital data traffic, including the internet.

## SUBSEA CABLES AND CLIMATE CHANGE

Subsea cables and the shore-based stations that connect them to terrestrial networks are typically designed to operate over 20-30 years. It is increasingly recognised that the risks posed to this infrastructure will change as a result of future climate change and its knock-on effects. This was recognised by the Under-Secretary-General for Legal Affairs and United Nations Legal Counsel who commented: 'Sea-level rise is projected to negatively affect various economic sectors, including by damaging electrical and telecommunication support facilities' and (as a result of rapid rates of sea level rise) 'low-lying communities, including those in coral reef environments, urban atoll islands and deltas, and Arctic communities, as well as small island developing States and the least developed countries, are particularly vulnerable.'[4].

***(See schematic in Figure 1 on the following page).***




▲ **Figure 1:** Cable system architecture and examples of damage[1]. (A) Schematic of a submarine fibre-optic cable system as it transitions from the ocean to the beach manhole and landing station. From there, the cable connects to the terrestrial network. (B) Photograph of cable protection (cast iron casing) damaged by mobilisation of the seafloor substrate. (C) Boulders moved over a cable (labelled with yellow arrow) by Hurricane Irma. Photographs courtesy of J.M. Koppers, Saba, Statia Cable System B.V.

## RECENT IMPACTS OF NATURAL HAZARDS ON SUBSEA CABLES

The global network of subsea cables, which has a combined length of >1.4 million km, is designed to be resilient; however, damage does occur, requiring often-costly repairs. Human activities, dominantly fishing and ship anchoring, are responsible for most of the 200-300 instances of cable damage that occur each year[5]. While natural events such as storms, vigorous seafloor currents and earthquakes, account for less than 20% of cable faults, where such events occur, they can damage multiple cable systems across large areas, which can have significant impacts for connectivity in some regions that rely on fewer cables than others[6]. Cable damaging events can dis-proportionately affect remote island states. A timely and recent reminder was in January 2022, when the only cable connecting the Kingdom of Tonga to the rest of the world was severed following the eruption of the Hunga Tonga-Hunga Ha'apai volcano, cutting international communications at a critical time for disaster response[7]. A number of recent events have provided a clear reminder of how natural hazards can impact subsea cables.

- A sediment flow in the deep-sea Congo Canyon offshore Angola was triggered by an unusually large river flood[8]. This powerful and long run-out flow (travelling >1000 km) broke cables connecting West and South Africa, and restricted internet connections during the early stages of the first COVID-19 lockdown.
- In 2017, Hurricane Irma left millions without internet when floodwaters cut off power and submerged terrestrial data cables, while storms caused widespread damage to cables and landing stations across the Caribbean in 2015[9].
- Tropical cyclones severed subsea cable links to Taiwan in 2009[6], and storm surges knocked out internet connections in New York in 2012[10].

Peer-reviewed science shows that the global climate has been (and will highly likely continue) warming at an unprecedented rate due to human-induced greenhouse gas emissions that are superimposed on natural climatic cycles. It is also highly likely that changes to the global climate will affect natural hazards, which may become more frequent, intensify, occur in new regions, or create new types of hazards that have not been experienced before. Here, we discuss some of the ongoing and future changes that may impact subsea cables and their landing stations and what can be done to mitigate or adapt to them.

