MARINE TECHNOLOGY REPORTER

November/December 2025
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Captain Charles Robert MacVean

Volume 68 Number 8


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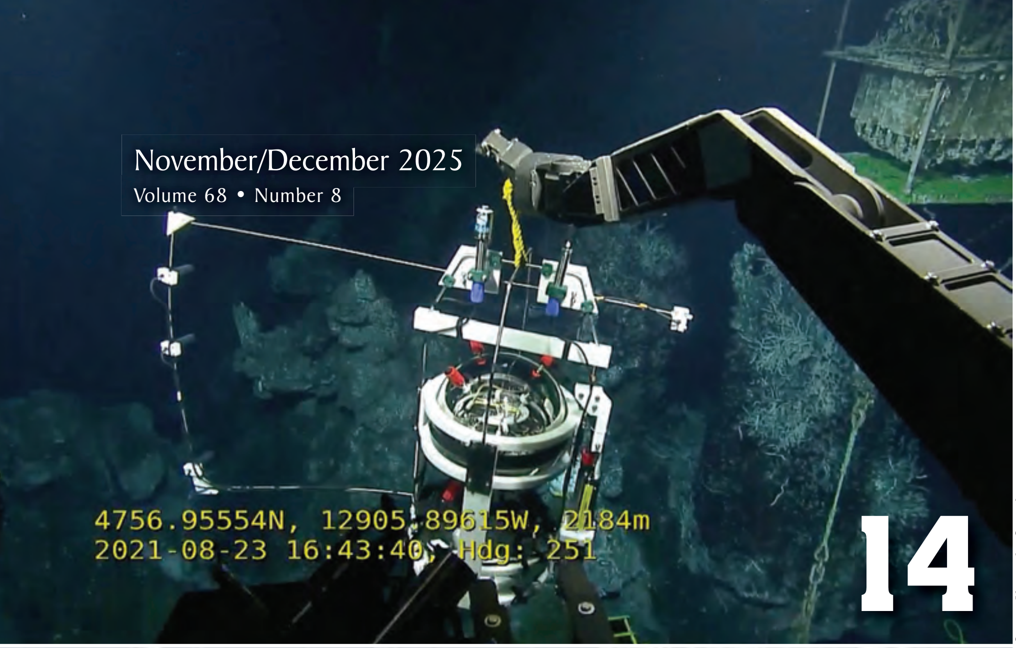

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Editorial

Scan the QR code to access the Marine Technology TV YouTube page:

As the hustle of the *MTR 100* fades, we turn our attention to ocean observation and subsea defense in this issue. We examine the threats to, as well as the technology for, maritime security, and we monitor the seas with cameras and buoys. We seek to recover shipwrecks and to power autonomous and unmanned systems.

Starting on page 8, David Strachan explores multi-domain defense systems—platforms designed for use in the air, on land and at sea. Closely following, on page 12, David Hunt discusses the shortcomings of protecting critical subsea cables from sabotage—despite increasingly frequent and occasionally successful attempts. Page 20 keeps us on the seafloor, exploring the impact of AI traffic on subsea fiber networks.

On page 14, Kevin Hardy brings forth another edition of Lander Labs, in which he tackles the challenges and opportunities for powering autonomous ocean landers.

Page 24 takes us Down Under, where Wendy Laursen explores how Australia is expanding access to wave data with increased buoy deployments and an online portal.

Later, on page 32, we met Dan Vela, vice president - OPG Americas at Oceaneering International, who gives us a peak into offshore operations with a multi-vessel, multi-mission fleet. His full video interview can be found on our YouTube page, **https://www.youtube.com/@marinetechnologytv7446**.

On pages 28 and 36, we explore the shipwrecks of Russian submarine K-129 and the freighters *Henry B. Smith* and *Scotiadoc*, respectively. The latter celebrates the role of underwater camera technology, as does the SYRENE project for invasive fauna monitoring on page 40.

Last, but certainly not least, we celebrate the life of Captain Charles Robert MacVean, USN, (Ret.), PhD on page 44.

Marine technology, as this issue shows, can take us to great depths and unlock lost discoveries, invaluable data and technological solutions. This theme will continue as we head into December, where you'll find our team at Underwater Intervention (alongside the International WorkBoat Show), December 3-5, in New Orleans. We'll be looking for new stories, innovative technologies and cutting-edge research. We'll also be conducting interviews on site—a can't-miss opportunity to share your work with the world while still at the event.

We hope to see you there. As always, please reach out to connect, whether in New Orleans or otherwise. In the meantime, happy reading!

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Credit: HOVERAir

HYBRID THEORY:

Multi-Domain Unmanned Systems are Blurring Maritime Boundaries

***By David Strachan,** Strikepod Systems*

[2031: Somewhere in the Luzon Strait]

Under cover of darkness, an elite team of Navy SEALs reaches an uninhabited island and moves inland. Fifty km out to sea, a flotilla of autonomous underwater and surface vehicles (AUSVs) shifts between the surface and the safety of the deep, keeping a stealthy, unblinking eye on enemy fleet movements and transmitting near-real-time intelligence to USINDOPACOM and the embarked SEALs. From behind the beach, a small amphibious quadcopter takes to the sky, traveling ten km offshore where it descends, lands on the water's surface, and submerges, its onboard acoustic modem broadcasting a single high-frequency message to an object resting quietly on the seabed - NOW. As the drone reemerges and climbs back into the sky, a prepositioned cargo trimaran rises slowly through the water column, breaks the surface, and begins its wind-driven journey toward shore. On reaching the surf zone, SEALs slip from behind the rocks to haul the vessel onto the beach and recover its payload of provisions and power modules before dismantling and concealing it among the weathered landscape. Meanwhile, a flotilla of autonomous low-profile vessels (ALPVs) is inbound from Guam, loaded down with four-ton payloads comprised of modular autonomous air, underwater, and surface vehicles for detecting, tracking, and striking enemy warships.

This scenario may read like a passage from a speculative techno-thriller, but these platforms and capabilities already exist, and are coming to contested waterways around the world. The lines between warfare domains are blurring as a generation of innovative hybrids enters the battlespace. Whether rising from the depths to take flight or diving below the surface to evade detection, these systems are poised to redefine maritime mission sets.

Air to Surface: Where the Sky Meets the Sea

The emergence of unmanned air systems (UAS) with amphibious and submersible capabilities represents a potentially transformative development in maritime defense. Among the most mature of these cross-domain systems is the Naviator, developed at Rutgers University and now marketed by SubUAS LLC. First demonstrated in 2017, the Naviator is a quadcopter drone that can transition from the air to water depths of up to 1000 feet. Its four rotors serve double duty: providing lift and maneuvering in the air, and functioning as propellers underwater. The vehicle has demonstrated missions ranging from bridge inspection to harbor access reconnaissance, and shows potential for mine hunting, hull inspection, and search and rescue. With the ability to dive, maneuver, and return to flight, the Naviator represents perhaps the most battlespace-ready realization of an aerial-aquatic hybrid to date.

Another contender is from Vancouver-based Seahawk Robotics. With its ruggedized, waterproof airframe, the F4 is designed to land, float, and operate on open water for extended periods. Rather than fully submerging, it uses the water's surface as a base for deploying and retrieving sensors using an onboard winch. For navies and commercial operators alike,

THE NAVIATOR DRONE

Credit: U.S. Navy photo by John F. Williams/Released the F4 can provide a rapidly deployable, targeted sensing or communication capability at dramatically reduced cost and logistical overhead.

Some intriguing recreational COTS systems also offer defense potential. Chinese manufacturer SwellPro has carved out a niche with its SplashDrone 4, a self-righting, ruggedized, fully waterproof quadcopter that can fly, land, float on water, and take off again. And then there's the HOVERAir Aqua, a pocket-sized, IP67-rated drone by Zero Zero Robotics, makers of the popular HOVERAir self-flying camera drone. The Aqua can float, stabilize, and even film below the ocean surface in "Snorkel Mode" using its tilting 4K camera. While neither vehicle dives fully beneath the waves, they demonstrate how quickly amphibious UAS are maturing in the commercial space, and could readily be adapted for maritime drone operations.

Surface to Undersea: Piercing the Interface

Imagine an autonomous vehicle that can operate both above and below the ocean surface, combining the persistence and communication advantages of a USV with the stealth capabilities of a UUV. Now imagine it is powered exclusively by wind and solar energy, and can be organized into distributed, high-endurance, attritable fleets for full-spectrum maritime surveillance.

San Diego-based SubSeaSail has spent nearly a decade perfecting just such a vehicle. HORUS is a compact, lightweight, monohull AUSV designed for persistent maritime operations and data collection. A patented, transparent wingsail enables low-signature operations at sea for months without fuel or maintenance, while its ability to submerge to depths of 100 meters allows it to evade detection or adverse weather conditions. Measuring approximately 1.6 meters in length and weighing around 32 kilograms in its base configuration, HORUS can achieve sailing speeds of 0.5 to 2.5 knots under wind power and up to 4 knots using its electric thruster for station-keeping or low-wind transit. With the Defense Innovation Unit supporting the vehicle's transition to contract manufacturing, HORUS represents a next-generation approach to scalable, "disruptively affordable" autonomous maritime systems.

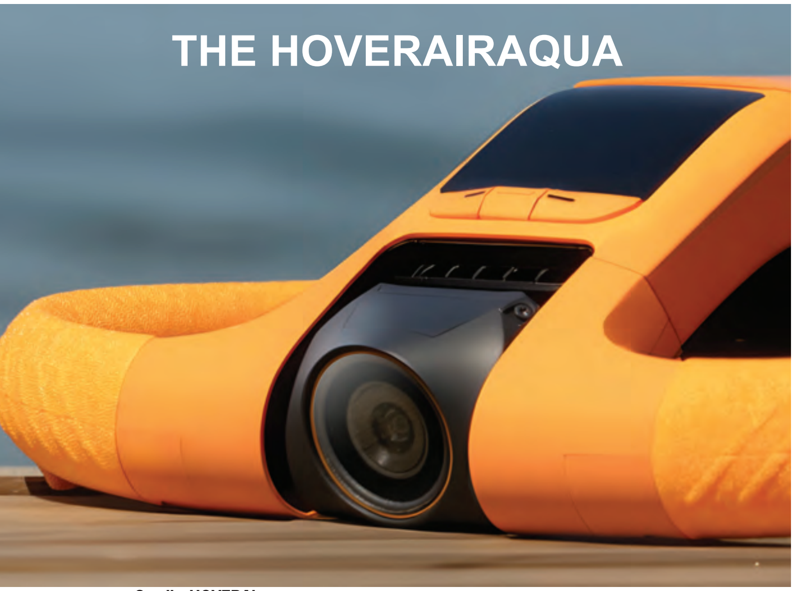
SubSeaSail's HERMES, meanwhile, is a scalable, self-righting, semi-submersible trimaran designed for long-duration surface and subsurface operations, and is envisioned as a cargo and expeditionary power supply platform. Like HORUS, HERMES can submerge to 100 meters to evade detection or ride out severe weather. With speeds of 5 to 15 knots, and large-volume payload space, it offers a high-speed, attritable platform for contested logistics.

Another maritime innovator, Gulfport-based Ocean Aero, has developed a first-of-its-kind hybrid autonomous platform, the Triton. Measuring approximately 4.5 meters in length and weighing 350 kilograms, its folding rigid sail, integrated solar panels, and electric drive enable months-long surface operations or dives to 200 meters for up to five days. In addition to surface surveillance, the Triton's body payload capacity of 23 kilograms (with additional space in the wing and keel) enables underwater survey and intelligence operations, making it well suited for missions such as anti-submarine warfare (ASW), mine countermeasures (MCM), and critical infrastructure protection. The vehicle is designed for one or two-person launch/recovery from ship or shore, and a small logistics footprint allows it to be easily transported and deployed in remote or contested regions.

On the higher displacement end of the spectrum, the Leidos Sea Specter is an autonomous low-profile vessel (ALPV) developed for the U.S. Marine Corps to support distributed operations and contested logistics. Inspired by semi-submersible "narco-boats," the 65-foot diesel-powered craft rides low in the water to minimize visual, radar, and infrared signatures. Designed to carry up to five tons of cargo at speeds of eight knots and ranges exceeding 2,000 nautical miles, it offers a stealthy, attritable platform for clandestine supply chains. A prototype is already undergoing field testing in Okinawa, where Marine Corps Combat Logistics Battalion 31 and the 12th Littoral Logistics Battalion are putting the vessel through its paces.

A Vanishing Divide

The ocean surface is increasingly a flexible membrane through which platforms can transit at will, and as autonomy continues to advance, the distinctions among air, surface, and underwater domains may blur. Future strike groups may be accompanied not only by fleets of heterogenous drones, but an array of clever and capable hybrids - vehicles that can fly, sail, dive, and relay information seamlessly across domains. The erosion of fixed maritime boundaries is underway, and could usher in a more fluid, adaptive, and interconnected battlespace.



Credit: HOVERAir

Credit: SubSeaSail

AN OCEAN AERO TRITON UNMANNED SURFACE VESSEL (USV), LEFT, OPERATES IN THE ARABIAN GULF WITH A SAILDRONE EXPLORER USV DURING A BILATERAL EXERCISE BETWEEN THE U.S. NAVY AND UNITED ARAB EMIRATES NAVY, FEB. 16, 2023.

Credit: U.S. Navy photo by Lt. Jay Faylo

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SUBSEA CABLE SABOTAGE:

Underwater, Underprotected, and Under Attack!

