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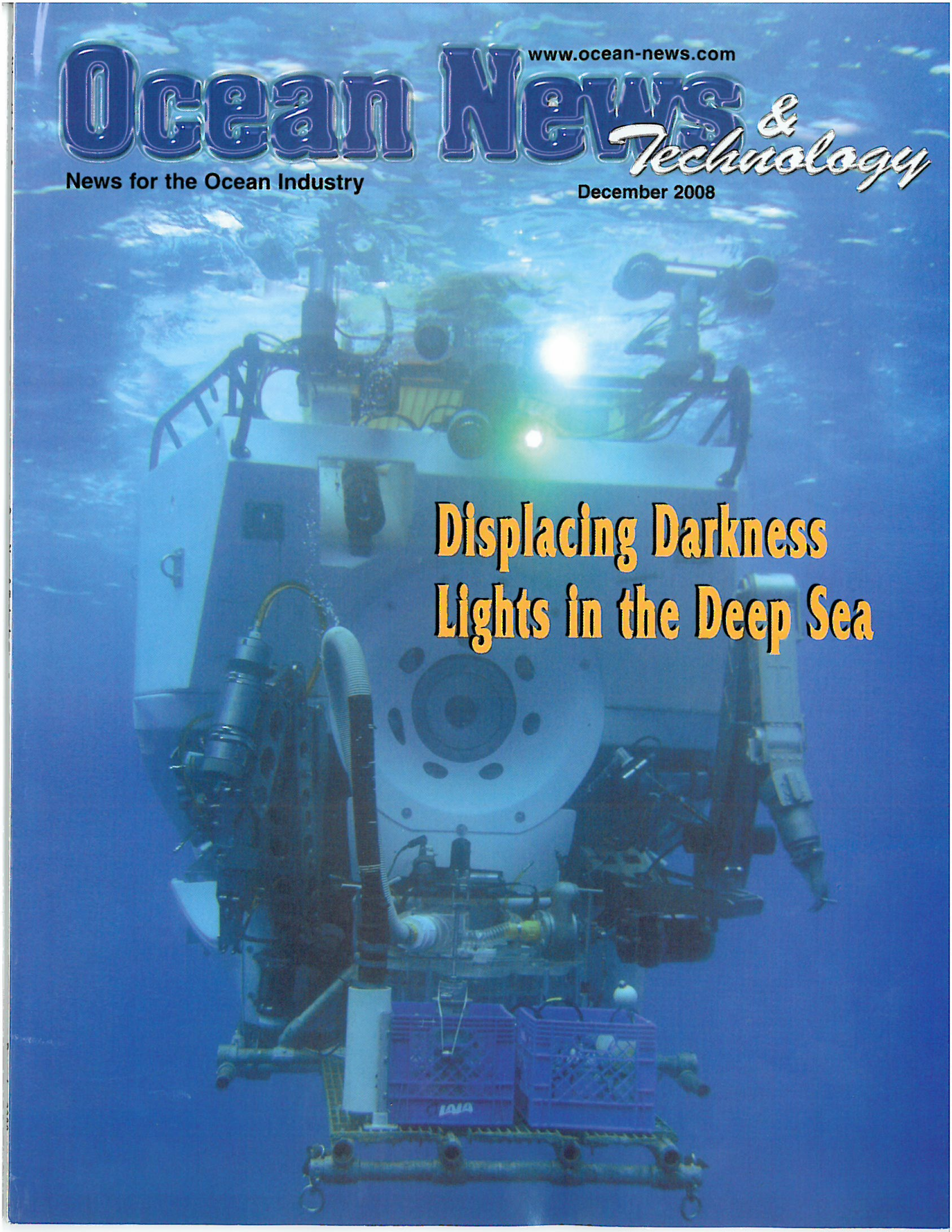
News for the Ocean Industry

December 2008

Displacing Darkness Lights in the Deep Sea



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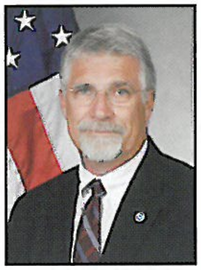
"United We Stand"



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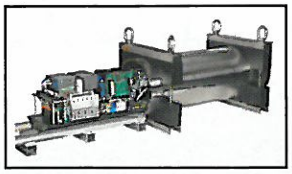

