

Safety and conservation at the deepest place on Earth: a call for prohibiting the deliberate discarding of nondegradable umbilicals from deep-sea exploration vehicles.

Highlights:

- Vast quantities of single-use, plastic coated tether, have been observed littering Challenger Deep, the deepest place in the ocean.
- Following intentional discarding from exploratory vehicles, these form a significant risk to future unmanned or manned exploration
- To ensure safe exploration in the future, we propose to ban this method and an exclusion zone to prevent entanglement.

Keywords: Mariana Trench, Deep Ocean, Marine Debris, Marine litter, Plastic pollution, Exploration, Hazards, Contamination, Policy.

Abstract

Exploration vehicles can introduce vast quantities of single-use, plastic-coated tether that have been deliberately discarded as observed at the deepest site of all Earth's oceans. Manned submersible dives to Challenger Deep (10,925 m deep) in the Mariana Trench in 2019 and 2020 revealed hundreds of metres of yellow and white tether strewn across the seafloor. Due to its composition, these fibre-optic tethers will not only persist environmentally, but form a significant risk to equipment and life should unmanned and manned craft become entangled. As a result, the site of the iconic first descent to the deepest place on Earth by Piccard and Walsh in 1960 is unlikely to be safely explored again if this practise continues.

1. Introduction

The onset of new technologies often open new opportunities to explore and study the planet's most extreme environments (Danovaro et al., 2014). The marine environments, and particularly the deep oceans, may be the most susceptible to successful development and operation of such exploration technology. Access to the deepest places in the oceans, the hadal trenches, has long lagged behind that of the overlying, shallower water ecosystems due to the technical challenges of working at such great depth (Jamieson, 2015).

In recent years there has been an almost exponential increase in scientific exploration of hadal depths (6000 - ~11,000 m; Jamieson, 2018). Typically, samples and imagery are acquired through free-fall autonomous lander vehicles and wire-deployed systems (Jamieson, 2018). However, there is a growing interest in developing Remotely Operated Vehicles (ROVs) such as the ROV Kaikō (1995-2003; Kyo et al., 1995), the crawler, ABISMO (2007-present; Yoshida et al., 2009) and the Hybrid-ROV *Nereus* (2009-2014; Bowen et al., 2009). Similarly, there has been resurgence in manned-exploratory vehicles for full ocean depth nearly 50 years after the bathyscaphe *Trieste* first reached the deepest place on Earth (Piccard and Dietz 1961). Examples of those manned, Deep Submergence Vehicles (DSV) are the *Deepsea Challenger* (Gallo et al., 2015), the DSV *Limiting Factor* (Jamieson et al., 2019), and the forthcoming DSV *Rainbow Fish* (Cui et al., 2017) and *Shenhai Yongshi* (Wu et al., 2018).

2. Technical challenges of full ocean depth exploration

While manned-vehicles host a plethora of engineering challenges relating to deep-sea safety and life support of human occupation, ROVs have similarly difficult challenges in the physical connection between the vehicle and mother ship. This connection can either be made through a power and data surface-to-seafloor umbilical, which, in the Kaikō and ABISMO systems requires heavy cable (29 mm diameter), large surface winch, complex launch and recovery system and subsea launcher platforms with tether management systems. Another solution, as in the HROV *Nereus* design, is to power the vehicle internally, thus negating the need for power transfer from the surface, meaning the data transfer tether could be extremely thin (<0.5 mm diameter), but would have to be discarded after each dive. 'The use of Autonomous Underwater Vehicles (AUVs) is an alternative to ROVs with heavy but recoverable umbilicals, and expensive manned submersibles. AUVs are pre-programmed vehicles capable of surveying large swaths of seafloor, underpinned by complex underwater navigation systems and artificial intelligence. Although AUVs are becoming commonplace in conventional deep-sea exploration (Wynn et al., 2014), they have limited ability to explore dynamic environments and rough or unpredictable terrain.

However, based on the concept of the 'Hybrid' ROV *Nereus* – *Hybrid* being defined as being capable of ROV or AUV operations – new unmanned vehicles are being designed with light-weight umbilicals for real-time control. Unlike the HROV *Nereus*' ultra-thin tether, these new vehicles are using thicker plastic or aramid coated fibre-optic tethers that are deliberately discarded, to become free-floating in the ocean, at the end of the mission.

3. Evidence of bad practice

In May 2019 and June 2020, the DSV *Limiting Factor*, a two-person full ocean depth untethered submersible, made ten successful dives, of ~3-hour bottom time, spanning the three 'pools' of Challenger Deep in the Mariana Trench, Pacific Ocean (the deepest place on Earth at 10,925 m). On three separate occasions the submersible encountered at least two types of discarded umbilical tether strewn across the seafloor for what appeared to be tens or hundreds of metres (Figure 1). A loose coil of yellow tether of undeterminable length was seen in the eastern pool during the 2019 and 2020 dives. One of the autonomous free-fall landers that supports the submersible operations even landed on a yellow tether in 2020, suggesting the observed discarded tether is not an isolated occurrence, but is pervasive throughout Challenger Deep. During a dive to the western pool in 2020, lengths of white tether was seen throughout the entire dive. This tether was seen in chaotic entangled sections, straight sections, at times multiple lengths of it crossing one another, and long taut sections leading up slopes pulling the tether off the seafloor into the water column.