By David Hunt, *Boies Schiller Flexner*

Around the 6th September 2025, 15 undersea cables in Bab el-Mandeb Strait in the Red Sea were severed, resulting in increased latency and widespread disruptions in internet provision across the Middle East and South Asia. As this incident illustrated, modern communications are profoundly dependent on vulnerable sub-sea infrastructure. This comes against a backdrop of increased hostile action against subsea cables, with the UK and Japan both recently announcing measures to secure vital cable infrastructure.

While the most recent damage appears to have been accidental, it further illustrates the deficiencies of the international legal regime for management and protection of these vital assets.

Geopolitical context

The Red Sea is an area of major geopolitical interest. It sits between Africa and Asia, and is surrounded by States who are major players in energy industries. The region is also characterized by geopolitical tension, with Saudi Arabia and Iran vying for supremacy and large external powers like the US and China exercising considerable influence over relations in both Africa and the Middle East. The Houthis, an opposition military group operating from Yemen, have since October 2023 attacked many ships in the Red Sea, prompting speculations that it was they who damaged the undersea cables in question.

Why are cables a prime target for hostile actors?

Undersea cables are major points of interest for hostile actors of both state and non-state varieties for three chief reasons – strategic importance, ease of interference and plausible deniability. First, they are vitally important to States since they are the primary means by which telecommunications are transmitted. This means that a vast range of infrastructural domains depend on undersea cables to function – for example, finance, healthcare, and the media.

Secondly, cables are rather easy to interfere with. Their locations are publicized, largely to prevent innocent unaware ships from accidentally damaging them. They also tend to be unguarded and located at a sufficiently shallow depth that they are reachable without much difficulty.

Crucially, they are also surprisingly fragile – they tend to be constituted by a bundle of glass fibres surrounding a metal core that provides structural support but lack much further physical reinforcement. This ties into the third reason – it is easy for an actor to damage an undersea cable but to then assert that the damage was merely an accident.

Liability: What legal recourse is available?

The existing legal regime provides scant protection to affected States. Historically the leading instrument for protection of cables was the 1884 Convention for the Protection of Submarine Telegraph Cables, to which a limited number of maritime states are party. More recently, the UN Convention on the Law of the Sea 1982 provides additional, but still deficient, protections.

In outline, UNCLOS requires States to enact criminal legislation prohibiting the willful (or culpably negligent) damaging of undersea cables (Article 113). It also provides for compensation to be paid where one cable-owner damages the cable of another (Article 114). This regime presents a number of difficulties:

• Jurisdictional – States do not have universal jurisdiction over the cutting of underseas cables. As a general rule, in the high seas, only the flag State (i.e. the State to which the ship that damages the cable is registered) has jurisdiction to prosecute.

• Scope – UNCLOS does not impose an express international law obligation on states not to deliberately damage or interfere with cables.

• Implementation – in practice States have not implemented the regime – they either have not passed criminal legislation at all or have merely provided for the exaction of monetary fines, surely insufficient to deter the commission of the offence.

The sparse legal framework protecting undersea cables is a hangover from the relatively marginal importance afforded by States to these cables in the eras in which the legal protections were enacted. The vital significance of these cables for modern communications as well as the growth in informal conflict between states demands improvements to the international law regime. Such improvements would include:

• A strengthened jurisdictional regime.

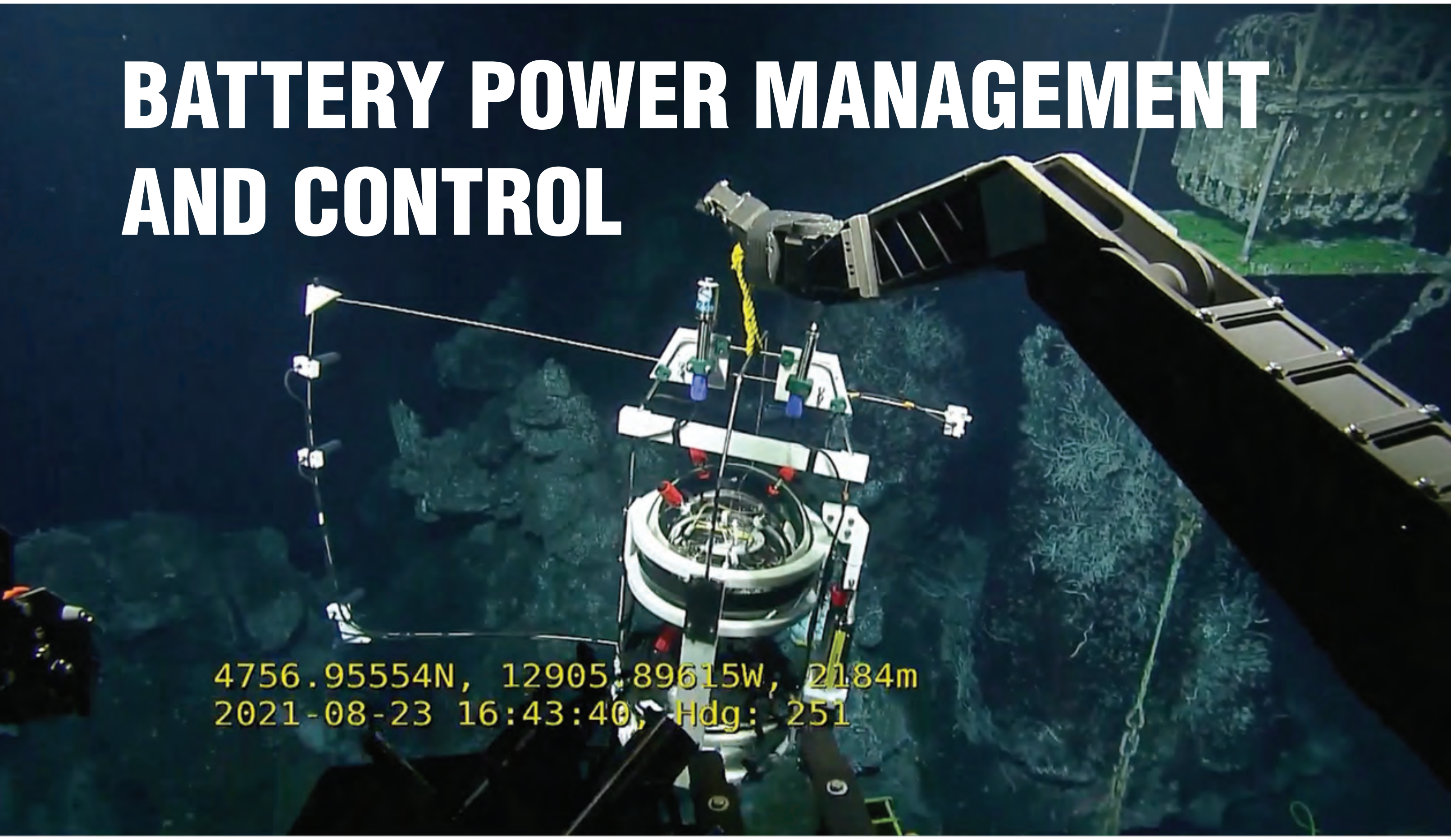
• A clear international law obligation on states not to interfere with cables, with consequences for such interference.

• A strengthened regime for private commercial actors (such as telecoms companies and cable operators) to seek compensation in cases of deliberate damage.

About the Author

David Hunt, partner at Boies Schiller Flexner, specializes in international arbitration, representing clients in complex multijurisdictional disputes, investor-state matters, fraud claims, and high-stakes global enforcement proceedings.

BATTERY POWER MANAGEMENT AND CONTROL



By Kevin Hardy, MTR Columnist, President, Global Ocean Design LLC

The management of DC power is one of the basic challenges in designing an autonomous ocean lander. We can go pretty far down the rabbit hole with this topic. This article is intended to share a few thoughts for the readers' consideration.

We start with a premise. A lever without a fulcrum is just a stick. A fulcrum without a lever is just a door stop. Bring both together and you have a simple machine. Similarly, a sensor or microcontroller without an amplifier is just a novelty. Both must work together to effectively manage power in an ocean lander.

Batteries

Batteries power circuits in autonomous vehicles. Different chemistries have their own issues with self-discharge and loss of capacity driven by low temperature. (See Lander Lab #10, *Marine Technology Reporter*, March/April 2024). Onboard circuits may require different voltages. Critical function circuits, such as the release, should be powered by a "sacred" battery pack, not shared with anything that might inadvertently deplete it.

Charging batteries can be done in one of several ways, including: 1) opening the housing and charging, 2) charging through the end cap, or 3) external batteries that are swapped out using an underwater connector or inductive link.

Charging through the endcap can be easily done with a 4-socket connector. I usually assign pin 1 as battery GND since the industry color code on the #1 wire is black. Other pin assignments flow from that. Pin 1: Battery GND, Pin 2: Battery POS, Pin 3: System GND, PIN 4: System POS. Using only PIN 1 and PIN 2, a mating connector connects a battery

Figure 1 (above)

Ocean Networks Canada's hydrophone and Dalhousie University's Deep Acoustic Lander are used to monitor hydrothermal vents. Brendan Smith and his Ph.D. advisor, Prof. David Barclay, used hydrophones operated by Ocean Networks Canada in the Pacific Ocean and the European Multidisciplinary Seafloor and water column Observatory in the Atlantic Ocean to monitor two vents on the seafloor. *(Photo by Ocean Networks Canada).*

charger directly to the battery. During charging, the battery is disconnected from the circuit it powers. Charge as normal. After charging is complete, the battery is connected to the system using a shorting plug. A shorting plug looks like a dummy plug, but has pins connected inside the overmold: Pin1 to Pin 3, Pin 2 to Pin 4. Some chargers have a thermal sensor that dials back the charging if the battery temperature gets too high due to increasing internal resistance as the battery gets older. This can still be done through the endcap but requires two additional pins (Pin 5, and Pin 6) to connect the thermistor inside the battery to the charger control circuit. I've charged 4 different battery packs with separate chargers through an 8-pin connector. Like a wall plug, I used socket contacts to directly connect to the batteries. A jumper cable brought the power back into the sphere through another 8-pin connector, this one with pins. The jumper cable was essentially an extension cord, pins on one end, sockets on the other.

If battery outgassing is a warranted concern, a PRV (Pressure Relief Valve such as made by Prevco or Deepsea) could be installed, or the purge port opened during charging (be sure to replace the pressure proof cap!), or endcap restraints, such as bolts, removed.

If the system requires a fast topside turnaround, external battery packs are a practical solution. Recover the system, pull the spent batteries, install a fully charged second set, and re-deploy. The first set then goes back on the charger.

Voltage Conversion

Internal to the unmanned ocean lander, a variety of DC voltages may be used, such as 3.3vdc, 5vdc, 10vdc, 12vdc, 21vdc, or higher. Battery discharge curves are never flat, though some are better than others.

Multiple voltage regulators may be used to provide different voltages and constant power levels to separate circuits.

Multiple switching regulators can be wired in parallel to a single battery, as long as the battery is large enough to supply the total demand current. Optocouplers can be used to isolate each circuit from the microcontroller.

Voltage regulators (DC-DC Converters)

There are two types of voltage regulators: 1) Linear or Analog, and 2) Switching.

With power limited to batteries, efficiency is a priority. Linear or Analog regulators have conversion efficiencies of around 40%, so they're out. With a switching regulator, efficiencies between 85-95% are common, while also providing a step up in current output.

There are three types of switching voltage regulators: boost, buck, and a combination boost-buck. A boost regulator can step up a voltage, a buck regulator can step down a voltage, and a Boost-buck will do both.

The simplicity of the buck design makes it more efficient than a boost, so when trying to put every electron to work, stepping down a higher voltage to lower makes sense.

Quiescent current during light-load or standby modes is important to consider when efficiency is a priority. Power to a voltage regulator may also be cycled on a schedule using a microcontroller controlled MOSFET.

Microcontroller

A microcontroller is a programmable computer on a chip that offers intelligent control of a system. They are small and power efficient. Examples include Arduino, Raspberry Pi, ESP32, and others. Power output is limited. An Arduino I/O pin can output 5v @ 20 mA max. Make Magazine publishes an annual Boards Guide that describes dozens of new microcontrollers and single board computers.

Figure 2

The Addicore LM2596 Step-down Adjustable DC-DC Switching Buck converter can drive a 3A load with 90% efficiency, with excellent line and load regulation, thermal shutdown and current limit features. The LN2596 has an addressable minimum low power standby mode of 80 µA. (Cost: $2.48)
(Photo: Addicore)

Figure 3

A MOSFET schematic and 3-lead part in a TO-220 package.
(Photo: Hong Kong Olukey Industry)

MOSFET

MOSFET stands for metal-oxide-semiconductor field-effect transistor. The MOSFET has three terminals: gate, drain, and source. MOSFETs are valued for their ability to control large currents using small gate voltages, their efficiency, and small package size. Some MOSFETs can be switched fully on by 5v (Vgs) logic levels, such as the IRL540 (Cost: $0.77). Amazon sells a sampler kit of logic level MOSFETs for $19. (Search term in Amazon “EEEEE 70 Pcs Logic Level MOSFET”.)

A small electrical signal can turn on LED lights for imaging or a motor in a pump. Great devices to know about. Google “How to Choose a MOSFET” for many good links, including videos. A helpful component selection worksheet may be found at ***https://www.addohms.com/mosfet-guide/***.