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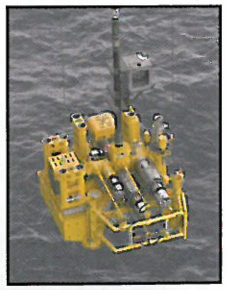

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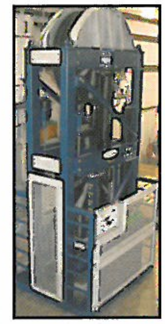

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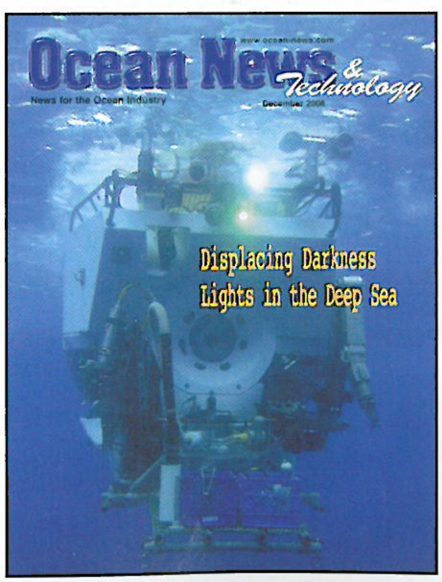
Editorial Focus

- *Underwater Vehicles & Submersibles*
- *Diving Technology*

COVER STORY



EDITORIAL

FEATURE STORIES

Displacing Darkness
Lights in the Deep Sea

By Kevin R. Hardy,
Mark S. Olsson,
Peter A. Weber,
DeepSea Power & Light,
San Diego, CA

We carry a torch into the dark places

Undersea vehicles, manned and robotic, travel through the photic zone, that upper layer of ocean with enough sunlight for photosynthesis to occur and for our eyes to see. Below that layer we enter the much larger aphotic zone, the "Other Earth," that space Jacques Cousteau once called a "World Without Sun." Since the seas were formed 4.2 billion years ago, more than 70% of our planet's earthen surface has never been touched by sunlight. The affects of the sun are only felt second-hand by the inhabitants of that place, such as the change in the amount of marine snow tied to seasonal fluctuations in the upper ocean.

Mineral recovery and fisheries work is now heading towards the abyssal plain at depths up to 5,500 m, where pressure tolerant lights accompany deep sea cameras or the human eye peering through a view port.

Artificial lights extend the day or depth, and let us work, do science, attract fish, or sometimes just play.

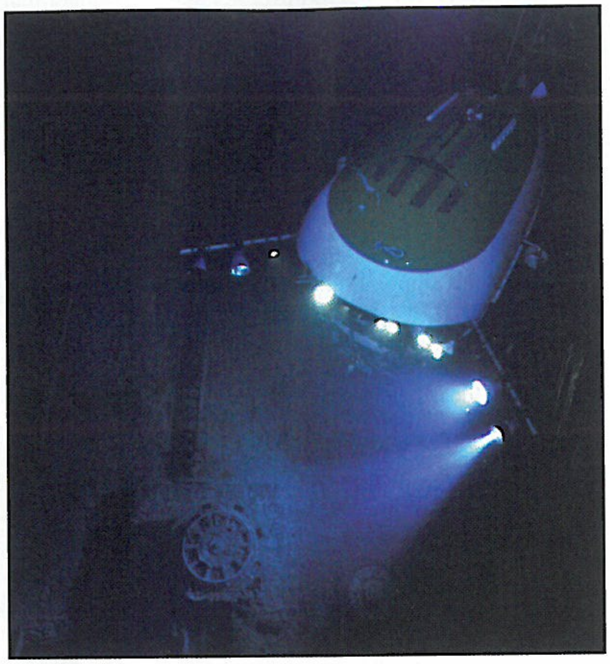


Figure 2. *The Russian submersible MIR-1, outfitted with four DSPL 1200w HMI lights and six DSPL 400w HMI lights, cast daylight upon the decks of the sunken wreck of the RMS Titanic.* (Photo by Ralph White)