The presence of these plastic or aramid coated cables present a number of serious concerns. Firstly, they are a *deliberate* disposal of plastic or synthetic material in the ocean, and secondly, they are not heavy enough to embed within the sediment surface, not buoyant enough to float to the surface, and are not delicate enough to simply break if they were entangled in a vehicle. In this sense, these residues left behind pose a very serious entanglement hazard to future manned, and unmanned, exploration of the deepest place on Earth. The DSV *Limiting Factor* was forced to execute emergency evasive manoeuvres twice to avoid the suspended white tethers encountered in the western pool of Challenger Deep.

The exact source of the yellow umbilicals is not known, but they do appear to be from tethered vehicles. They do not appear to be jetsam on the grounds they have only been found (repeatedly) across the deepest two points of the Mariana Trench, where nearly all recent exploration has been undertaken, and have not been observed by the Five Deeps Expedition at the deepest point of the Southern, Indian, Atlantic or Arctic oceans. They were also not observed in the neighbouring Sirena Deep, suggesting it was specifically from Challenger Deep exploration.

The white tether resembled long-line fishing gear that can have surface origin, but there was no sign of any bait hooks or rigging attached to it, which would be obvious on that type of gear. This also suggests that it was indeed expendable tether, perhaps coincident with the recent increase in diving acticity with the new DSV *Haidou-1* and *Fendouzhe* to Challenger Deep (Makichuk, 2020 and Westcott, 2020 respectively).

While we acknowledge that most scientific exploratory vehicles discard some sort of ballast weight at the end of each mission. These mild steel weights sink immediately into the sediment where they corrode over time and thus alteration of the habitat is minimal when compared with plastic-coated materials. They also offer no navigation risks to any manoeuvring subsea vehicles. Similarly, the ultra-thin fibre-optic tether used with *Nereus* is composed of glass and will break down over time. The use of contemporary plastic-coated fibre-optic umbilicals, deliberately designed to be abandoned after each mission, amounts to intentional littering and constitutes a reckless disregard for the environment and the safety of future exploration of such an iconic and prestigious place.

Recently discovered anthropogenic contamination of the Mariana Trench range from high concentrations of lead in the Mariana Snailfish (Welty et al., 2018), the detection of 1950s hydrogen bomb radiation in crustaceans (Wang et al., 2019), bioaccumulation of persistent organic pollutants in amphipods (Jamieson et al., 2017), ingestion of microplastic and synthetic fibres by amphipods (Jamieson et al., 2019; Weston et al., 2020), plastic litter on the seafloor (Chiba et al., 2018), and plastic contamination of sediments (Peng et al., 2018). Considering all of this, it is ludicrous to think that certain methods adopted in the exploration of this environment would not only add to the problem but prohibit further study into the extent of the problem.

4. Recommendation

The majority of the Mariana Trench falls within Marianas Trench Marine National Monument (MTMNM) that was given conservation status, granted under the Antiquities Act of 1906 by former President George W. Bush in 2009 (Presidential Proclamation 8335; Presidential Documents 2009). It is managed by United States Fish and Wildlife Service (USFWS). However, Challenger Deep is located 9 km southwest of the monument boundary in the exclusive economic zone (EEZ) of the Federated States of Micronesia and regulated by the National Oceanic Resource Management Authority (NORMA).

We call for NORMA in the Federated States of Micronesia and the USFWS in the United States to ban the deliberate disposal of expendable umbilical tethers, which persist in perpetuity, on exploratory vehicles in the Mariana Trench on the grounds of conservation and safety. The presence of these hazards in such a localised part of the trench, and ongoing use of this method, may render the Challenger Deep a permanent no-go zone for both manned and unmanned exploration. As a precautionary measure we strongly advise that propeller driven exploratory vehicles avoid the western section of the western pool of Challenger Deep (Figure 2) due to the significantly increased risk of entanglement on discarded tethers.