SCR

SCR stands for Silicon Controlled Rectifier. Another three lead component, (Anode, Cathode, Gate), normally used to rectify an AC signal, has the interesting characteristic in a DC circuit of behaving like a latching relay. Consider the NTE5455 SCR (Cost $0.80). When a 1.5v pulse is applied to the gate, current begins to flow from the anode to the cathode, and continues to flow even when the gate voltage is removed. Current will flow until the current drops below a certain level, called the holding current, at which point it turns off. A simple, yet reliable, time release is a small lab countdown timer that outputs a 1.5v signal to a piezoelectric beeper. Bring the signal for the beeper to the gate of the NTE5455 instead to start a 10vdc source corroding a burnwire.

Sequencer

Powering up multiple parallel circuits might be challenging due to initial in-rush currents. The TI LM3880 Simple Power Supply Sequencer is a device that controls power up and power down sequencing of three independent voltage rails. By staggering the startup sequence, the instantaneous battery loads are moderated. The robust part is qualified for automotive applications and features a low quiescent current of 25 µA.

Transducers and Sensors

The terms “Sensors” and “Transducers” are sometimes used interchangeably, though there are subtle differences.

Sensors may be required to initiate action by the microcontroller or dedicated circuit.

There are only two types of transducers. Active transducers produce a voltage in response to a change in a parameter.

These include thermocouples, photovoltaic, and piezoelectric. Passive transducers produce a change in resistance (potentiometer, strain gauge, thermistors, reed switch), capacitance (gauges), or inductance (differential transformer) as the response to a change in a parameter.

A sensor detects a specific physical, chemical or biological quantity and converts the value it receives into an electrical signal. Sensors require an amplifier as they are limited to signal level power, often less than 1W. They cannot pass a great deal of power themselves. For power management, use a sensor to control an amplifier circuit: a relay, transistor, optocoupler, or MOSFET.

Reed switch

One of the originals: a reed switch is a magnetically activated switch. It opens or closes depending on the presence or absence of a magnetic field. Because they can't handle much current, it's important to think of a reed switch more as a magnetic sensor than a switch. They are commonly available as SPST and SPDT. They come in a variety of sizes. Smaller units are more sensitive to magnetic fields, but carry the least power. Reed switches have small leakage currents compared

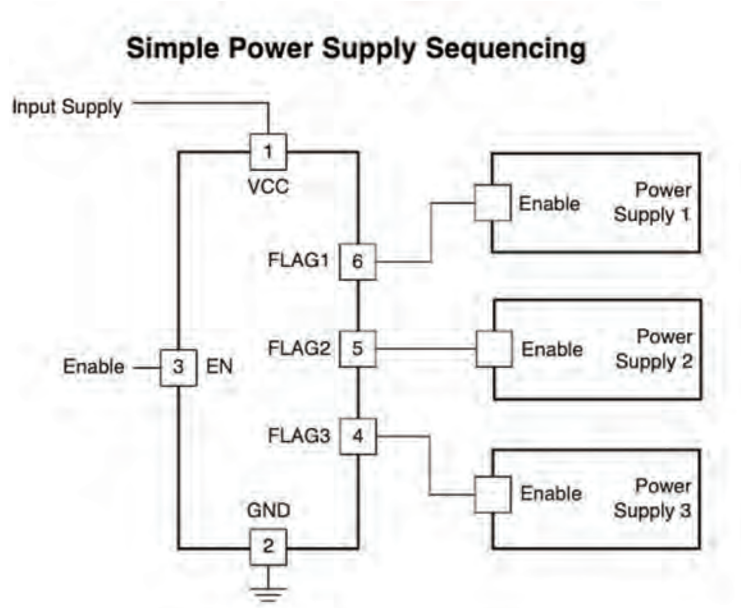


Figure 4

Schematic of the 6-pin TI LM3880 Simple Power Supply Sequencer. (Cost: $1.02)
(Photo: Texas Instruments)

to solid state devices. They have low resistance. The reeds are hermetically sealed within a tubular glass envelope, which will implode with direct exposure to increasing depth. Thus, a reed switch must be placed inside a nonferrous housing, such as plastic, aluminum, or titanium. They can be potted in a hard epoxy for medium depth applications. A circular ring of reed switches can be simultaneously triggered by a single magnet located in the center. Hot switching, switching with maximum power on, can damage the part. As the switch opens or closes, an electrical arc can burn or weld the contacts. As the contact plating is damaged, the resistance will eventually rise until the reed switch no longer works.

Figure 5

Reed Switches come in a variety of sizes and packages, small to large, with different power, switching voltage and current ratings. A better design uses these to control a MOSFET to handle the real power.
(Photo: Littelfuse)

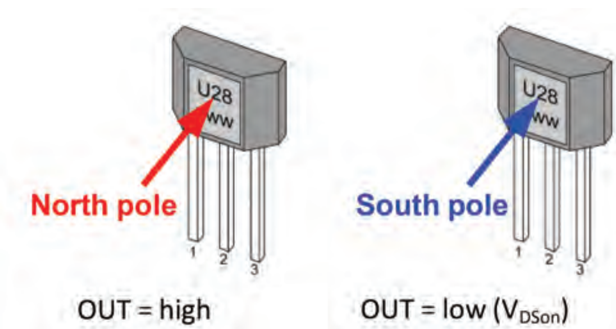


Figure 6

A bipolar Hall Effect Switch acts like a latching relay.
(Photo: Melexis)

Hall Effect Sensor

A Hall Effect sensor is another magnetically activated switch. They produce a low signal level and require amplification. Its output is controlled by the presence or absence of a magnetic field. Like a reed switch, a Hall Effect sensor can be operated inside a nonferrous housing, such as plastic, aluminum, or titanium.

Because the Hall Effect sensor is a solid-state device, it is not prone to breakage, mechanical wear, and is pressure tolerant. A Hall Effect sensor can be potted and operated in a high-pressure water environment.

Hall Effect sensors are sensitive to higher temperatures, but generally not within the range most ocean landers will see. Higher temperature variants are available.

Hall Effect sensors come in two flavors: Unipolar and Bipolar. Each have uniquely useful characteristics.

Unipolar Hall Effect sensors act like a SPST switch. The Unipolar Hall Effect switch is normally closed. The part can be selected to be sensitive to either a north or south pole magnetic field. Exposing the part to the opposite magnetic polarity does not affect the output state. (ref: Melexis US5881, Cost: $0.60))

Bipolar Hall Effect sensors act like a latching relay. They can be selected to latch open with a north or south pole magnetic field. The opposite magnetic field will latch the bipolar Hall Effect switch in the closed state. (ref: Melexis US2882, Cost: $0.63)

Microswitch, Momentary On-Off

A microswitch is a miniaturized mechanical device. The momentary on-off push button type can be used to determine position limits of components, such a piston in a bore. The smaller the switch, the smaller load it can handle.

Other sensors include Light, temperature, salinity, and vibration.

Experimenters Workshop

For those interested in tinkering with the parts discussed here, consider some of the components and kits offered by ***SparkFun.com***, ***Adafruit.com***, ***Makershed.com***, and ***Addicore.com***, among others. Some are under a dollar or two. Practice makes perfect, or at least gives room for thought.

Future developments

New pressure tolerant and pressure protected battery technologies are being developed for marine applications. Likewise, globally, sensor engineers are investigating, characterizing, and developing new sensors to translate the marine environment into a digital equivalent for scientific investigation, machine control, and government oversight.

Invitation to Readers

Would you like to share your insights on this topic? We'll publish some of the best replies we'll get to the questions below.

1. Can an Op Amp be used as an amplifier for a sensor? Are there advantages? Explain.
2. Can an Optocoupler be used as an amplifier for a sensor? Are there advantages? Explain.
3. Can an Accelerometer be used to indicate, internal to the command/control sphere, when an ocean lander has reached the seafloor? Explain.

Acknowledgements

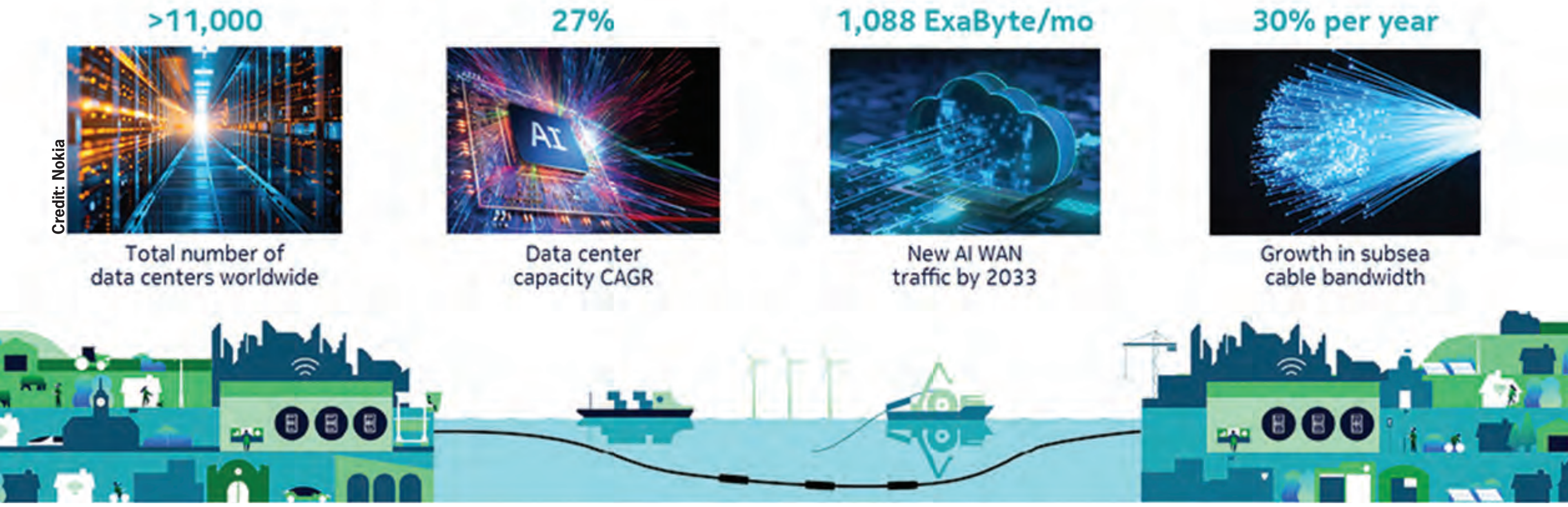
"Fundamentals of Transducers," R.H. Warring and Stan Gibilisco, (ISBN 0-8306-1693-4)

"Practical Electronics for Inventors," Paul Scherz, Simon Monk, (ISBN 978-0-07-177133-7)

"The Art of Electronics," Horowitz and Hill, (ISBN 978-0-52-137095-0)

"Lander Lab" is a hands-on column of Ocean Lander technologies and strategies, a unique class of unmanned undersea vehicles, and the people who make them. It is meant to serve the global ocean lander community in the manner of Make Magazine and other DIY communities. Comments on this article, or suggestions for stories of interest to other Landereans are welcome. Ocean lander teams are encouraged to write in about their work. Please feel free to contact Kevin Hardy <**khardy@marinelink.com**>.

Figure 1



Credit: Nokia

THE IMPACT OF AI TRAFFIC ON SUBSEA FIBER NETWORKS

By Serge Melle, *Nokia Optical Networks*

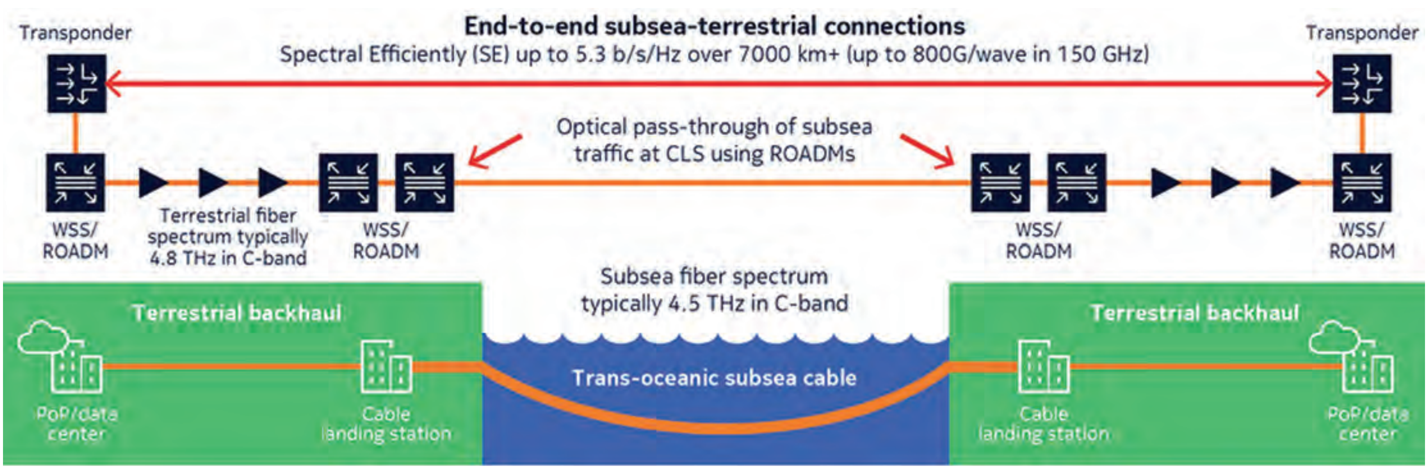
Fiber optic networks provide the connectivity ubiquitous to modern society, enabling financial transactions, business critical traffic, national defense, entertainment, and personal interactions across the globe. Optical fiber extends to homes, businesses, and 5G radios in metro networks, connects cities within countries, and countries within continents. Subsea fiber cables spanning seas and oceans extend that connectivity between continents.