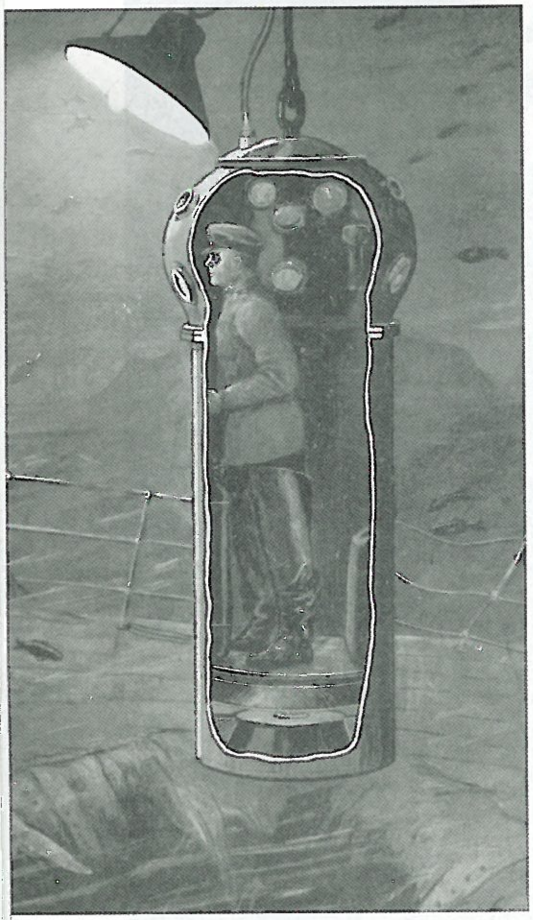


Figure 1. *A British submarine observation chamber (c1930), with mercury vapor "electric lamp" and diffuse reflector for wide area illumination.*
(Deep Diving and Submarine Operations, Robert H. Davis, 1951)

A little history

In the late 19th century, marine salvors and hardhat divers pushed underwater lamp development, as they needed light for underwater construction of bridge foundations, piers, and harbor facilities.

The definitive handbook of diving in its day, "Deep Diving and Submarine Operations," by Great Britain's Sir Robert H. Davis, was in its fifth edition by 1951. From first person interviews he made for earlier editions, Davis shared stories of European advances made as far back as the 1870s. In one story, in a time between the Great Wars, the British routinely employed submarine observation chambers to scout wreck sites prior to salvage diving operations (Fig. 1). The chamber was fitted with an "electric lamp," described as a Westinghouse mercury vapor lamp that provided 3,000 candle power from 200vac at 3.5A. A diffuse white reflector was used for wide area illumination.

DeepSea Power & Light® (DSPL), San Diego, CA, was founded in 1983 with a knack for developing high quality pressure compensated batteries. The timing was right as the ROV market was just taking off, and DeepSea Power & Light® (DSPL) moved to answer the demand for robust but compact underwater lights and cameras by the offshore industry.

DSPL went on to apply its lighting expertise to other challenging problems. In 1991, twin Russian submersibles, Mir-1 and Mir-2, carried the most advanced underwater lights to date, down 2-1/2 miles to illuminate the pinnacle of technology from an earlier age, the sunken RMS Titanic (Fig. 2). Today, DSPL maintains a full line of deepwater lights sources, including high brightness LEDs, adapted to work in that harsh, but now familiar, world without sun.

"Electric Lamp" Light Sources

Light may be generated from electricity by:

- Thermal radiation (Incandescent)
- Low Pressure Discharge (Fluorescent)
- High Pressure Discharge (High Intensity Discharge)
- Semiconductors (LED)

Incandescent lights, functionally demonstrated in the 19th Century, use a tungsten filament that resists the flow of electricity. The resistance generates heat causing the filament to glow red hot, then ultimately whiter as the temperature increases. They are not too efficient, around 9-lumens per watt (lm/W). They have a simple design, short bulb life, are inexpensive, and generate warm color temperatures in the range of 2400°K-2800°K.

Incandescent lights improved in the 1970's with the development of Halogen bulbs. The halogen gas limits the loss of tungsten filament by vaporization that would otherwise blacken the lamp envelope through deposition. This increases the bulb life, while also allowing more light to pass through the clear quartz. The quartz envelope can tolerate higher temperatures than glass, so it can be made much smaller, permitting higher interior gas pressures. Efficiency jumps up to between 20-30 lm/W. Color temperature increases to 3300 °K.

Low pressure gas discharge lamps, also known as fluorescent lights, have no filaments, increasing their durability and life span. They require a ballast to strike and maintain the arc between tungsten electrodes in a tube filled with a low pressure mercury vapor and other gases. The arc excites the mercury vapor, which generates radiant energy, primarily in the ultraviolet range. This energy causes the phosphor coating on the inside of the tube to "fluoresce," converting the ultraviolet into visible light.

