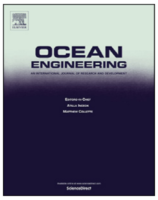
Ocean Engineering 157 (2018) 251–261

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng



Seabed recovery following protective burial of subsea cables - Observations from the continental margin

Christoph Kraus, Lionel Carter *

Antarctic Research Centre, Victoria University of Wellington, PO Box 600, Wellington, 6035, New Zealand

ARTICLE INFO

Keywords:
Submarine cable burial
Seabed recovery
Continental shelf
Continental slope

ABSTRACT

Subsea communication and power cables are critical infrastructure whose protection is paramount, especially on the continental shelf where fishing and ships' anchors cause ~70% of cable faults. Protection is often afforded by cable burial and this paper deals mainly with physical seabed recovery from that process.

Varied sedimentary environments and different modes of cable burial mean that recovery is site-specific. Repeated seabed surveys show restoration is fastest where cables are buried by ploughing in zones of high sediment supply and energetic waves/currents such as on the inner to middle continental shelf (~0–80 m water depth - WD). There, recovery can take weeks to 1–2yr. As sediment supply and wave/current activity reduce offshore, recovery from ploughing on the outer shelf (~80–130 m WD) is typically longer than in shallower depths. Recovery from water-jetted trenching, which can be more disturbing than ploughing, can take ≥5yr. On the upper continental slope (130–2000m WD), trenches infill after ~8yr where sediment supply is high, but ≥15yr where supply is low.

Surveys also suggest that benthic communities recover at rates similar to physical restoration. With few exceptions, the physical presence of a cable and the disturbance caused by its burial have little effect on the benthos studied.

1. Introduction

Submarine fibre-optic communications cables (hereafter *C-cables*) carry >95% of international voice communications and data, plus internet traffic (Burnett et al., 2013). Submarine power cables (*P-cables*) also play a major role; in this case the transfer of energy from terrestrial and offshore renewable sources to markets (e.g., BERR, 2008; Copping et al., 2016).

The social, economic and strategic importance of subsea cables require special protective measures, especially in the presence of other offshore activities. Between 1986 and 2003, ~70% of all reported C-cable breaks occurred between 0 and 200 m WD, with benthic fishing and ships' anchors being the most common causes (Allan and Comrie, 2001; Kordahi and Shapiro, 2004; Noad, 1993). In response, cables are armoured with steel wire and/or buried under the seabed. Depending on the risk, burial may extend into ~2000m WD, which is nominally the present limit of benthic fishing (Carter et al., 2009; Noad, 1993). Risk also determines burial depth. This commonly ranges from 0.5 m to 2 m sub-seabed depth (SD) but can extend to 5 m or more, especially in major shipping lanes and harbours (Meiβner et al., 2006; Mole et al., 1997; Pyrah, 2010). For example, a 4 tonne anchor, deployed from a 5000 tonne ship, can penetrate 5 m into soft mud (Shapiro et al., 1997).

In a climate of heightened environmental awareness, regulatory bodies may require environmental impact assessments (EIA) to be undertaken for offshore activities including the deployment and maintenance of cables. An EIA typically involves a synopsis of relevant environmental information but may also outline the need for new information. Repeated cable surveys have been requested to ascertain any changes in the seabed after cable burial (e.g. Carter et al., 2009; Sherwood et al., 2016). These surveys are enlightening as they provide time series that address the main point of this paper, "How long does it take for the seabed to recover from protective burial of cables".

To address that question, we present new unpublished data from repeated surveys of subsea cables (Fig. 1) together with information gleaned from open-file reports and the peer-reviewed literature. The focus is on physical change and recovery in predominantly terrigenous sediments. However, the response of benthic biota associated with those sediments is also briefly discussed using published studies that deal specifically with cables.

---

* Corresponding author.
E-mail address: lionel.carter@vuw.ac.nz (L. Carter).

https://doi.org/10.1016/j.oceaneng.2018.03.037
Received 29 June 2017; Received in revised form 22 February 2018; Accepted 11 March 2018

Fig. 1. Locations of case-study areas.