The massive data-carrying capacity of optical fiber has led to wide deployment of subsea fiber cables. Today, over 570 in-service subsea cables carry more than 99% of all international traffic and connect data centers around the globe to deliver cloud-based and emerging AI services.

A massive global data center build-out is currently underway to satisfy the compute needs of AI training. These build-outs are being led by hyperscale, neo-cloud, an AI companies, all of whom are seeking to develop market-leading AI models, agents, and applications that seek to transform work and so-

Figure 2

Optimizing subsea-terrestrial networking by connecting wavelengths end-to-end between data centers using optical pass-through at cable landing sites.



Credit: Nokia

ciety. These data centers will house ever-larger clusters of inter-connected GPUs, which serve as the engines for machine learning and AI training.

Modern AI training and large language models (LLMs) require a "scale-up" design, where thousands of GPUs function as a single logical unit, with the bandwidth needed to interconnect these GPU clusters soon exceeding 1 Pettabit per second; multiple orders or magnitude greater than the server-based internet traffic of traditional data centers.

While the interconnection bandwidths needed within a data center explode for both "scale up" and "scale across" requirements to increase GPU training clusters, what impact will this will have on inter-DC bandwidth, and across trans-oceanic subsea cables?

Some of these increasing bandwidth requirements will bleed into metro data center interconnections (DCI), as limits on maximum DC size and improvements in training protocols require, and enable, connectivity for AI training to be distributed across multiple DCs using "scale-across" architectures.

Beyond the metro, the roll-out of AI applications delivered from data centers to global end-users will drive even more global subsea capacity and connectivity. Nokia Bell Labs is forecasting that global AI wide area network (WAN) traffic will add one Zettabyte/month of capacity by 2033. In terms of annual bandwidth growth, this represents a continuation of the recent industry trend of approximately 30% per year growth in bandwidth transmitted over subsea cables.

More fundamentally, however, the continued growth in cloud-based services, augmented and accelerated by new AI services, is leading to fundamental changes in both the players involved and the network architectures optimized for global end-to-end subsea terrestrial networks. This article will describe these dynamics, and what changes are occurring in subsea networks.

Taking a step back in time to 1866, when the first practical trans-oceanic copper cable was put into operation connecting Ireland to Newfoundland, Canada, one sees that the cable landing station (CLS) performed a key role, with an operator detecting the trans-Atlantic telegraph signal, which was then handed off to another telegraph operator to re-transmit over terrestrial copper cables to New York City or London.

Fast-forward 150 years to the mid-2010's, and trans-oceanic cables evolved from copper to fiber. The dominant operators of subsea networks were international communications service providers (CSPs) and bandwidth wholesalers, who led the deployment of new cables, or participated in cable consortium for cost-sharing of these expensive infrastructure projects.

While data rates had increased tremendously since 1866, from approximately 8 words per minute to 12Tb/s per fiber pair, little had changed in the CLS architecture. Subsea traffic continued to be terminated at the CLS with transponders, to then be connected via back-to-back client interfaces to another set of transponders, which re-transmitted the subsea traffic to its ultimate destination over a terrestrial backhaul network.

But today's cloud and AI- based data traffic is different. Firstly, for the past decade or more, the majority of new subsea fiber cable build-outs have been led by hyperscalers, to support the large traffic demands between data centers spread across different continents. With that, traffic across subsea cable s does not originate or end at a CLS; it flows end-to-end between data centers that may be located meaningful distances away from a CLS. One impact of this for subsea networks is that DC operators are increasingly optimizing their subsea-terrestrial networks end-to-end, encompassing everything between the data centers at each end.

This leads to a change in the network architecture, where back-to-back transponders at the CLS are removed, and subsea traffic is transparently passed through in the optical domain to directly to the terrestrial network fiber, all the way to the data centers (**see figure 1**).

This optical pass-through of subsea wavelengths is enabled using the latest generation of multi-degree reconfigurable optical add/drop multiplexers (ROADMs) supporting subsea-optimized features, such as amplified spontaneous emission (ASE) spectrum power insertion into the subsea fiber, spectrum sharing, and optical channel monitoring, while also supporting the features needed for terrestrial networks.

Optical pass-through at the CLS sites eliminates two-thirds of the transponders needed for end-to-end connections, and reduces power and space usage at the CLS, where these are often at a premium. While the extra backhaul distance may marginally reduce the maximum data rate of each connection, this is partially offset by the performance of the latest generation of 140 GBaud coherent optics.

Thus, a CLS-to-CLS connection at 800Gb/s per wavelength across the Atlantic will be able to achieve an end-to-end speed of 700Gb/s when connecting to the data centers at each end of the subsea-terrestrial link. This end-to-end optimization provides important benefits to hyperscalers and AI companies that control both the subsea and terrestrial fiber routes that connecting their data centers.

The growth in cloud-based and AI services also implies global coverage and reach, balancing the fact that foundational AI models and training occurring in one region will be delivered via inferencing to other regions or continents. Overlay with that with national data sovereignty requirements and regulations related to network ownership, and oftentimes, a hyperscaler or AI service provider may need to partner with local network operators to provide terrestrial backhaul connectivity from a subsea cable to data centers in other countries.

This terrestrial backhaul connectivity from a CLS to a data center is often provided by a Managed Optical Fiber Network (MOFN) provided by a local CSP, which can sometimes come at high cost if extending subsea wavelengths across the terrestrial network requires as many fibers for the backhaul as exist in the subsea cable.

An alternative end-to-end optimization leverages the use of additional bands in the terrestrial backhaul fiber spectrum, such as C+L or Super C+L, to enable more wavelength division multiplexing (WDM) channels (**see figure 2**). While a subsea fiber typically provides 4.5THz of WDM spectrum, C+L supports 9.8THz and Super C+L supports 11.6THz, or 2.5x more than the subsea cable.

Combined with coherent wavelengths on the backhaul fiber operating at higher data rates than on the subsea fiber due to shorter distances, leveraging C+L or Super C+L WDM can reduce the number of backhaul fibers needed by 50-75% compared to the number of subsea fibers, providing significant overall savings for leased backhaul capacity.

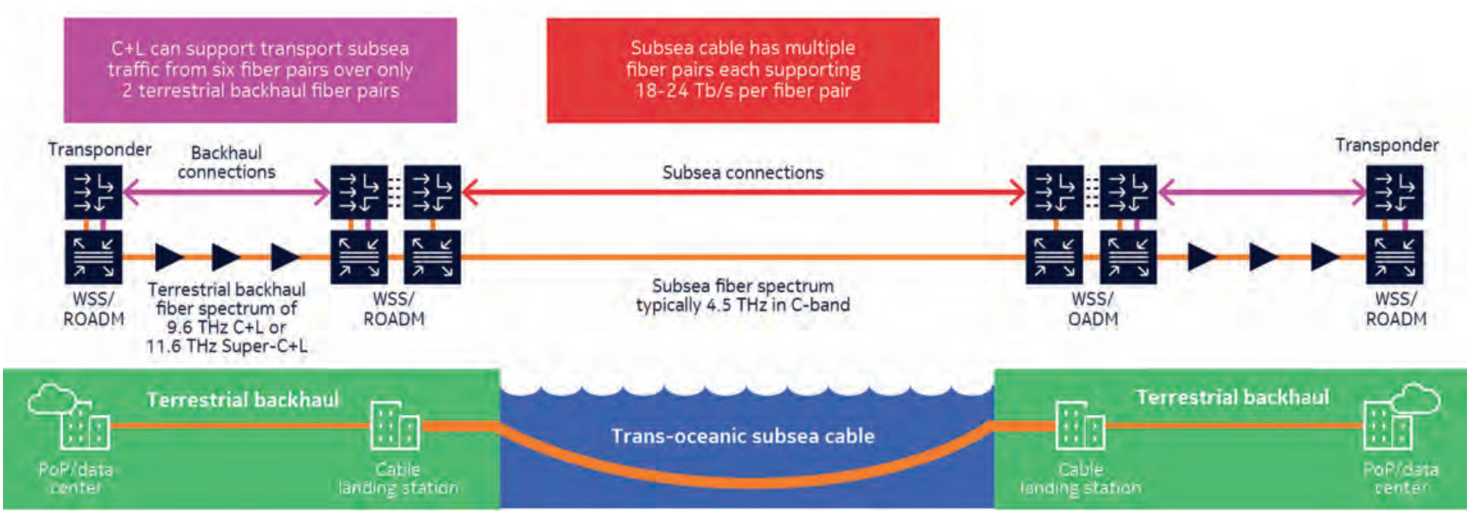
Operators can complement the end-to-end network co-optimizations described above by using a common transport solution across their subsea-terrestrial networks. This can. in turn, deliver more than lower costs and the operational simplicity of common spares, training, and management; it also unlocks the benefits of end-to-end automation to plan, optimize, turn-up, and monitor the network.

Network automation can help reduce operational costs and enable faster turn-up of end-to-end subsea bandwidth, leveraging zero-touch commissioning tools to automate subsea channel optimization and service configuration, reducing the manual time and effort needed to turn-up traffic, while also ensuring optimal performance and resource usage.

The well-used expression “it’s a small world” takes on a new meaning in today, where AI applications will permeate the globe. Ensuring cost-efficient and ubiquitous global connectivity and providing equitable access to new AI-based applications will help bring people, cultures, and societies together across continents; more than ever enabled by the fabric of end-to-end subsea terrestrial networks.

Figure 3

Reducing the cost of subsea traffic backhaul by using more WDM spectrum in the terrestrial network using C+L.



Credit: Nokia

Source: UWA

AUSTRALIA OPENS A WAVE DATA PORTAL

Australian researchers are expanding the availability of wave data with more buoy deployments and a freely-accessible online portal.

By Wendy Laursen

Nearly 90% of Australians live within 50 kilometers of the coast, and Australia's State of the Climate Report 2024 found that the nation's weather, climate, and ocean conditions continue to change. Rising sea levels pose a significant threat to coastal communities and coastal ecosystems by amplifying the risks of coastal inundation, storm surge, erosion, and saltwater intrusion into groundwater systems.

For most of Australia, coastal floods that currently occur occasionally are predicted to become chronic later this century. Extreme sea levels that had a probability of occurring once in a hundred years are projected to become an annual event.

Oceanographers from The University of Western Australia (UWA) are supporting science-based management of coastal resources by expanding the use of ocean buoys for recording wave data and making it freely-available. Most recently, they have advanced wave forecasting capabilities by deploying a fleet of 10 drifting wave buoys in the Southern Ocean between the Western Australian coast and South Africa. These small, solar-powered wave buoys are expected to float in ocean currents and collect wave data for several years.

RESEARCH FELLOW MARZIEH DERKANI AND PROJECT LEAD AT TIDE DR JEFF HANSEN WITH ONE OF THE DRIFTING BUOYS.

Images this page: UWA

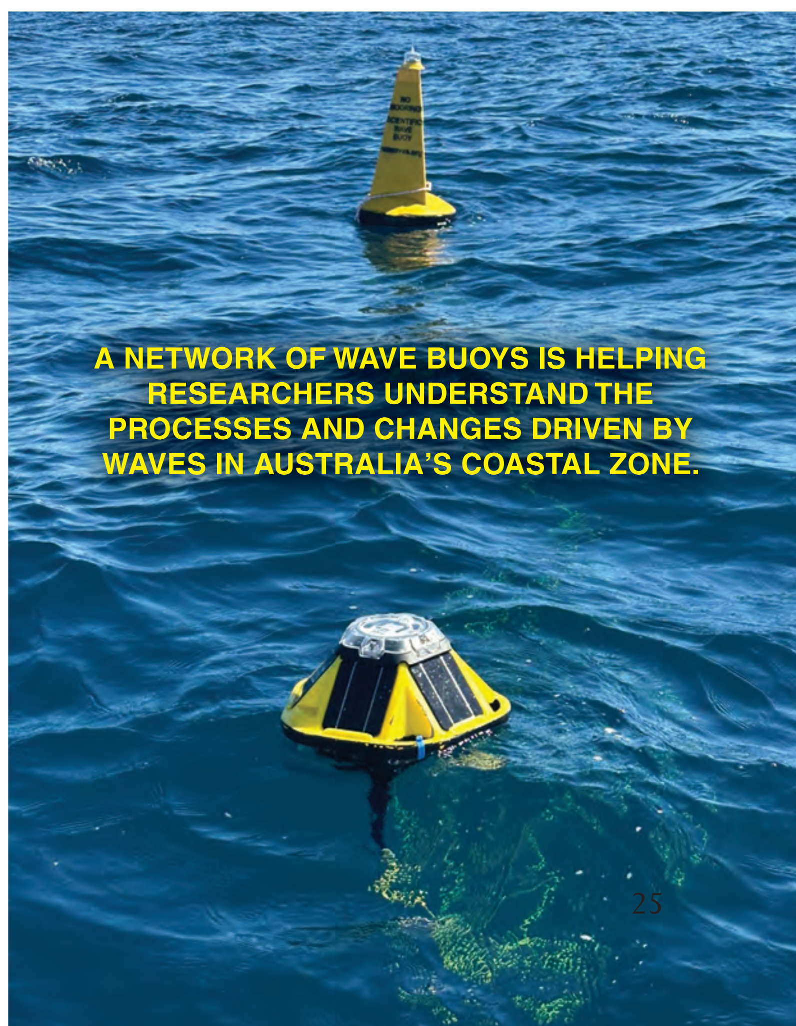
They provide data crucial for forecasting wave and swell conditions, says Dr Jeff Hansen. "These new low-cost wave buoys now make it possible to collected detailed wave data, in real-time, from the middle of the ocean, where historically we haven't had observations of waves. This allows us to compare and feed these data into wave forecasting models to improve their accuracy, something we're working on with the Bureau of Meteorology."