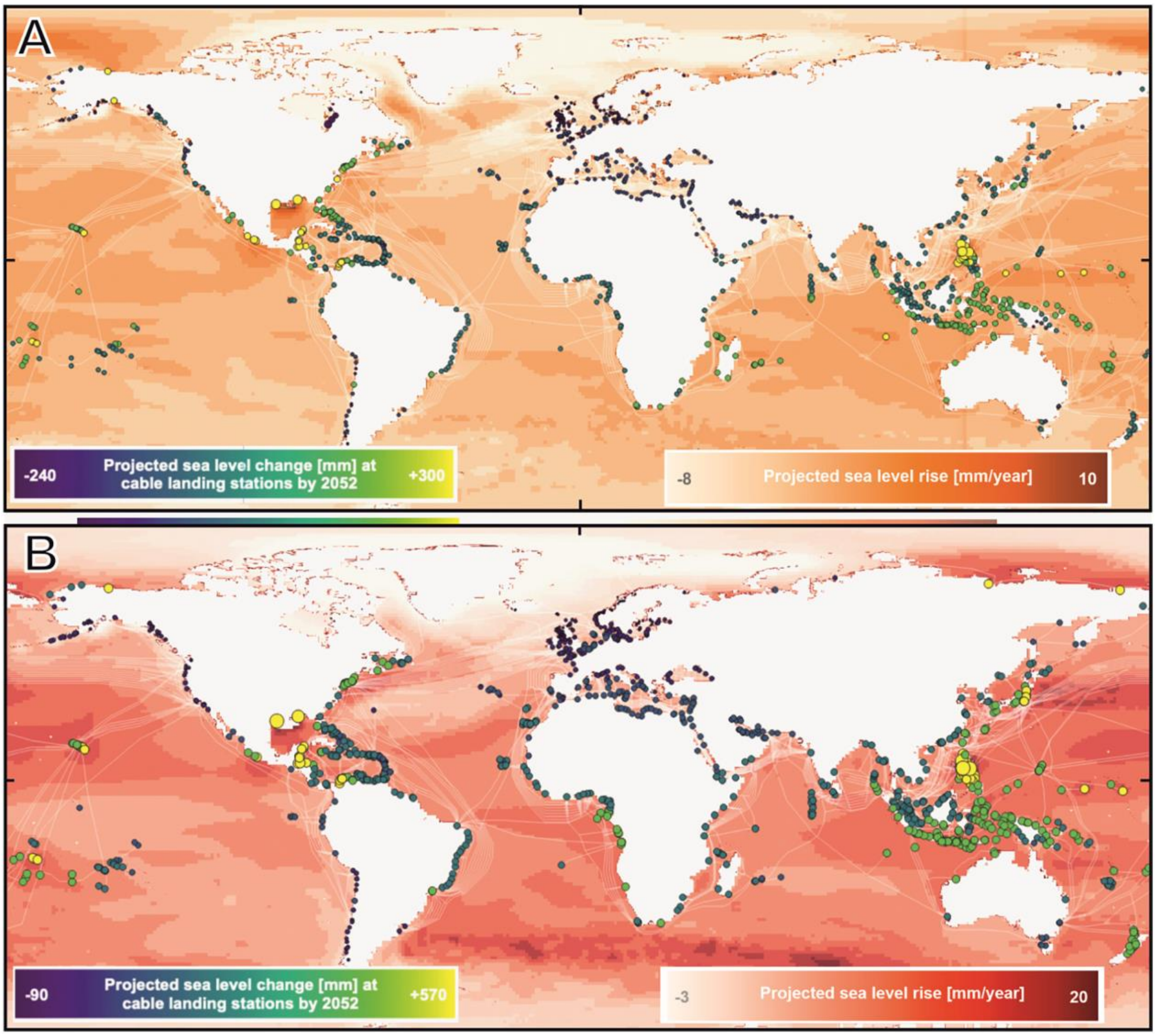
## IMPACTS FROM SEA LEVEL RISE AND COASTAL FLOODING

Sea level is rising on a global basis as a result of the increased melting of ice sheets and glaciers and expansion of the ocean as it warms. The rate of sea level rise has increased over recent decades. The rate of global mean sea level was 8 mm per year between 2006 and 2015, which is 2.5 times the rate for the period between 1901 and 1990 (1.4 mm per year)[2]. However, this rate of sea level rise is not geographically uniform, and it varies around the world due to land ice loss, and changes in ocean warming and circulation. In a few locations, vertical movement of the land may occur, instead creating a relative drop in sea level. This occurs in areas where ice sheets have retreated and the land mass 'rebounds' and moves upwards. Sea level rise may be accelerated due to some human activities, such as where ground water is extracted in sufficient volumes.