Fluorescent lamps have two electrical requirements. To start the lamp, a high voltage surge is needed to establish an arc in the mercury vapor. Once the lamp is started, the current must be regulated to compensate for the decreasing resistance of the ionized gas. Special circuitry in a ballast is used to accommodate this. Their efficiency reaches 69-lm/W, and color temperatures can be as high as 5000°K, meaning a cool white color.

High pressure discharge lighting, also called high intensity discharge lighting (HID), is in some ways similar to fluorescent technology: an arc is established between two electrodes in a gas-filled tube which causes a metallic vapor to produce radiant energy. However, a combination of factors shifts the radiant energy directly within the visible range, negating the use of phosphors.

There are three main types of HID lamps: mercury vapor, metal halide and sodium. The names refer to the elements that are added to the gases in the arc stream, which cause each type to have somewhat different color characteristics and overall lamp efficiency. The mercury vapor lamp in Figure 1 illustrates an example of the earliest underwater HID light. The lamps of the Titanic dives are HMIs, a specialized version of metal halide HIDs. Light efficiencies for HIDs range from 65-lm/W for Xenon, such as found in car headlights, to as much as 120-lm/W for the high output HMI. DSPL has produced HIDs with power inputs ranging from 35 W to 1,200 W.

A Light Emitting Diode (LED) is an electronic component consisting of several layers of semiconductor material. Light is generated when the LED is forward biased, and electrical power is driven through the semiconducting structure, where bound electrons capture, then release electrical energy as a narrow spectrum or monochromatic light. Different doping materials in the semiconducting material produce different colors of light. Most white LEDs are actually blue LEDs covered with a phosphor compound layer to absorb the blue, then reradiate white light. LEDs themselves have estimated life expectancies of more than 5 years of continuous operation. Initial cost is high, but lowered maintenance saves costs elsewhere. Efficiencies are now over 100-lm/W. There are many companies that make high brightness LEDs, but only a few good ones. Cree®, Philips® Lumiled™, Nichia®, Osram®, and Seoul Semiconductor® are among those.

LEDs are known to have extremely long life times under ideal circumstances, but they are also part of a larger electronic circuit that can be affected by fluctuating voltage inputs, excess heat, splash, marine air, or normal component failure rates. Adequate consideration for field maintenance also provides a convenient upgrade path, as LED brightness is increasing annually.

Applications

DSPL's line of underwater lights are used around the world by the most demanding end users in the earth's most extreme environments, including hot water hydrothermal vents, high pressure ocean trenches, radioactive nuclear storage facilities, and biohazardous sewage treatment plants.

Hanford Nuclear Storage Facility (Hanford, WA) uses halogen drop lights for radioactive tank monitoring and inspection, an application where once they go in, they never come out.

DSPL Seaquarium LED lights are used in large display tanks where long term immersion is a necessity. The Seattle Aquarium uses them in their newest exhibit "Windows on Washington Waters" for general illumination and spotlights.

Undersea photographer Steve Drogin, owns a SEAmagine® Triumph Submarine (Claremont, CA), which carries six DSPL 150W HID, two 70W HIDs, and an LED SeaLite (Fig. 3). He has captured stunning, deep water, high definition video off Cocos Island, Guadalupe Island, and in the Gulf of California using these lights.

The cover photo shows Woods Hole Oceanographic Institution's iconic DSV ALVIN as it begins a 1-mile deep test dive off San Diego, CA. DSPL's LED SeaLites® are powered up, the upper one producing 2000-lm of cool white light, and the other producing monochromatic green light (520 – 535nm). ALVIN pilots report less backscatter from the green light in near bottom high turbidity conditions, though most favored the bright white light for general illumination. The high efficiency LED lights also draw less power, increasing bottom time available for observations. WHOI has replaced its older DSPL SeaArc®3Xe Xenon lamps with LED SeaLites®. Figure 4 shows DSV ALVIN in its high bay aboard RV Atlantis. The submersible's contingent of lights included three DSPL LED SeaLites (2 on the port side), and three SeaArc2 400W HMIs. The sub currently operates with 7 LED SeaLites.