Wave forecasting models lag behind atmospheric models in terms of accuracy partly due to the lack of data assimilation, a technique where observations are used to adjust models to better match actual conditions.

"If the starting point is wrong, the rest of the forecast is likely to be wrong," says Hansen. "Forecasting is inherently difficult as errors often compound in time leading to incorrect forecasts, but by using observations and data assimilation we can improve the starting point of each seven to ten -day forecast produced several times a day."

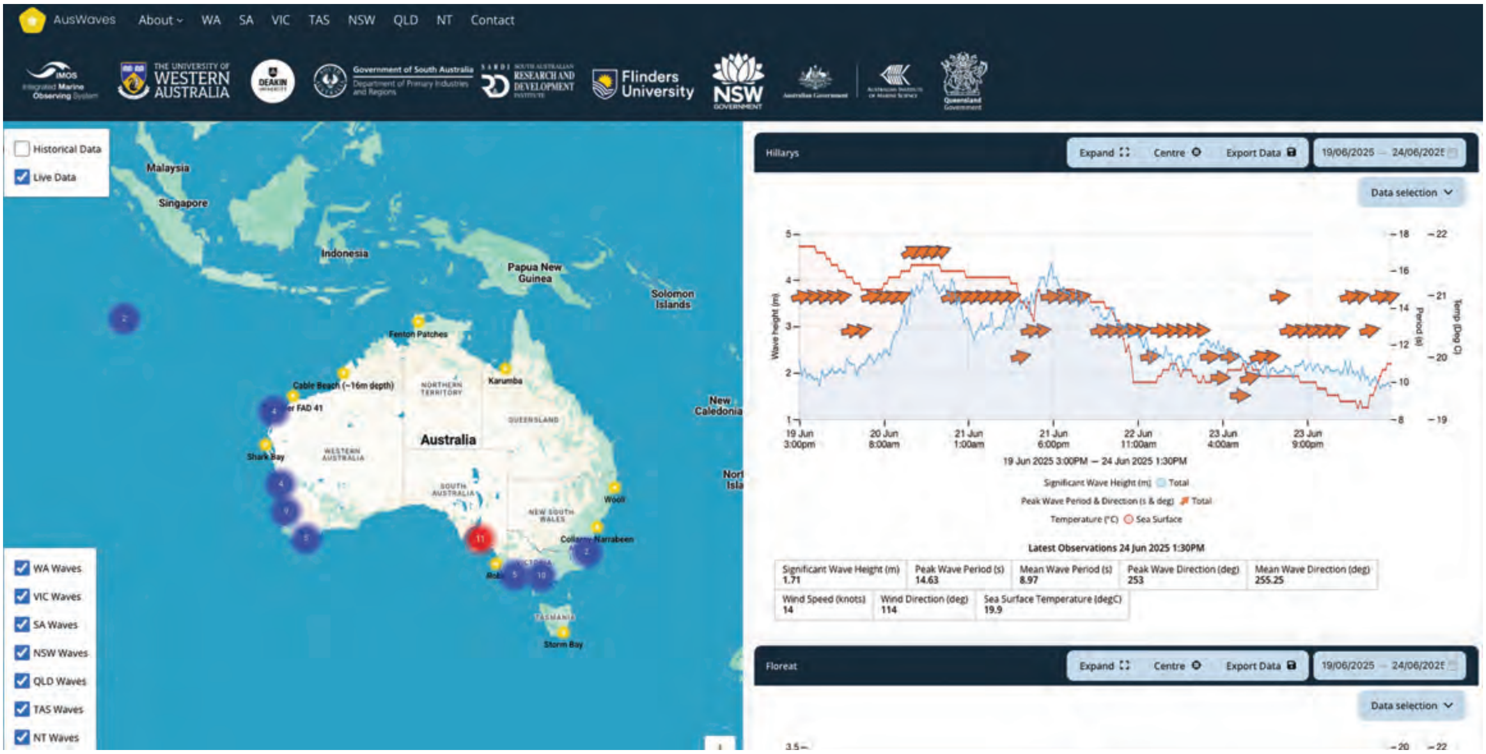
The data from UWA's drifting and moored wave buoys will soon be available to the World Meteorological Organization Information System 2.0 (WIS 2.0) which became operational this year. WIS 2.0 is already enhancing the accuracy of weather forecasts globally and supporting early warning systems, as it provides a framework that enables international, regional, and national real-time data sharing.

The drifting buoys are part of a larger wave buoy network



A NETWORK OF WAVE BUOYS IS HELPING RESEARCHERS UNDERSTAND THE PROCESSES AND CHANGES DRIVEN BY WAVES IN AUSTRALIA'S COASTAL ZONE.

NEAR REAL-TIME WAVE DATA IS AVAILABLE ON A NEW WEBSITE: AUSWAVES.ORG



operated by the university consisting of either Sofar Spotters, Sofar Smart Moorings, or Datawell Waverider Mk4 units. This network is currently supporting a range of research projects focused on improving wave forecasting, coastal dynamics along reef-fronted coasts, marine heatwaves, wave energy development, and the long-term Western Australian wave climate.

With investment from Australia's Integrated Marine Observing System (IMOS), Dr Mike Cuttler and Professor Ryan Lowe recently deployed 23 new wave buoys at coastal sites around the country, with at least one new wave buoy in every state. The buoys measure wave height, period, and direction as well as water temperatures in nearshore waters, with sites varying in depth from 10 to 70 meters.

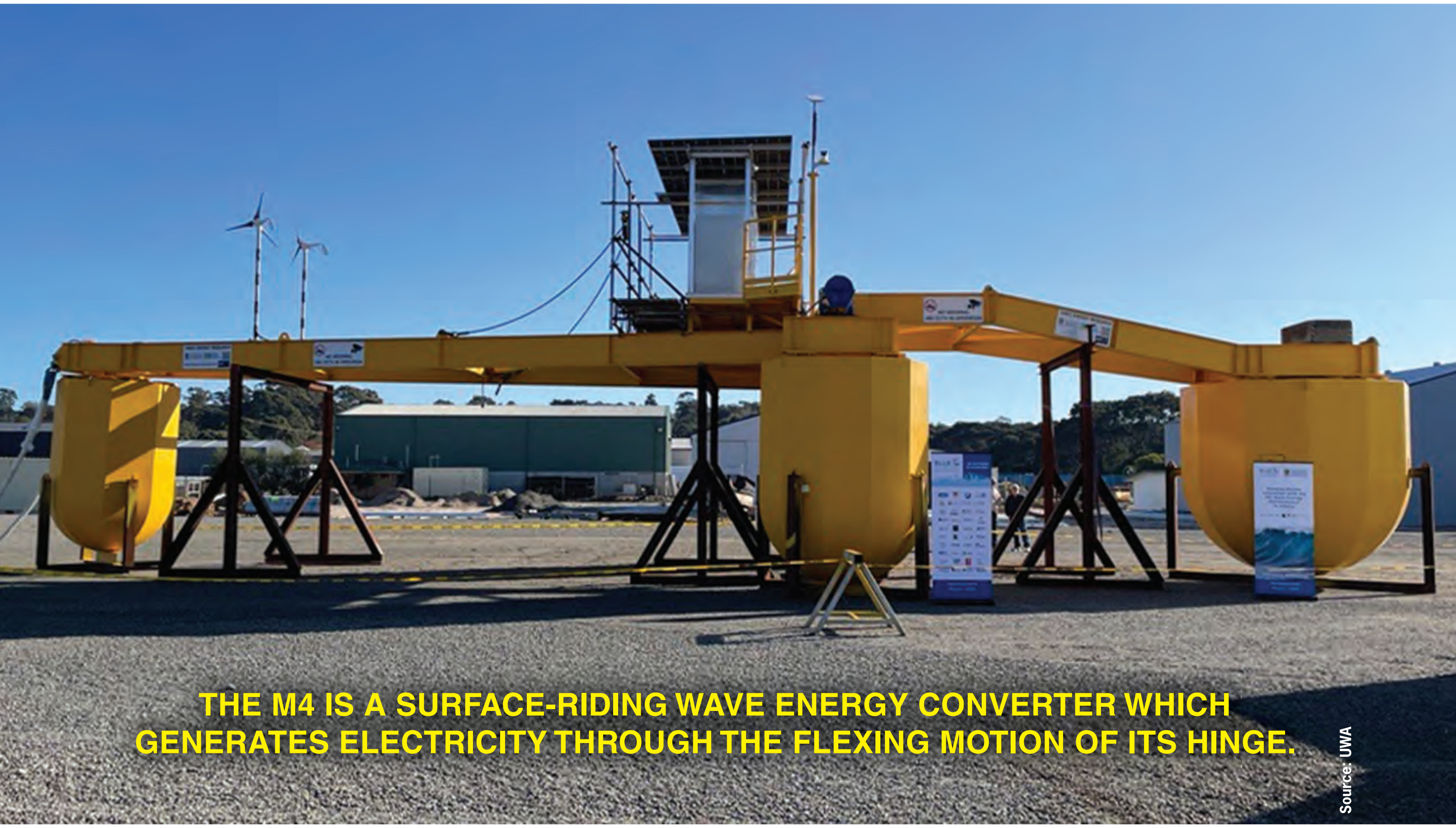
Like their drifting counterparts further from shore, these small, solar-powered wave buoys are low-cost and relatively easy to deploy. Moored to the sea floor they collect critical near real-time data required to verify and improve marine forecasts, inform marine operations and recreation, and form the basis of an improved understanding of ocean and coastal processes.

The near real-time data is easy to view and download via a new national website, **AusWaves.org**, which was created by Cuttler and Hansen to collate data from all of UWA's wave buoys and merge it with existing websites created by regional partners to provide access to the first nationally consistent platform for the display of quality-controlled near real-time wave data.

Cuttler says the AusWaves website presents unique coastal wave data in a user-friendly manner, designed to meet the needs of a wide range of coastal stakeholders. "Through visual displays and the ability to download wave and surface temperature data, this new website will enable wider uptake of the data around Australia," he said. "We aim to enable all those dependent on the ocean, including aquaculture, tourism operators, local fishermen, and surfers, to better prepare and be safe out on the water."

The university is also developing a unique way of harnessing wave energy for renewable power generation. There is immediate potential for renewable energy development, as the world's largest and most consistent wave energy resource is along Australia's southern coast, says Dr Hugh Wolgamot from the university's Oceans Institute. The average power of the ocean waves crossing the perimeter of Australia's continental shelf is estimated at about 10 times Australia's average rate of electricity consumption.

"Persistent strong winds along the vast Southern Ocean create large waves which bring renewable energy towards the shores virtually continuously," Wolgamot said. "The south and south-west mainland coastline and the south-west coast of Tasmania in particular experience the highest wave power levels, with exceptionally high-quality waves, with minimal


THE M4 IS A SURFACE-RIDING WAVE ENERGY CONVERTER WHICH GENERATES ELECTRICITY THROUGH THE FLEXING MOTION OF ITS HINGE.

Source: UWA

intermittency and relatively small extremes — two characteristics essential for uninterrupted energy production."

A project is underway to use a "Moored MultiMode Multibody" (M4) device to validate modelled predictions under the leadership of Wolgamot. The M4 is a surface-riding wave energy converter which generates electricity through the flexing motion of its hinge. When the back and front of the 24-meter device are at the crest of the wave, the center is at the trough. The resulting rotational movement of the parts is converted into electricity by an onboard generator.

This year's M4 deployment in King George Sound in southern Western Australia was a world-first trial at scale designed to demonstrate the technical feasibility of harvesting ocean waves in Australia and to generate operational data for researchers and industry. The project is fully open-source, so data is being shared with scientists, energy developers, and the community.

A PROJECT C
AZORIAN:
DOING THE ‘IMPO

The Glomar Explorer off Maui after the recovery mission.

Credit: David Pasho

By David Pasho

More than fifty years ago in March 1968 the US Navy observed a massive Soviet naval and air search in the North Pacific Ocean. The USN monitored the search over the next few months and concluded the Russians lost a submarine and were unable to find her. Using acoustic records from listening stations in the Pacific, the Navy discovered an explosive event that occurred just before and in the same area where the Soviet's were looking. The Navy deployed a specially equipped spy submarine to secretly search the seabed where the event occurred and found and photographed the wreckage of the Russian submarine K-129 that rested on the seafloor of the North Pacific Ocean.

The K-129 was a diesel electric Golf II-class Soviet submarine armed with nuclear tipped ballistic missiles. The large intact portion of her wreckage included one ballistic missile with its warhead, the submarine's sail where top-secret code equipment and documents would be found, and her bow section with nuclear torpedoes. It would be an amazing intelligence coup if the US could secretly recover the submarine. The problem was that it lay on the bottom of the North Pacific Ocean at a depth of sixteen thousand feet. But, the Central Intelligence Agency came up with an audacious plan to recover the submarine without the Russians knowing. It became a top-secret project code named Azorian.