2. Cable installation and burial

Prior to installation, marine surveys involving some combination of multibeam mapping, side-scan sonar, sub-bottom profiling, seabed sampling and *in situ* testing of seabed physical properties, are usually carried out to refine knowledge of the seabed - in particular the type and thickness of sediment suitable for cable burial (Burnett et al., 2013; Jonkergouw, 2001). That information helps define the mode of burial namely ploughing, jetting, horizontal directional drilling, mechanical trenching or, as in one study, a shallow-water trench cut by a barge-mounted backhoe (Birklund, 2005). Unless a cable develops a fault, the overlying seabed will not be disturbed again during a cable's 20–25yr design life time, which may extend to 30yr with the advent of more efficient signal processing (Burnett and Carter, 2017).

2.1. Ploughing

Ploughing is used widely as it simultaneously lays and buries a cable (Allan, 1998; Allan and Comrie, 2001; Worzyk, 2009). Ploughs are usually 2–8 m wide assemblies mounted on skids, wheels or caterpillar tracks, and are towed by a cable laying ship. A basic unit uses a plough blade, however, more advanced systems have also been developed. Some ploughs incorporate water jets to allow deeper penetration, while others have rock-penetrating teeth attached to the leading edge of the plough to cut through consolidated sediment or rock. Meanwhile, vibrating blades have been added to ploughs to better penetrate difficult substrates such as chalk and gravel, or environmentally sensitive areas, for example salt marshes (BERR, 2008; Kober et al., 2000; Linders et al., 2003).

As a plough traverses the seabed it excavates a narrow furrow into which the cable is placed (Gooding et al., 2012; Pyrah, 2010; Worzyk, 2009). The excavated sediment is then allowed to fall back and fill the furrow (BERR, 2008; Kober et al., 2000). Typically, a plough blade disturbs a swath of seabed ≤1 m wide and can extend down to 3 m SD. However, the precise extent of disturbed seabed depends on plough size, the depth of burial and substrate type (e.g. Jonkergouw, 2001). The skids, wheels or tracks that support the plough may compress sediment either side of the furrow. Overall, the total disturbance strip is likely to range between ~2 and 8 m width (Carter et al., 2009).

2.2. Jetting

Jetting is the preferred method when (i) previously laid cables require reburial, such as when they are exposed on the seabed following repair, or (ii) seabed conditions are unfavourable for ploughing, e.g. steep slopes (Pyrah, 2010). Cables are usually buried to 1–3 m SD, but this can extend to larger depths where necessary (Alcatel-Lucent, 2013; BERR, 2008). Jetting works by pumping water at 5–15 bar to liquefy the seabed thereby allowing the cable to sink into the trench. There, the cable is covered with sediment settling out from the slurry (Gooding et al., 2012; Pyrah, 2010; Worzyk, 2009). Substrate disturbance is pervasive in a jetted trench, which is commonly ≤1 m wide. Steep-sided, U-shaped trench profiles often form in cohesive sediments whereas broad, ill-defined V-shaped profiles are typical of non-cohesive deposits. Jetting also suspends sediment that may escape from the trench leaving it partly filled. Coarse sand and gravel ejected by jetting usually settles along trench margins to form berms. Meanwhile, observational and modelling studies have found that fine sand commonly deposits within ~100 m of the trench, whereas suspended mud may disperse up to 2 km away (Gooding et al., 2012). Compared to ploughing, the effects of jetting can be more widely felt (BERR, 2008).

2.3. Mechanical trenchers

For rocky substrates, a tracked vehicle, equipped with a mechanical chain excavator or rock-wheel cutters, may be used to excavate a trench (BERR, 2008; Gooding et al., 2012). These cutters make incisions down to 1.5 m SD, whereas chain excavators go to 3 m SD and deeper. A trench is usually ≤1 m wide and can have a berm of rock/sediment cuttings. Because mechanical trenchers are slow, costly and damaging to the benthos, laying cables in rocky areas is avoided when possible. If the