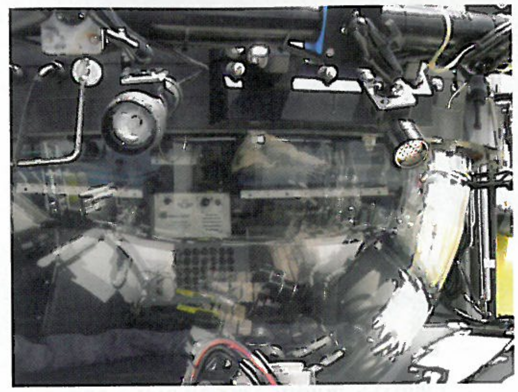


Figure 3. *A SEAmagine Hydrospace® Triumph class submarine owned by undersea explorer Steve Drogin, and capable of 1,500-ft dives, is outfitted with a DSPL Super SeaArc® 150 W HID (left) and a DSPL LED SeaLite® (right).* (Photo by Peter Weber)

An interesting possibility for LED lights may be to help researchers studying fish behaviors without affecting those behaviors, and ROV operators who do not want to attract fish that can obscure ROV camera vision. Due to millennia of adaptation to blue-green bioluminescence, some marine biologists suspect many fish will not be attracted, or possibly can't even see, the monochromatic red light produced by LEDs (620 – 630nm). This would greatly benefit oil platform ROV operations in the Gulf of Mexico, for starters.

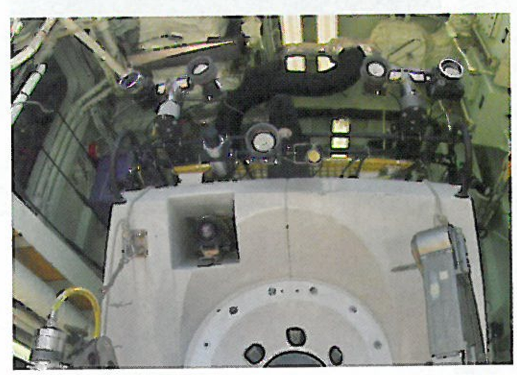


Figure 4. *ALVIN rests in its high bay aboard RV Atlantis. Providing the submersible light are 3 DSPL LED SeaLites, and SeaArc2 400W HMIs. The sub now runs with 6 LED SeaLites.* (Photo by Mark Spear, WHOI)

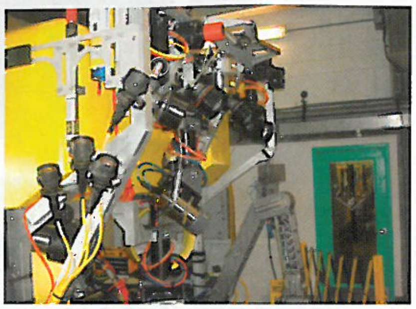


Figure 5. *MBARI's newest ROV, "Doc Rickets," carries DSPL 400W HMIs and Deep Multi-SeaLites®. The "Doc Rickets" will replaces the "Tiburon," and will service the MARS OOS.*
(Photo by Brock Rosenthal)

Monterey Bay Aquarium Research Institute (MBARI) is building a new ROV, dubbed "Doc Rickets," with expanded capabilities to service the Monterey Accelerated Research System (MARS), an element of the Global Ocean Observing System. "Doc Rickets" will replace their current workhorse, "Tiburon," and their current suite DSPL 400 W HMIs and Deep Multi-SeaLites® will jump to the new robot sub (Fig. 5).

Commercial divers like the compact size of the Multi-SeaLite®, as well as the LED-Mini SeaLite®, for helmet mounted applications. Paired with a Multi-SeaCam®, topside observers can monitor the diver's progress below, and record events for later playback (Fig. 6).

In a project to explore the use of multiple autonomous underwater vehicles to increase the performance of underwater optical imaging systems, Prof. Jules Jaffe, Scripps Institution of Oceanography /UCSD, built a system using monochromatic blue and green LED Multi-SeaLites® (Fig. 7). An experiment was conducted on a cruise during September, 2008 in the Santa Barbara channel. "In all deployments the cameras and lights functioned well," said Dr. Jaffe.