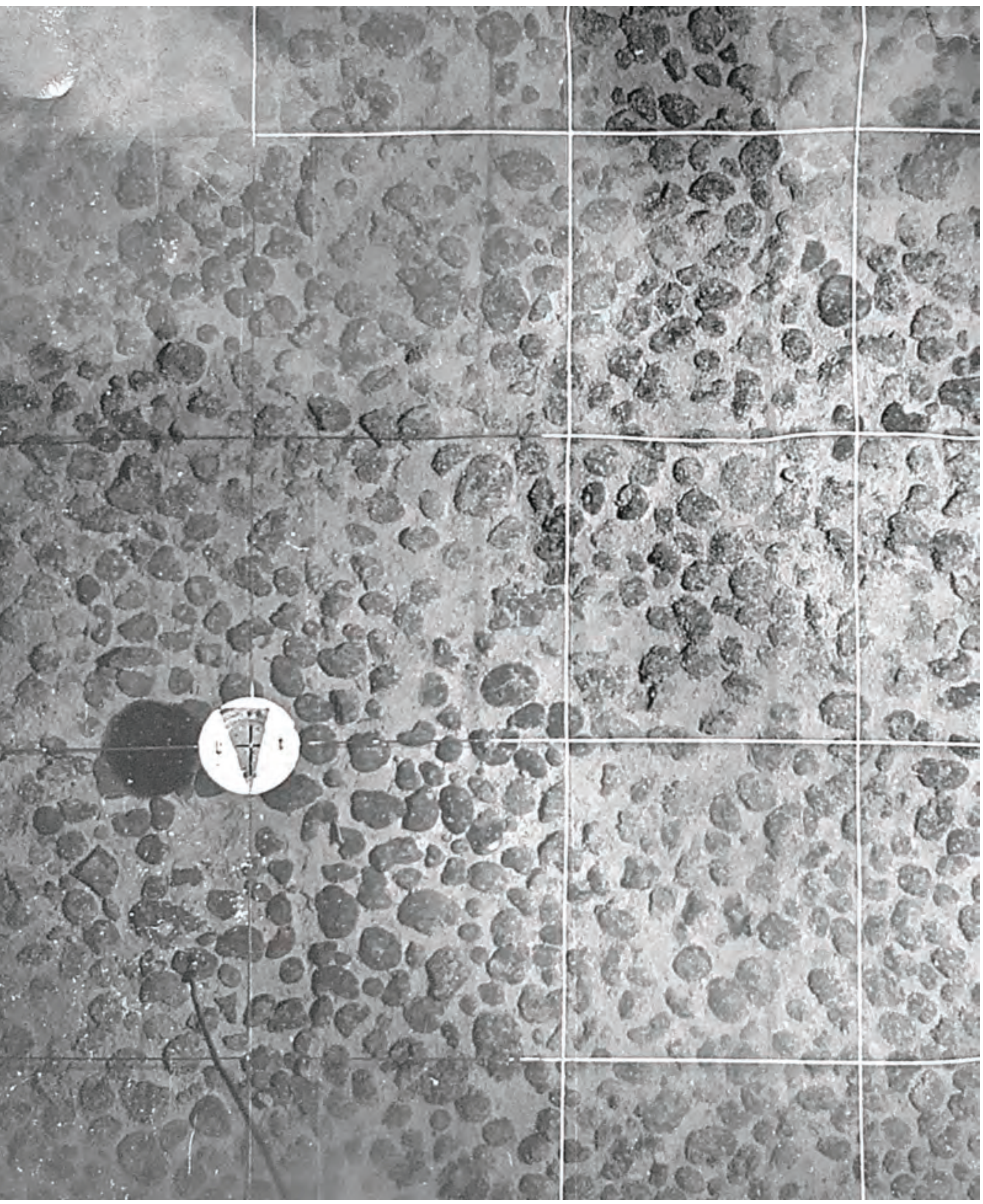
How to Secretly Recover the Submarine

Initially, a Navy special projects group proposed using small, unmanned vehicles to recover selected components that had particular intelligence value. However, the Chief of Naval Operations wanted to recover the whole submarine, and the Defense Department turned to the Central Intelligence Agency and asked if they could come up with a way to secretly pick up the forty-million-pound section of the submarine from a depth of three miles.

The challenge was accepted by the "wizards" of the CIA's Science and Technology Directorate who developed the first intelligence satellites and the high-altitude U-2 reconnaissance spy plane. Although the group had near zero knowledge or experience in ocean technology, they came up with a plan to use a giant surface ship to lower a three-mile-long pipe string with a claw or capture vehicle on the end to grab the submarine and raise it to the surface.

Aside from the extreme technical challenge, they would have to do it without the Russian suspecting what they were doing. To hide the real purpose of Azorian, the CIA developed an elaborate cover story that the Project was a commercial venture to mine mineral deposits called manganese nodules that were found on the deep seabed of the Pacific Ocean (below). At the time, a number of companies were beginning to explore for manganese nodules that some claimed would displace existing land mines as the primary source of nickel, copper, cobalt, and manganese. The cover story explained the ship as a deep ocean mining vessel that lowered a mining machine to the seabed on a long pipe string where it would collect nodules and be raised back to the mining ship when it was full.

The CIA recognized that there could be no overt U.S. Government involvement without attracting close Soviet scrutiny and learning the actual purpose of the Project. Howard Hughes agreed they could use his Hughes Tool Company in Houston, Texas as the front for a commercial deep ocean mining operation. The company was ideal because it was privately owned, had no shareholders, was financially capable of funding the project and Hughes habitually operated in secrecy and was known for his personal eccentricities and speculative investments.



Bottom photograph of manganese nodules in the central Pacific taken through a one-foot square wire grid during a seabed survey.

Credit: David Pasho

The Ship and the Capture Vehicle

The surface ship was built by Global Marine and named the Hughes Glomar Explorer. She was designed by John Graham, Global's chief naval architect, and later recognized as nothing short of an engineering marvel. The engineers did calculations on slide rules, plans were drafted using pencils, erasers, T-squares, triangles, and drafting paper to produce blueprints. Specifications were handwritten in cursive and typed on manual typewriters.

At first glance the Explorer appeared to be similar to a supersized offshore oil and gas drilling vessel with a derrick to lower and raise the pipe string, a moon pool under the derrick for the pipe to pass through, a pipe handing system and thrusters to keep the ship on station over a specific location on the seabed. The Explorer displaced over fifty thousand tons, weighed more than the battleship Missouri, was over six hundred feet long, had a beam of over one hundred feet, and a derrick that was over twenty-four-story high.

The heavy lift system needed forty-eight hydraulic pumps; the derrick and lift system sat on a base that used sixty-five-inch air springs; the largest gimbled bearings ever built were used to isolate the system and the derrick from the ship's pitching and rolling motions; and, two long docking legs on either end of the moon pool to stabilize the submarine when it was raised into the moon pool that was two hundred feet long, seventy-five feet wide and sixty-five feet high.

The capture vehicle, designed and built by Lockheed, was one hundred eighty-foot-long, fifty-eight foot wide. It was nicknamed Clementine after the daughter in the song about a miner, forty-niner who was excavating for a mine. To minimize the weight, the sections of the pipe string were tapered, and the capture vehicle was made up of individual high strength steel tines or davits attached to a long central beam or strong back.

Acoustic sensors, closed circuit tv cameras, and propellers driven thrusters on the capture vehicle were used to position it over the wreckage of the submarine. The large hydraulic cylinders at each corner of the capture vehicle would support it on the seabed while the davits were driven under the submarine using water jets to help them penetrate the sediment. Once the davits cradled the submarine, the cylinders would be extended, pull the submarine out of the sticky sediment and left behind as the submarine was lifted off the seabed.

The collector vehicle was assembled out of sight in a huge specially built barge so no one would get even a glimpse of what it looked like. Named the Hughes Mining Barge, it was about three hundred feet long, one hundred feet wide, one hundred feet high and still holds the record as the world's largest submersible structure. It had a retractable roof and was submerged in shallow water while the Explorer was positioned over the barge and the capture vehicle was lifted into the Explorer's moon pool without being observed. Once the submarine was recovered, it was intended that the process would be reversed and the capture vehicle with the submarine would be lowered into the submerged barge.

The Mission

The Explorer arrived over the wreckage of the K-129 in the North Pacific on July 4, 1974. Because of bad weather it was mid-July before the Explorer began to lower the capture vehicle to a depth of sixteen thousand two hundred feet and position it over the submarine. When the davits were extended under the submarine they encountered higher than anticipated resistance but were successfully extended. Once cradled, the capture vehicle's hydraulic breakout legs were extended and the K-129 broke free of the seabed on August 1. A few days later when the submarine had been raised to about three thousand feet above the seabed, the heavy lift system lost a tremendous amount of weight. A large part of the K-129 was lost and sank back to the seabed. While on site, Soviet intelligence vessels watched, harassed and questioned what the Glomar was doing but did not interfere the recovery operation having concluded the Americans were looking for oil.

After reporting the loss of most of the submarine, the Explorer was instructed to go to a location off the west coast of Maui where the B crew would relieve the A crew. On the way, the A crew began to exploit the forward section of the submarine and carried out a formal burial at sea of several Soviet seaman found in what was the K-129's torpedo room.

When the Explorer anchored off Maui in August, the B Crew relieved the A Crew and finished exploiting the forward section of the K-129. A small group of engineers who worked with John Graham met on the fantail of the Explorer at sunset and released his ashes into the Pacific Ocean. It was the last request of the man responsible for what was arguably the most impressive feat of marine engineering in the twentieth century.

Patch worn by A and B crews of the Hughes Glomar Explorer for Project Azorian.

A Second Mission was Cancelled

Because the Soviet's closely observed but did not interfere with the recovery operation, the CIA believed the Soviets did not suspect what the Explorer was doing and planned a second project, code named Matador, to recover the lost section of the K-129. That was until March 1975 when a reporter broadcast a reasonably accurate story about what he called the most audacious covert operation in CIA history on his weekly radio show. The next day, the bold headline at the top of the front page of the New York Times morning edition read CIA Salvage Ship Brought up Part of Soviet Sub Lost in 1968, Failed to Raise Atom Missiles. The Soviet Ambassador to the United Nations lodged a formal protest and demanded the US cease efforts to recover the K-129. The CIA cancelled Project Matador.

The Soviets Knew but Considered it Impossible

The CIA did not realize that the Soviet naval attaché at their Washington, D.C. embassy received an anonymous letter in late 1970 saying the CIA was hunting for a submarine that sank in the Pacific in March 1968. The Soviet intelligence vessels followed and observed the Glomar Explorer, but it was not until the news stories in March 1975 that the Soviets realized the CIA had located and recovered part of the K-129.

The reason the Soviets did not interfere with the Glomar Explorer was their belief that it was technologically impossible for anyone to raise the submarine from a depth of sixteen thousand feet. Although operational security and the deep seabed mining cover story held, it was the technological brilliance of the system that provide the real cover for Project Azorian.

All images courtesy Oceaneering International

THE FLEET OF THE FUTURE:

HOW OCEANEERING IS REDEFINING OFFSHORE OPERATIONS

As offshore energy development confronts more applications, increasingly complex operating environments, and a turbulent global market, adaptability and integrated offerings may be the solution. At the center of this vortex is Oceaneering International's Offshore Projects Group (OPG) Vice President **Dan Vela***, who shared insights with* ***MTR*** *about the operations of a multi-vessel, multi-mission fleet.*

By Celia Konowe

Dynamic flexibility

Dan's wide-ranging career in oil and gas has spanned from an offshore technician to sales, account management and now operations. He's held his current role as vice president - OPG Americas for three years.

A typical day may vary greatly, but there's a common emphasis on developing the teams and scopes that will address the projects that come their way. "It's a lot of planning of future work, of current work, and a lot of risk and hazard identification and management," Vela said. "We spend a lot of time on quality and making sure that our teams are prepared. Then, it's just the flawless execution of the projects and making sure that that they're going off the way that we planned, and that we can come back, reload and head out to the next one."

The role is dynamic, requiring flexibility. "Whereas in manufacturing, you plan something, you put it in the system, and it kind of flows through. This does that, but it tends to move around in that process," he explained. "Our job is to keep it as tight and as in line as we can with the plan and follow it all the way through execution. That's evolved over time of us learning how to do that the most effective way for both internal and external results. And we're still learning. It's always something new. It's never a dull moment, that's for sure."

External factors pose dynamic challenges. "Whether that's weather that affects us doing our operation or it's a customer schedule that moves. A lot of our day-to-day is reacting to those inputs as they come in and then reshuffling or replanning, repreparing, re-evaluating and then moving forward to the next step."

Fit for mission

From a vessel activity standpoint, the bulk of OPG America's work in the Western Hemisphere is in the Gulf of America, with additional projects ranging across the Caribbean and down to South America.

Its five vessels underwent an update in recent years as Oceaneering considered how to approach fleet management as an enduring strategy. In addition to operating their own ships, they entered into long-term agreements with other vessel owners to build fleet capability and scope.

There are two large vessels in the fleet, which have 250-ton heave cranes onboard, with a back deck of about 12,000 square feet. These ships specialize in subsea hardware installation and interventions—projects that require bigger equipment and larger crane capabilities at deeper water depths. Ocean Evolution was built for and is owned by Oceaneering, while the second is chartered from an independent vessel owner. Speaking about the latter, Vela explained, "The boat is staffed with Oceaneering management and execution teams, and then the vessel owner staffs it with the marine team that operates the vessel. We coordinate with them on operations and on what's needed for the vessel, like maintenance."