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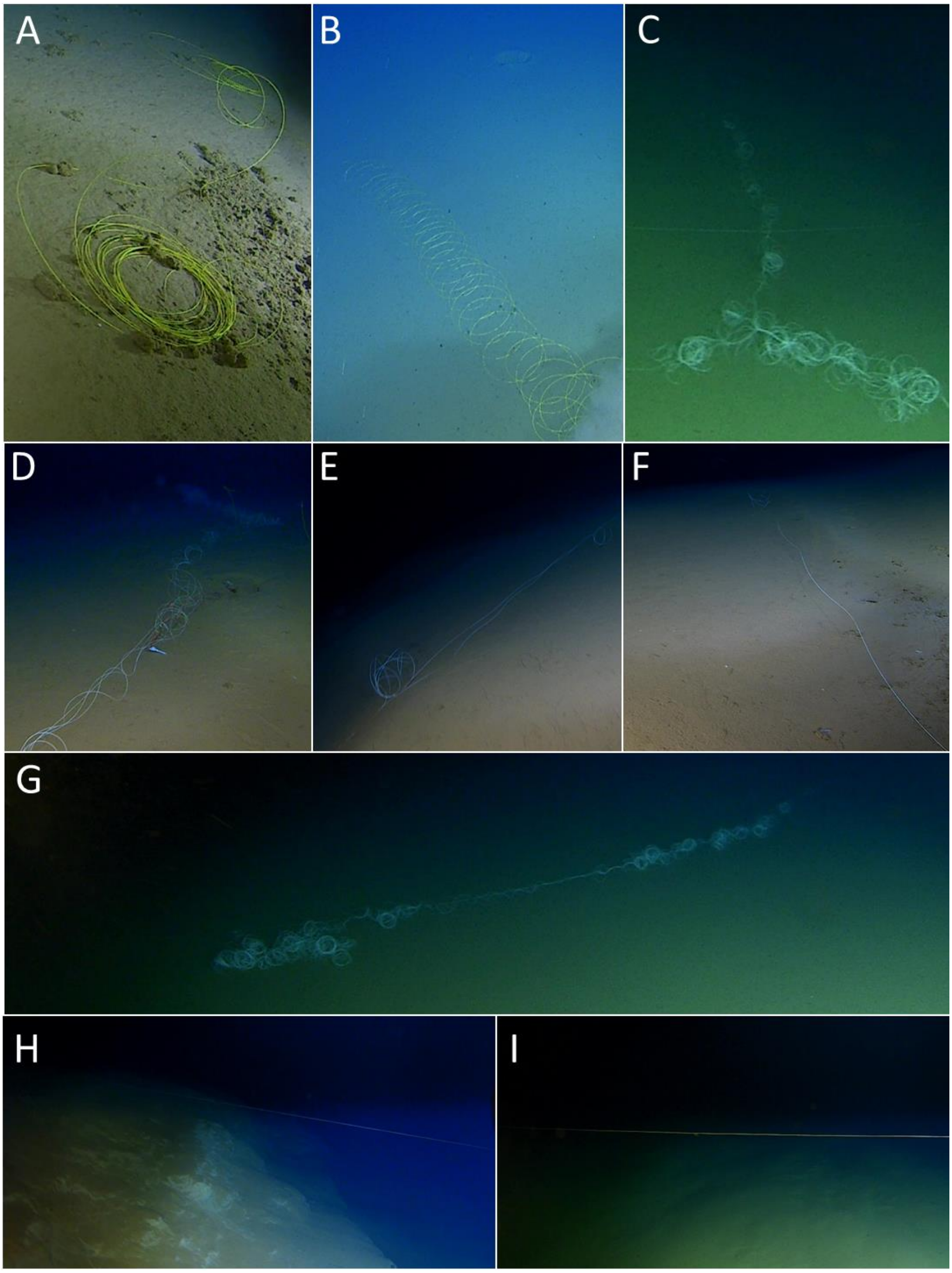

Figure 1. The yellow tether found at the eastern pool of the Challenger Deep, C-G; the white tether strewn across the floor of the western pool of Challenger Deep, where in some instances (H-I) it has become taut and pulled high above the seafloor, creating further potential for entanglement.

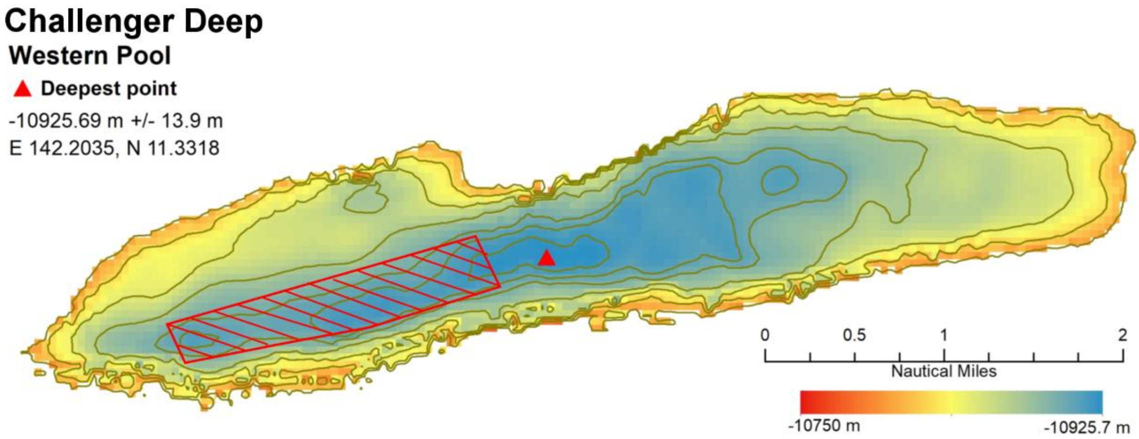

Figure 2. The western pool of Challenger Deep with a proposed exclusion zone due to significant tether contamination and risk to propeller driven exploratory vehicles.

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