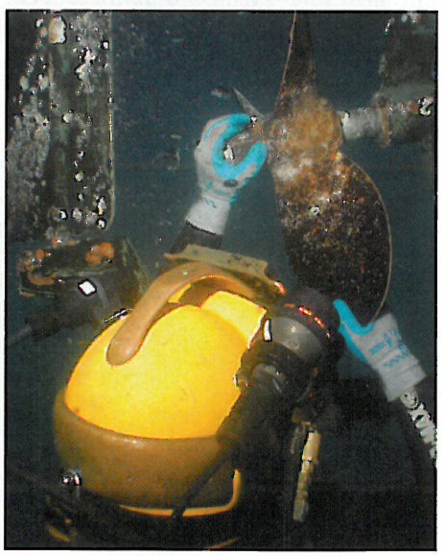


Figure 6. *A commercial diver inspects a propeller, with help from a helmet-mounted Multi-SeaLite® (right). The inspection is recorded topside using a DSPL Multi-SeaCam® (left).*
(Photo by Coast Diving Service)

Just as a pool light changes the appearance and functionality of the pool itself, boaters are finding that DSPL Thru-Hull SeaLites® increase the utility and attractiveness of their vessels. Fishermen use the lights at dawn, dusk, and at night to attract bait fish and squid that bring in the larger game fish. Some old salts favor the blue and green, while others prefer a white light for this task (Fig. 8). With the high price of fuel, some boat owners use the lights to entertain guests on their boats without leaving the dock (Fig. 9). Their Thru-Hull SeaLites® transform the black surface of the bay into a colorful crystal aquarium, while the seafloor takes on the appearance of a not-so-distant moonscape.

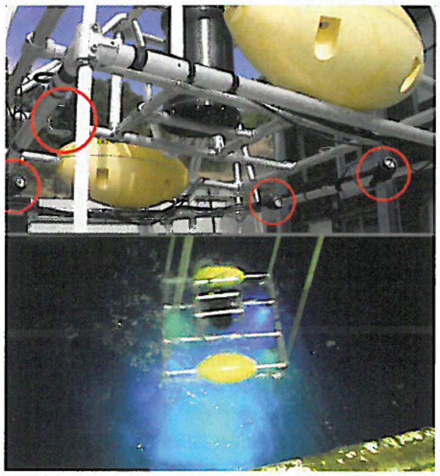


Figure 7. *MAUVIO (Multiple Autonomous Underwater Vehicles for Increased Optical imaging) uses pairs of blue and green DSPL LED Multi-SeaLites® (upper photo, highlighted by red circles) in underwater optics research. Lower photo shows system as deployed with lights on.*
(Photos by Fernando Simonet, Scripps Institution of Oceanography/UCSD)

Before a boat owner bores a hole through his perfectly good hull below the waterline, it occurs to them that the first design problem is a mechanical one. They want to be certain they buy from a respected supplier, recognizing whatever they use to plug that hole must maintain hull integrity and perform as well as any other hull section in keeping the ocean on the outside. The light fixture must be able to survive wave slap, impact with flotsam or pier pilings, exposure to hydrocarbon fuels or solvents, run up on a beach, trailering, and other dangers that are part of normal boating operations. For their Thru-hull light window designs, DeepSea Power & Light uses high impact strength materials that are able to survive repeated impact blows from a ball peen hammer. The housing design also minimizes the affects of stray electrical currents and dissimilar material galvanic corrosion.

Figure 8. *Two 150W HID Thru-Hull SeaLites® bring bait fish to the stern of the charter fishing boat, Play-N-Hookey. Fishermen, always in search of the best lure, find DSPL Thru-Hull SeaLites® bring in the bait that attract the game fish.*
(Photo by Bill Larkin)

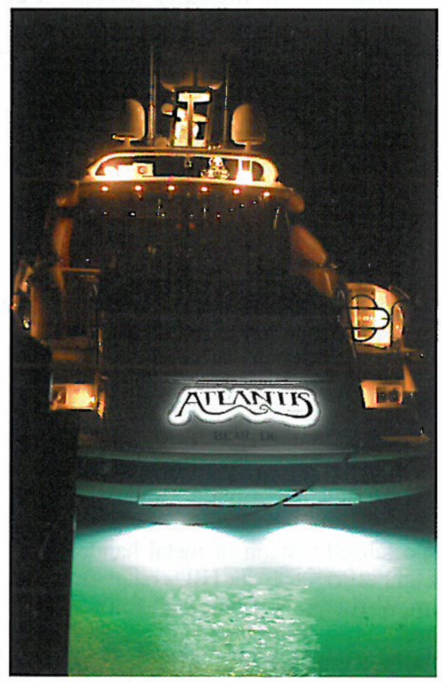


Figure 9. Hanging out at the dock with friends is a little more fun with the ambiance of a luminous sea provided by DSPL's Thru-Hull SeaLites®.

More stories about DSPL lights may be found in their eNewsletter. To receive a copy, please sign on at their website http://www.deepsea.com

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