Two medium-sized vessels have 165-ton heave cranes and slightly smaller back decks. Those boats flex up or down based on the project; often they are used for smaller installation or intervention work, but also tasked for inspection, maintenance and repair (IMR). Oceaneering's smallest vessel is also chartered and primarily does IMR-based work.

What makes the company's fleet unique is that regardless of the vessel, all boats are equipped with its own ROVs and survey services. This holistic approach, Vela said, allows the company to collaborate and coordinate internally.

"On a day-to-day basis, we evaluate the needs of projects coming in and look at the vessel best available to suit that," he added. "We try to match the vessel to the scope the best we can, and if we don't have it available then we're able to move things around and shift work from vessel to vessel."

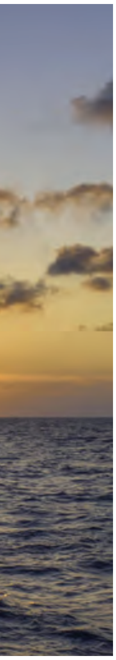
One-stop shop

A recent project, although non-traditional, showcased Oceaneering's service capabilities from start to finish. The customer, a pipeline company in the Gulf of America, wanted to change their production lines subsea, as opposed to shutting down processes before starting the work. Oceaneering's engineering team was able to build complex skids with isolation valves that would allow for operations to continue. "They built the system, tested it and then we received the system and went offshore to do the installation," said Vela. "It allowed us to bring the full weight of what Oceaneering can do to the table, from creating the engineered product, to building it, testing it, delivering it and installing it."

He added, "We're looking forward to doing more of that with this customer. They've got several more of these projects coming up and we're well positioned to help."

Ship shape

In a turbulent global business environment, with rapidly growing trends like marine autonomy and the use of artificial



"In the next three to five years, we're trying to really understand what our fleet needs to look at. What does it look like? How many autonomous vehicles are included in that?"

– Dan Vela,
Vice President – OPG Americas at Oceaneering

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intelligence (AI), Oceaneering is embracing adaptability to best serve its customers. "There are a lot of external impacts that affect our business and are the biggest drivers," said Vela. "A lot of that has to do with the market and where and how our customers are spending their money. That's a key point for us to understand to help us react or be proactive to those trends. When we think about AI on the vessels, there's some opportunity there, but I think the biggest part is how we can use it to help us work more efficiently." He noted that tracking and planning can be streamlined using AI.

Regarding autonomy, Oceaneering's fleet already features autonomous processes, such as dynamic positioning systems, subsea survey equipment, ROV systems and the cranes. "We also have a group whose sole focus is looking at autonomous vessels. We collaborate with them on what we use the vessels for and how can we integrate autonomy into how we use our fleet in the Gulf of America. And that's an ongoing discussion.

Plotting a course

For Vela, the near-term future holds exciting potential for Oceaneering. "In the next three to five years, we're trying to really understand what our fleet needs to look at. What does it look like? How many autonomous vehicles are included in that?"

Crewing is one factor that requires the right balance. "We're looking at how we can reduce our crew sizes offshore. Not that we want to reduce people, but we see areas where we can move into remote operations."

It's just one element under consideration. "So, on top of our day-to-day operations, we're looking at a lot in the background. There's a lot of things going on, a lot of moving parts and challenges, but we have great people here that want to be challenged. They want these new and exciting opportunities to think about and plan for and problem solve with."

All photos courtesy: Jerry Eliason

A shot of the *Henry B. Smith*, benefitting from Eliason's drop-down system with the lights positioned away from the camera to reduce visual interference.

IMAGING 100-YEAR-OLD SHIPWRECKS UNDER 800 FEET OF WATER

By Jon Boucher and Andrea Van Landingham

Jerry Eliason, a lifelong shipwreck hunter from Cloquet, Minnesota, has become one of the most respected figures in the quest to locate and document lost ships beneath the depths of the Great Lakes. Eliason's decades-long dedication and innovative use of technology have led to some of the region's most significant underwater discoveries, including the *Henry B. Smith* and the record-breaking *Scotiadoc* wrecks.

A critical enabler of Eliason's work has been his use of specialized imaging tools tailored for extreme underwater environments. Chief among these is Theia Technologies' MY125M ultra-wide no-distortion lens, which plays a central role in capturing clear, expansive visuals of deep-water wreck sites. Its ability to deliver wide-angle coverage without introducing geometric distortion is essential for documenting the often vast and structurally complex wrecks resting hundreds of feet below the surface. Combined with custom underwater housings and remote-operated camera rigs, the MY125M allows Eliason and his fellow shipwreck enthusiasts to deliver visually compelling and historically significant documentation of shipwrecks unseen for over a century.

EARLY BEGINNINGS AND TECHNICAL EVOLUTION

Jerry's passion for shipwreck exploration began as a child inspired by the 1960s TV show Sea Hunt. After relocating to Wisconsin in 1964, he purchased diving gear and started

Figure 1. *Scotiadoc* shipwreck as imaged with Theia's MY125M ultra-wide no distortion lens.

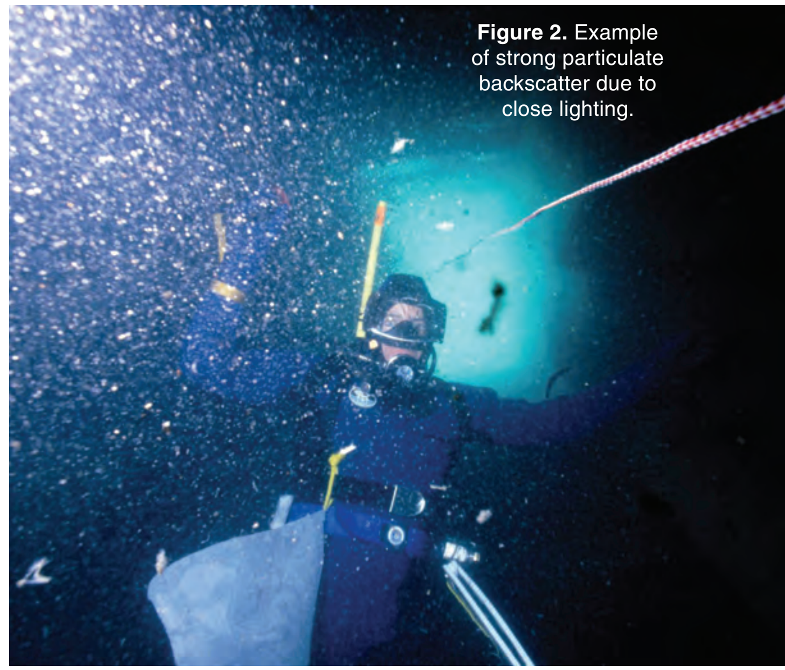
Figure 2. Example of strong particulate backscatter due to close lighting.

scuba diving, initially limited by visibility and equipment constraints. By the mid-1980s, Jerry shifted focus to hunting Great Lakes shipwrecks, evolving from drop-down standard definition cameras to high-definition systems with improved lighting and control. With a tight budget and no remotely operated vehicles (ROVs), the group innovatively controlled camera positioning through skillful boat handling and incorporated a dynamic positioning system using an electronic trolling motor with built-in GPS. This system allows precise station-keeping over wrecks, enhancing imaging capabilities.

LOCATING LOST WRECKS: HISTORICAL RESEARCH AND SONAR

Locating shipwrecks begins long before the boat ever hits the water. The group conducts extensive historical research, poring over old newspapers, life-saving service reports, and archival data. They supplement this with advanced sonar techniques, including side-scan sonar built by Jerry's son Jarrod, and magnetic anomaly detection. By submitting Freedom of Information Act requests to the National Geospatial-Intelligence Agency and applying signal averaging techniques to raw geospatial data, they extract subtle clues about probable wreck locations. This meticulous approach allowed them to pinpoint the *Henry B. Smith* after nearly a century lost.

The 2013 discovery of the *Henry B. Smith* was a landmark achievement. Found largely intact about 30 miles off Marquette, Michigan, at a depth of 535 feet, the freighter had been lost in the infamous 1913 storm with all hands. Jerry described the moment they saw the flying bridge live on camera as the culmination of years of effort, research, and teamwork. Their precision in narrowing the search area allowed them to locate the wreck within 20 minutes of deploying sonar—an extraordinary feat compared to previous years of searching.

PUSHING DEEPER: FINDING THE *SCOTIADOC*

Later that same year, the group achieved an even more technically demanding success by confirming the location of the *Scotiadoc*, a 424-foot freighter that had vanished in 1953 after colliding with another ship in heavy fog near Thunder Bay, Ontario. The wreck rests upright and largely intact at a staggering depth of 850, making it the deepest known shipwreck ever found in the Great Lakes.

Unlike the *Smith*, which was located through government-sourced geospatial data, the *Scotiadoc* was found through sonar searching in a defined area based on historic court documents Jerry had obtained. The group had to factor in post-collision drift, run sonar in tight grid patterns, and wait for a rare convergence of good weather, permits, and equipment readiness to deploy the imaging system. Confirmation came when they captured footage of the ship's name still visible along its side (Fig 1).

"If *Henry B. Smith* was the entrée; *Scotiadoc* was the dessert," Eliason later said, highlighting the technical progression the group had made between the two discoveries. The much greater depth of the *Scotiadoc* required improved pressure-resistant housings, lighting systems, and precision cable control—foreshadowing the group's readiness for even deeper expeditions in the future.

CHALLENGES OF DEEP-WATER EXPLORATION: WIDE-ANGLE, NO-DISTORTION IMAGING

Whether at 535 or 870 feet, Eliason and his group operate in near-total darkness. Below 200 feet, natural light disappears entirely, and visibility is further compromised by suspended particulates like copepods, which cause "snowy" visual interference when artificial lights are too close to the camera (Fig. 2). To combat this, the group carefully positions lighting 4 to 6 feet from the lens, mounted along the same cable (see main image).

Due to limited visibility and zero ambient light in these conditions, a distortion free, ultra wide-angle lens with short working distance is essential. To overcome these challenges, the group used a Sony SNC-CH240 camera with Theia Technologies' MY125M ultra wideangle lens, which offers low distortion without software correction and a close working distance of just 0.5 meters. On that camera with its HD sensor and 1920 x 1080 pixel array, the 1.3mm focal length lens offers 133 degrees wide in air and from .5m will cover an

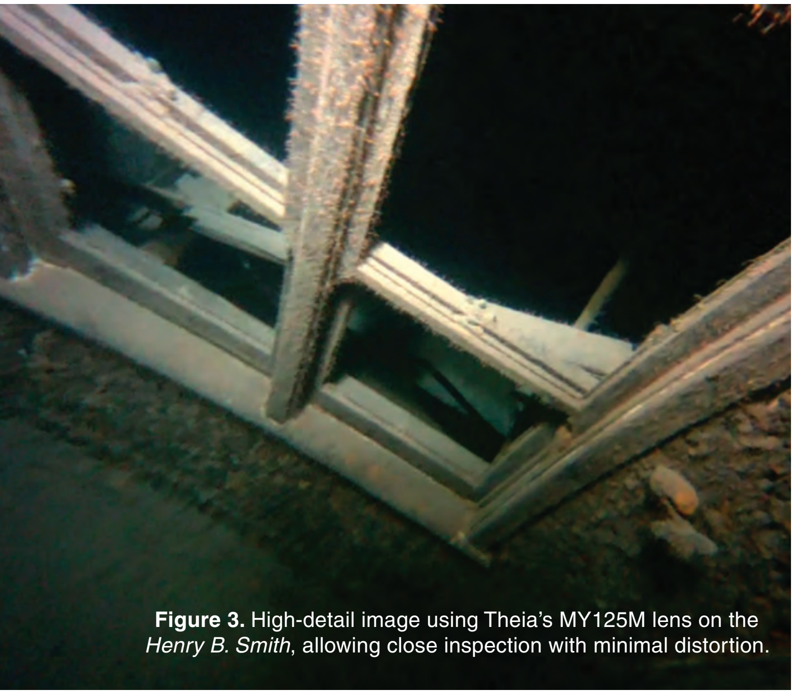

Figure 3. High-detail image using Theia's MY125M lens on the *Henry B. Smith*, allowing close inspection with minimal distortion.

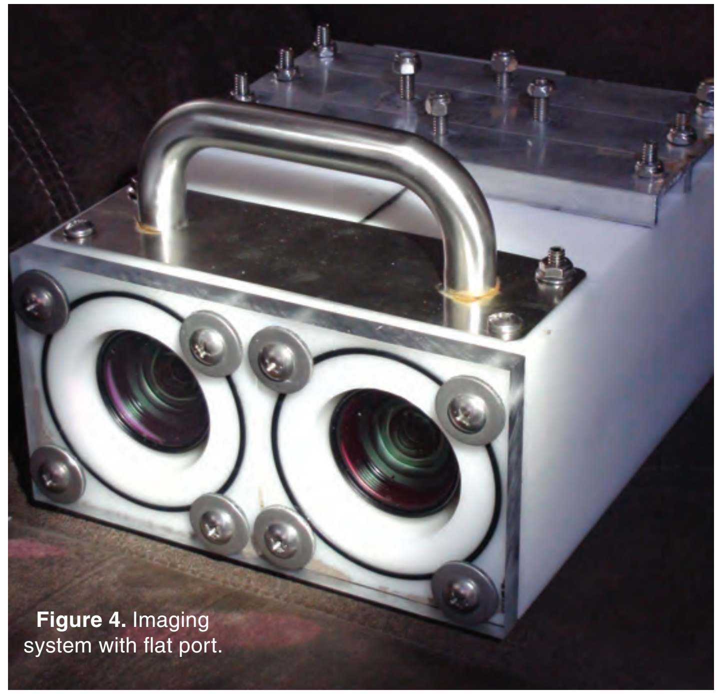

Figure 4. Imaging system with flat port.

image area over 2m wide and 1.2m high with very low barrel distortion. This enables detailed images of shipwrecks at close range—without the extreme distortion and lost edge resolution typically associated with fisheye lenses.