- A previous study examined the impacts of sea level rise on terrestrial internet infrastructure in the USA, finding that projected sea level rise may submerge thousands of kilometres of onshore cable that is not designed to be immersed in water by 2030 as a result of sea level rise[11].

- Offshore cables are designed to be resistant to sea water, so it is the shore-based landing stations that need to be designed to cope with future rates of sea level rise.
- Relative sea-level rise is projected to be far more pronounced in certain regions, including the Gulf of Mexico, NW Australia, Pacific islands (e.g., Hawai'i, French Polynesia, Samoa, Fiji), SE Asia (e.g., Philippines, Indonesia), Japan and West Caribbean.
- Other areas such as the Mediterranean and Red Sea, much of NW Europe and the majority of North and South American coastlines will experience lower rates of sea level rise.
- Some localised parts of high latitude regions (e.g., Alaska, Norway) are likely to experience relative sea-level fall, rather than rise, as a result of on-going continental rebound following the past removal of ice sheets[12].

***(See Figure 2 on the following page).***




▲ **Figure 2**: Projected rates of sea-level rise and elevation change at cable landing stations[1]. Cables shown in white Cable route locations and landing stations presented are based on the open-access Telegeography dataset (https://www.submarinecablemap.com). (A) Sea-level rise under IPCC low emissions (SSP1–2.6) scenario (brown gradational colouring), annotated with projected sea-level rise by 2052 at existing cable landing stations (blue-yellow coloured circles that are also scaled proportionally to sea-level rise). (B) Sea-level rise under under IPCC high emissions (SSP5–8.5) scenario (red gradational colouring), annotated with projected sea-level rise at existing cable landing stations (blue-yellow coloured circles that are also scaled proportionally to sea-level rise). Sea level data from Intergovernmental Panel on Climate Change (2021).

While sea level rise happens at a relatively slow rate, even small increases in sea level can make other hazards more severe. Indeed, sea level rise is often referred to as a 'threat multiplier.' One of the most significant hazards that will become more severe as a result of sea level rise is storm surges. Storm surges created by extra-tropical cyclones can raise sea levels by up to 4 m, and by over 9 m in the case tropical storms[13]. Tropical cyclones affect warm tropical regions such as southeast Asia, the south Pacific, Caribbean and northern Australia, while extra-tropical cyclones occur in regions including south America, northwest Europe, and south Australia. Some regions experience both, such as eastern China and the eastern USA.

- The frequency and intensity of storm surges is forecast to increase as a result of both sea level rise and mean global warming.
- It is predicted that was a previously considered a 1 in 100 year storm surge in the Gulf of Mexico, may become a 1 in 30 year event by the end of the 21st Century[14].
- Powerful winds and flooding are the main impacts for cable landing stations and cables that are located in shallow waters.
- Atlantic hurricanes Katrina in 2005, Sandy in 2012, Maria in 2017, and Laura in 2020 affected multiple cable landings on the eastern seaboard of the USA and parts of the Caribbean.
- Coastal flooding resulting from a nearly 3 m high storm surge during Hurricane Maria inundated a landing station and damaged telecommunications equipment[15].
- Another potential issue concerns power blackouts that can occur during hurricanes. The loss of power may halt cable operation unless the repeaters (that amplify the signal) can be powered by emergency backup generators.
- Existing cable landing locations that will be most exposed to storm surges are focused across

northwest Europe, higher latitudes of North and South America, eastern USA, east Africa, Bangladesh, Taiwan, and northwest Australia.

## ERODING COASTLINES AND IMPLICATIONS FOR CABLE LANDING STATIONS

As sea levels rise, storms become more frequent and weather patterns change, coastal regions are under increasing stress, which can result in an increase in landward erosion of shorelines. It has been estimated that coastlines will retreat by an average of 128 m by 2100; however, as in the case of sea level, the picture is far from uniform. Coastlines in some regions are building out, such as offshore from the Amazon River; however, most locations are eroding.

