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Training Spill Responders

MARINE TECHNOLOGY REPORTER

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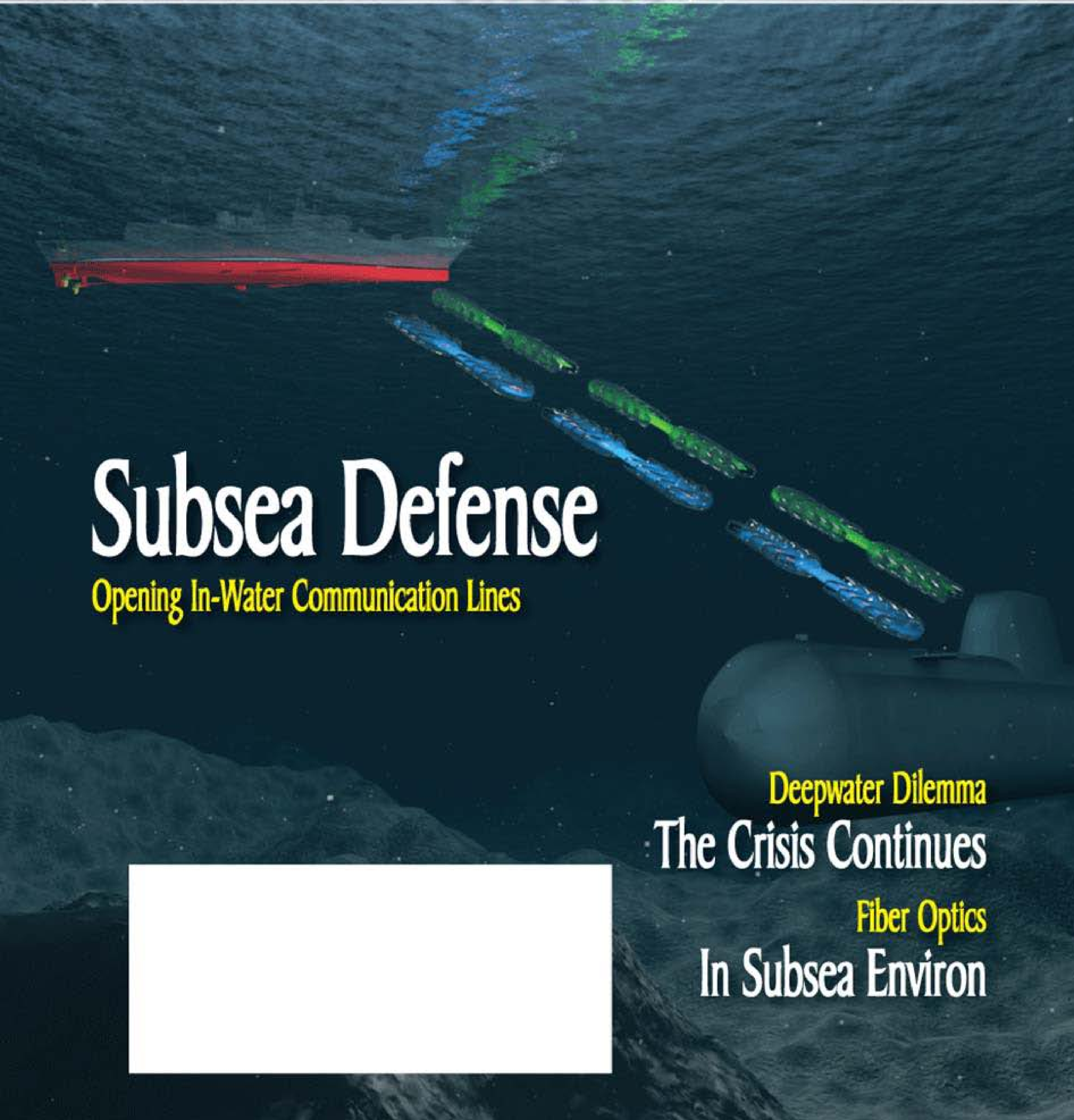

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Pictured in the background is the cable "unfriendly" jaw of a Triggerfish, as featured in Stephen O'Riorden's article "Fiber Optics in the Underwater Environment" on **page 20.**

Subsea Defense & Communications

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Fiber Optics in the Subsea Environment

by Stephen O'Riorden, Linden Photonics, Inc.

Fiber optics has become an ever increasing part of our daily lives and is partly responsible for delivering many of the modern conveniences to which we have become accustomed. Fibers deliver the data for our phone, internet and television and are in virtually every conceivable piece of high tech equipment. Fiber optics are also being increasingly deployed in harsh environments that range from space, to oil & gas down hole drilling to the deepest trenches of the ocean.

Data transmission via a fiber optic cable is achieved through pulses of light and is conducted through a silica glass in the core of the cable. This silica glass in and of itself is very delicate. Cable strength and reliability is achieved through buffers and jackets over the fiber that protect the silica and enable this otherwise delicate photon conduit to be deployed in the harshest environments on earth and beyond.

Cables used underwater may be exposed to corrosion, moisture, high pressure, high forces in the axial and lateral directions, high temperatures and assaults from various sea creatures. To perform well in these environments one needs a cable jacket that will protect the glass from many or all of these conditions. One way to do this is to give the glass a strong primary buffer. The most common type of buffer used is a polyimide jacket. This provides a very strong, while very thin, buffer layer that is also resistant to high temperature. The major drawback to polyimide coating is its stripability. One needs to use either a thermal stripping method - which can compromise the

Figure 2. The cable "unfriendly" jaw of a Triggerfish.

If one intends to deploy a fiber optic cable alone (not in an umbilical configuration), the necessity to ruggedize the fiber is quite obvious. The way one goes about protecting this fiber is not equally as obvious. The properties required to safeguard against all these harsh conditions are often contradictory. Typically weight is a byproduct of strength, yet weight becomes a major system handicap if long lengths are to be deployed. High tensile strength and flexibility also are usually mutually exclusive. And perhaps the most important correlative properties are a high level of protection and cost.

In addition to this, acrylate is a highly absorptive material and if moisture makes its way to the jacket of the fiber optic cable, it will undoubtedly be absorbed by the acrylate buffer, which will cause a change in the optical performance of the fiber.

Figure 1 compares the moisture absorption of standard Corning SMF28e fiber and Linden's Liquid Crystal Polymer (LCP) coated SMF28e fiber and shows just how much moisture can be absorbed by an unprotected fiber. In this experiment we exposed a 5m length of bare fiber to 100% humidity at 23°C. Within 30 minutes it has saturated and absorbed 2.3mg of moisture. When it is protected by a jacket which is impervious to moisture, in this case a 0.005" wall of LCP, it is still unsaturated after 340 hours at 70°C and 100% humidity.

Moisture that is absorbed by the acrylate buffer can permeate into any microcracks present in the silica and this will wreak havoc on the fiber strength, integrity and optikindly to fiber optic cables being introduced to their habitats.

The Triggerfish has overlapping jaws that introduce a shear bite force of 980N. The Blue Crab can impart a cut force of 120N, and the edges of its claws are very sharp. The Spiny Lobster has a crushing or chewing force of 230N. These are but three examples of the living hazards to fiber optic cables underwater and obvious evidence that a cable used in these areas needs to be properly armored. A broken fiber is a useless fiber and a cable that has a high strength jacket and/or is highly flexible will safeguard against breakage when under attack. The balancing act that one must play when designing or choosing a cable that will withstand these threats is one of strength vs. weight and armor vs. flexibility. Usually it is either one or the other, but some cables can be designed to be strong and light, armored and flexible. Cables that are used as tethers for ROVs must remain highly flexible because the ROV can move in any direction and loop back on itself presenting a situation in which the tether may form a loop and kink or hockle. Avoiding hockling is as critical as avoiding moisture or MBH because if a fiber is bent past its Minimum Bend Radius (MBR) one will lose optical transmission and at a critical radius the fiber will crack and break in half. This catastrophic failure will render the fiber optic link useless.

To avoid hockling, one must choose a cable jacket that is strong and highly flexible. Cables jackets like those shown in Figure 3 will prevent the underlying fiber from reaching the critical point at which it will break and will also help reduce the chance of reaching the MBR in a situation where the fiber loops back on itself. Using a properly designed fiber optic cable will help ensure your underwater operations are a success and reduce downtime from troubleshooting. Whether using a single fiber optic cable or a multi channel hybrid cable proper fiber protection is critical.