- Hotspots of coastal erosion, where coasts are forecast to retreat by >100 m by 2100, include central and eastern USA, central America, southeastern South America, central Europe, east and west Africa, southern Asia, north Australia, across the Pacific and Caribbean.
- Arctic coastlines are already experiencing high rates of retreat due to melting of permafrost and the loss of coastal ice. A total of 50–175 m of coastal retreat has been observed in the past two decades in parts of Alaska[16].
- Subsea cables on the shelf and that connect to shore can be at risk where erosion exposes them to waves and currents.
- Hurricane Sandy caused significant erosion, where beaches and dunes were reduced by up to 6 m in height by a storm surge, causing damage to a subsea cable.
- Erosion during storms may expose cables that have been buried to protect them from fishing and anchor drops; hence any burial needs to be sufficiently deep.

## RIVER FLOODING AND FAST-MOVING OFFSHORE AVALANCHES

- A warmer climate is predicted to increase the likelihood of river floods. Subsea cables may be damaged by avalanches of sand and mud that initiated as sediment-laden floodwaters plunge into the heads of underwater canyons that lay offshore from many rivers. This rapid delivery of sediment may directly triggered an avalanche (known as a turbidity current) or cause a pile up of material in the steep canyon head, that later collapses and mixes with seawater to flow downslope.
- Turbidity currents can reach speeds of up to 20 metres per second, and travel over distances of more than a thousand kilometres. Such a flow occurred in 2020 in the Congo Canyon, offshore Angola, that damaged multiple subsea cables, reducing data traffic during the early stages of the first COVID-19 lockdown[8].
- It is not just climate change that will affect the frequency and magnitude of floods. Human interventions and modifications such as land use change,

deforestation, installation of dams and hydropower schemes, or sand mining may increase or decrease the likelihood and scale of flooding events.

## DAMAGING TROPICAL CYCLONES

It is not only the storm surges that are generated by tropical cyclones that makes them hazardous. Tropical cyclones have the potential to damage subsea cables by:

- Eroding coastal sediments that expose buried cables or undermine shore-based landing stations.
- Exposure to vigorous seafloor currents that can lead to abrasion or chafe of cables.
- Collapse of submerged continental slope sediments due to the effects of repeated wave loading, triggering underwater landslides that can damage cables.
- Creating river flooding that flushes major quantities of sediment offshore that can trigger fast-moving and damaging turbidity currents.

Tropical cyclones are predicted to become more intense in some regions, but there remains a lot of uncertainty due to the relatively short observational records that exist. However, most climate models anticipate an increase in tropical cyclone intensity and an increase in their speed.

- Tropical cyclones explain several cable faults worldwide, in regions including Taiwan, Philippines, Japan, Indian Ocean, Gulf of Mexico and the Caribbean.
- Locations offshore Taiwan have been particularly affected because of the severity and frequency (three to four per year) of tropical cyclones and the density of cable routes. This region is traversed by at least 17 cable routes many of which cross underwater canyons that are the conduits for turbidity currents.

- In 2009, Typhoon Morakot resulted in nearly 3 metres of rain falling in three days. This heavy and sustained rainfall led to massive discharge of sediment-laden floodwaters offshore and into the head of the submarine Gaoping Canyon, creating a flow that broke two cables, and a subsequent landslide that cut seven more cables reaching water depths of up to 4000 m[17].