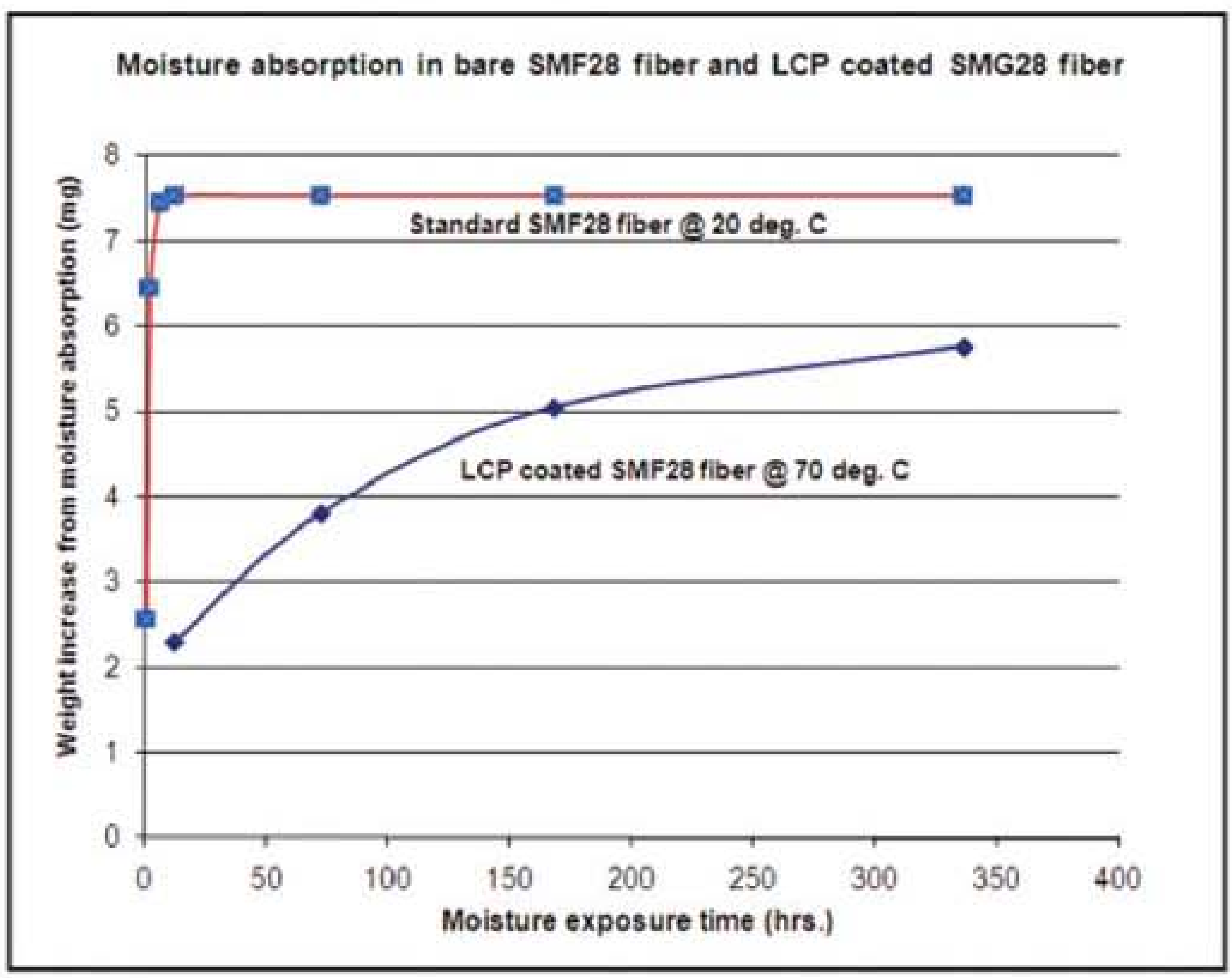

Figure 1.
Moisture Absorption vs. Time in LCP Buffered SMF28e Fiber Cable.