## CHANGES IN OCEAN CONDITIONS MAY CREATE NEW THREATS

Climate change is affecting ocean conditions, which in turn pose new or exaggerated threats to subsea cables. These include:

- Changes in surface waves that can create seafloor currents on the continental shelf that may expose and abrade previously buried cables. The degree to which a cable may be damaged will depend on its placement, the cable design (e.g., type of armour or other physical protection), the frequency and intensity of currents, and the composition of seafloor sediment. Mobile sandy sediments in particular, can lead to abrasion of the outer sheath of a subsea cable[5]. Abrasion accounts for around 10% of all cable faults.
- An overall trend of increasing ocean current intensity is anticipated; however, this will be extremely geographically-variable. In particular, acceleration of currents in the Pacific, Atlantic and Indian oceans is forecast.
- The most extreme changes in ocean currents are projected in the currently ice-covered parts of the Arctic Ocean and sub-Arctic seas. While these areas do not currently feature subsea cables, as ice retreats it is likely that new routes will be laid to connect to high latitude communities.
- Currents dominantly affect cables on the continental shelf, in shallow water; however,

ocean circulation can create currents that occur at thousands of metres water depth. For example, the third Canadian Trans-Atlantic (CANTAT-3) cable system was damaged faults offshore Iceland as a result of deep-sea currents that reached speeds of >0.3 m/s in water depths of 2500–4000 m[18]

## UNDERWATER LANDSLIDES

Until 1929, it was presumed that the deep seafloor was a largely stable and quiet place; however, a large earthquake that occurred off the coast of Newfoundland shook the continental slope so vigorously that part of it collapsed, generating an underwater landslide[19]. This landslide displaced the overlying sea surface, triggering a tsunami that impacted the coastline, but also triggered a sediment avalanche that ran out into the deep ocean, sequentially breaking all of the seafloor telegraph cables that connected the USA to the UK. It was because of these cable breaks that scientists first learnt about underwater landslides. Since then, evidence of underwater landslides has been provided on all the world's submerged margins, with multiple examples of cable damage from locations in the Mediterranean Sea, Canadian and Alaskan fjords, and offshore west Africa.

- Some studies have suggested that global warming may make such landslides more likely; however, the limited observations of these events precludes any firm conclusions.
- Submarine landslides may become more likely in areas where there is an increase in offshore delivery of sediment that may be enhanced by tropical cyclones, for example.
- Slopes may be destabilised by the effects of wave loading during storms. Extreme wave conditions during Hurricanes Camille, Ivan, Katrina, Rita caused multiple collapses of the submerged Mississippi Delta, triggering mud flows in the Gulf of Mexico that caused widespread disruption and destruction of offshore oil and gas infrastructure including a subsea cable network used to monitor hydrocarbon production and drilling operations[20].
- In 1982, Hurricane Iwa triggered several slope failures that damaged six coaxial telephone cables laid mainly along the upper continental slope off Oahu, Hawaii, in water depths of almost 1 km[21].

## OTHER KNOCK-ON EFFECTS OF CLIMATE CHANGE

It is not only natural hazards that will be affected by climate change. Human activities are shifting in their location and type in response to changes in ocean conditions, including fishing and shipping that are moving into new areas. As these activities account for most of the recorded cable faults to date, it is important to understand how and when these shifts may occur.

- Warming waters, ocean acidification, changes in storminess, and overfishing are pushing fishing into deeper waters. Many commercially-important fish species are migrating into new areas. Indeed, it is forecast that deep sea fish habitats will move between two and nine degrees towards higher latitudes, meaning that fishing may occur in areas that were not historically fished, and where cables may not be protected[22].

- It is projected that fishing may decrease in the tropics by up to 40% by 2055, and increase by 30-70% in higher latitudes.
- Cables are more susceptible to damage in deeper water as it becomes more challenging to bury them. Heavily armoured cable is also harder to deploy in very deep water, so cables in deep water tend to carry less or no armour. This may mean that cables will require burial, in some cases in water depths of up to 2 km; something which is now standard practice in the northeast Atlantic Ocean.
- As sea ice retreats due to warming, new opportunities for shipping routes as well as new cable routes may open up. In 2017, a Russian tanker transited through the Arctic without any assistance from an icebreaker for the first time.

## MITIGATION AND ADAPTATION TO ENSURE CONTINUED RESILIENCE OF THE GLOBAL TELECOMMUNICATIONS CABLE NETWORK

While this sounds like a major challenge for subsea cables, it is worth stressing that the topic of climate change is firmly on the radar of the subsea cable industry. In 2020, the International Cable Protection Committee published an internal Position Paper on climate change that stated 'the global climate has been and will likely continue warming at an unprecedented rate as a result of human-induced greenhouse gas emissions.' This was further emphasised at a consultative meeting of the United Nations on sea-level rise and its impacts, where the ICPC commented: 'It is critical that sea-level rise and climate change be considered in future route and landing station planning, as well as assessing the risk posed to existing systems.'[4].

The subsea cable industry is already adopting various mitigation and adaptation measures to proactively adapt to or protect against adverse impacts of climate change. Some of these examples include:

- Increased armouring and/or cable burial protection at shore-ends where erosion is worsening.
- Mitigation against threats related to deep sea fishing, including liaison with fishers, desktop study, route clearance of discarded fishing gear, and use of more resistant cable.
- Avoidance of low-lying areas for landing points, beach manhole cover and cable landing stations.
- Avoidance of submarine canyons where possible, and where they must be crossed, then identify the most appropriate crossing points by understanding the potentially hazardous flows that may run along them.
- Local knowledge ascertained from site visits regarding environmental conditions and historical events.
- Use of model outputs of future projected changes in ocean conditions to pinpoint hazard hotspots.
- Geographical Information System (GIS) analysis using various geospatial datasets that are incorporated into desktop studies to identify the optimal routes and landing points.

It is clear that the impacts of climate change will be diverse, but geographically variable, and are already being felt. Being aware of the current and future challenges will ensure that the global network continues to remain resilient and adapts as conditions change.

# *Sharing the seabed in harmony with others*

The International Cable Protection Committee (ICPC) was formed in 1958 and its primary goal is to promote the safeguarding of international submarine cables against human made and natural hazards. The organisation provides a forum for the exchange of technical, legal and environmental information about submarine cables and, with more than **200 MEMBERS** from over **69 NATIONS,** including cable operators, owners, manufacturers, industry service providers, and governments, it is the world's premier submarine cable organisation. The ICPC comprises of an 18 Member Executive Committee (EC)-led organisation voted in by its Full Members. In addition to the Marine Environmental Adviser (MEA), General Manager (GM) and Secretariat team, the ICPC also has an appointed International Cable Law Adviser (ICLA) as well as a United Nations Observer Representative (UNOR).

**Prime Activities of the ICPC:**

- Promote awareness of submarine cables as critical infrastructure to governments and other users of the seabed.
- Establish internationally agreed recommendations for cable installation, protection, and maintenance.
- Monitor the evolution of international treaties and national legislation and help to ensure that submarine cable interests are fully protected.
- Liaison with UN Bodies.

**Recommendations:**

- Taking into account the marine environment, the ICPC authors Recommendations which provides guidance to all seabed users ensuring best practices are in place.
- Educating the undersea community as well as defining the minimum recommendations for cable route planning, installation, operation, maintenance and protection as well as survey operations.
- Facilitating access to new cable technologies.

**Advancing Regulatory Guidance:**

- Promoting United Nations Convention for the Law of the Sea (UNCLOS) compliance.
- Championing uniform and practical local legislation and permitting
- Protecting cable systems and ships.
- Aiding education of government regulators and diplomats.

**Working with Science:**

- Supporting independent research into cables.
- Publishing reviews for governments and policy makers.
- Working with environmental organisations.
- Effective public education via various media.

***To learn how to become of Member organisation of the ICPC, please click on join here.***

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# FURTHER READING & REFERENCES

Further information on submarine cables and the marine environment can be found in the references and text within the peer-reviewed UNEP-WCMC report via: **'Submarine Cables and the Oceans: Connecting the World'** as well as other resources via: https://iscpc.org/publications.

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