The combination of a wide field of view and minimal distortion is critical in low-visibility conditions. It allows the group to document the largest possible area of wreckage from limited vantage points. Many other wide-angle lenses require longer working distances and provide narrower fields of view, forcing the camera farther from the subject and resulting in reduced resolution and image detail. The MY125M avoids these constraints, delivering high-resolution imaging even in confined or cluttered underwater environments (Fig 3).

Theia's MY125M lens features patented Linear Optical Technology, which eliminates barrel distortion optically—without the need for software correction and its associated latency, the method commonly used to correct images from fisheye lenses. And, unlike fisheye lenses, which lose resolution at the edges, Theia's patented technology provides more pixels at the image periphery, enhancing resolution—an essential advantage when using flat port housings.

For wide-angle imaging, the group used Theia's MY125M ultra-wide lens paired with a dome port housing, which preserves the lens's full field of view and minimizes distortion underwater. While dome ports offer superior optical performance, they come with tradeoffs—they are more expensive and prone to scratching, as they protrude forward and are more exposed. In contrast, flat ports are more rugged and cost-effective, but when used with ultra-wide lenses, they can introduce pincushion distortion and reduce the effective angle of view (Fig 4). As a result, flat ports are typically favored for narrower field-of-view lenses – another reason to use Theia's ultra-wide angle, MY125M lens with patented distortion correction technology. To prevent internal fogging caused by condensation during descent into colder water layers, the group also placed desiccant inside the housing—a simple yet essential measure to ensure optical clarity during extended deepwater deployments.

LOOKING AHEAD

The group's success with both the *Henry B. Smith* and *Scotiadoc* demonstrates their ability to operate at increasing depths with evolving technology. They continue to refine their equipment and methodologies, planning further expeditions to find the German U-boat U656. Building on their proven success with the MY125M lens for 1/2.5" sensors, they aim to upgrade to Theia's MY23F ruggedized, ultra wide-angle, no distortion lens designed for 1/1.8" sensors and a Bosch NBN-80052-BA camera. This new system is expected to deliver significantly higher image resolution and improved low-light sensitivity. Theia's MY23F on Bosch's NBN-80052-BA is projected to increase resolution to 1,842 pixels per meter (px/m), more than doubling the 842 px/m achieved with the MY125M on the Sony SNC-CH240.

Complemented by advanced LED lighting systems, improved dynamic positioning, and meticulous sonar mapping, these technological enhancements will push the boundaries of underwater exploration.

Jerry Eliason and his fellow shipwreck enthusiasts embody the spirit of persistence, blending passion, historical reverence, and cutting-edge technology to achieve remarkable discoveries of long-lost stories and forgotten vessels awaiting rediscovery.


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Marine ecosystems can be highly susceptible to invasive species.

SYRENE: AN UNDERWATER EMBEDDED ARTIFICIAL INTELLIGENCE CAMERA FOR INVASIVE FAUNA MONITORING

By Laurent Gautier, Stephane Barbot, and Damien Le Vourc'h

Invasive species have a major impact on marine ecosystems by disrupting the natural balance and biodiversity. Introduced mainly through human activities such as maritime transport, fishing and aquaculture, these invasive species can supplant endemic species and cause changes in the functioning of ecosystems. These changes can have significant negative consequences, both ecological and socio-economic, including biodiversity loss, leading to a decline in species stocks. In the Mediterranean Sea, one of the most affected regions, the introduction of invasive species has already caused profound changes in marine habitats and food webs. This amplifies the vulnerability of ecosystems to global changes.

The SYRENE project and the need for an invasive fauna active monitoring

Started in 2020, the SYRENE project (SYstème in situ de REconnaissance en temps réel de faune invasive sous-mariNE) aims to use embedded artificial intelligence to help local authorities detect and quantify invasive underwater species that threaten the balance of local marine ecosystems. Artificial intelligence makes it possible to detect complex shapes that were impossible to distinguish with any degree of accuracy just a few years ago.

Some invasive species, such as lionfish, are active at night or at dusk, making them difficult to count or detect by divers. Active, real-time monitoring would enable rapid detection of their appearance and assessment of their impact. A solution based on embedded AI, capable of continuously analyzing images over a long period of time, offers a promising alternative to post-process detections running on data centers, without energy constraints.

The team focused on Pterois volitans/Miles (lionfish), a species widespread across the globe. Accidentally introduced in the early 1990s to the Caribbean Sea and western Atlantic, it has invaded this area where it causes serious damage to marine ecosystems. For example, the biomass of small fish has declined by 65% in the Bahamas reefs in just two years due to its intense predation. It disrupts biodiversity and local food chains. [1]

SYRENE V1, a lionfish detector

The SYRENE prototype was initially developed in 2020 as a demonstrator to illustrate the capabilities of embedded deep learning image processing. The inner hardware architecture is simple and low cost, with an electronic board (Raspberry Pi 4B) allowing connection to an Intel Neural Stick V2 VPU (Vision Processing Unit), which accelerates the processing of images or videos (640*480 pixels) from a Raspberry Pi OV5647 5 Mpixels camera module.

As image processing requires significant computing power, the challenge was to achieve minimum performance on consumer hardware with limited energy, as the system runs on battery power: a compromise on performance was therefore made with this hardware.

The detection model we used in 2020 is YOLOv4 (You Only Look Once), a deep learning algorithm designed for real-time object detection. The model was adapted to take full advantage of the VPU's capabilities. We used transfer learning to adjust the model parameters to our dataset.

Creating a dataset and training the model

To train our specialized model for Pterois Volitans/Miles, or lionfish, a specific dataset was compiled. This dataset was assembled from various sources, including open-access resources and recordings made in natural environments and aquariums. This diversity of sources provided a broad representation of different lighting conditions and viewing angles, reinforcing the robustness of the future model.

The creation of this dataset was a crucial step in ensuring the relevance and performance of the model. By choosing to target a single species exclusively, we significantly reduced the risk of false positives (detection errors with other species), while optimizing inference time and, indirectly, the energy consumption of the device.

Detector test

The prototype was tested in March 2021 under near-real conditions, with budget in mind: submerged in a tank containing lionfish belonging to the Océanopolis marine center, with a return via the mobile telephone network enabling detection alerts and snapshots remote transmission.

Maximum performance with this hardware architecture enabled real-time processing at approximately 5 FPS (frames per second). The ultimate goal is to achieve 1 FPS in order to find a better compromise in terms of power consumption, as this species moves slowly.

The detector makes a local copy of the full-resolution photos of the detections made, which will ultimately enrich our learning dataset. It could also send the number of detections via an IoT network (e.g. LoRa), where bandwidth is very limited.

Power consumption averages less than five watts at 5 FPS, and its battery life exceeds 100 hours without optimization for the available battery volume in the enclosure.

A lionfish in its natural habitat.

© Adobe Stock/crisod

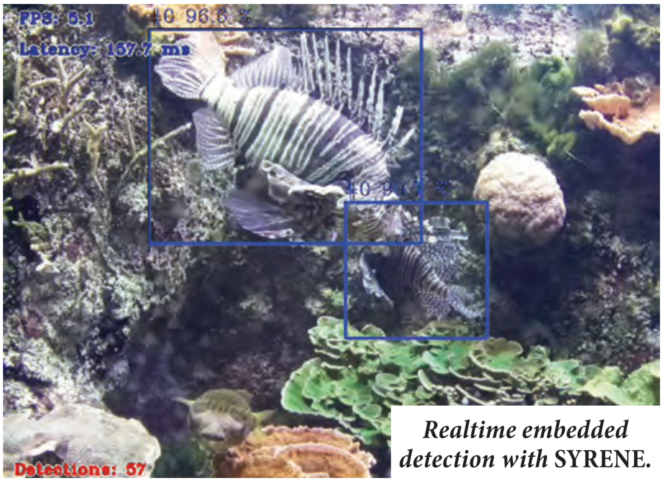
SYRENE V1 *ready to be vertically immersed with its mirror.*

Credit: IFREMER S. Barbot

Lionfishes' tank with **SYRENE** *in the right corner.*

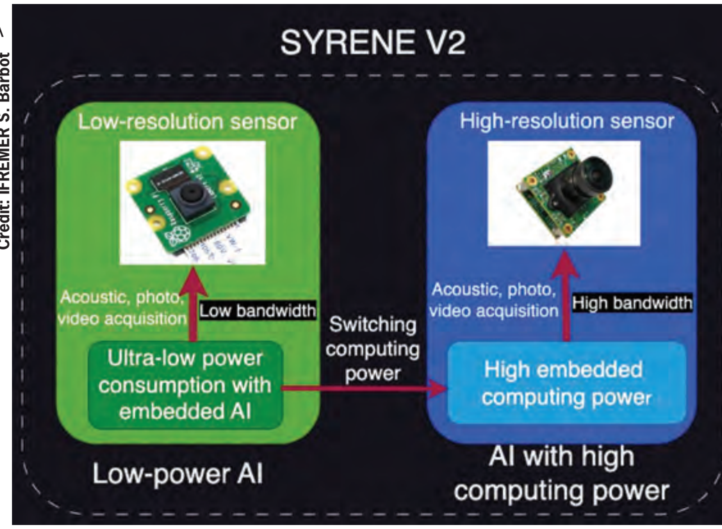
Credit: IFREMER S. Barbot

Credit: IFREMER S. Barbot



Realtime embedded detection with SYRENE.

Credit: IFREMER S. Barbot



Toward SYRENE V2 and Small Vision Language Models (sVLMs)

Updated in 2025, SYRENE has benefited from the hardware and software advances of recent years. We turned to an embedded GPU from Nvidia (Jetson nano Orin NX) to test the potential of a system where power consumption would be less of a constraint. This time, the entire system consists of two modules: a low-power AI module and an AI module with higher computing power.

Depending on the trigger conditions and remaining battery life, the low-power module switches the embedded GPU, providing embedded processing power for denser data and therefore more accurate detection than before.

Ultra Low Power AI

The module, designed for continuous operation, is based on a microcontroller incorporating an embedded convolutional neural network (CNN) accelerator, optimized for very low energy consumption. The embedded AI unit enables it to finely filter relevant events and trigger the high-computing power section only when necessary.

In the future, new types of more advanced neural networks, such as spiking neural networks (SNNs) and adapted processors, could be tested for the purpose, further reducing energy consumption while improving detection quality.

AI with high computing power

This new module can now integrate more powerful AI models such as YOLOv11, which significantly improves detection performance. This system allows YOLOv11 to take full advantage of the GPU's parallel computing capabilities, benefiting in particular from the optimizations offered by TensorRT, thereby reducing real-time latency by a factor of 4 in some cases we have tested.

Re-training (fine-tuning) the neural network significantly improved detection and processing performance. According to our tests, the computing power/energy consumption ratio with the old hardware is greater than six, opening up new possibilities in terms of image resolution: this translates into a greater detection distance, allowing smaller or more distant objects to be detected with greater accuracy.

This extra power also allows for the integration of Transformer-type networks [2] as well as small vision-language models (sVLM) [3]. These models favor a textual description of the image rather than a direct transfer of the image, thereby achieving significant information compression. This is particularly useful for acoustic links with seabed equipment, where a detector such as SYRENE will be deployed.

Very soon, it will be possible to integrate autonomous embedded AI agents designed to perform specific tasks, such as sending SMS alerts in the event of specific events (e.g. species counting). These agents will be able to analyze data locally, make decisions in real time and act independently, while limiting the energy consumption of embedded systems.

Conclusion

Evolving to keep pace with recent technological advances in AI, SYRENE is an example of an oceanographic application that improves environmental monitoring and anticipates the impact of invasive marine species, particularly lionfish. Coupled with an antenna and an IoT (Internet of Things) modem for shallow-water applications such as lagoons, or via a surface relay buoy for benthic applications, this type of architecture opens up a wide range of possibilities. It enables long-term monitoring of parameters such as acoustics, video, seismicity and other physicochemical parameters, as well as the compression of useful information.

In conclusion, the SYRENE detector thus offers new perspectives for real-time monitoring of underwater fauna via imaging, acoustics or other parameters.

Acknowledgments

We would like to thank Pierre Ternat et Dominique Bartelemy (Oceanopolis) for having kindly hosted the camera in their lionfish tank, Helene Leau (Ifremer), SincObs project coordinator as well as Amaury Tisseau, Thomas Morales and Alvaro Scarramberg for their involvement in this project.

Credits

[1] Green, S.J., et al. (2012)
[2] Vaswani et al., 2017 : https://arxiv.org/abs/1706.03762)
[3] https://hal.science/hal-04889751

2026
Editorial Calendar

MARINE TECHNOLOGY REPORTER

01 | Jan/Feb 2026
Ad close Jan 31

Underwater Vehicle Annual
- Research Vessel Fleet & Technology
- Subsea Defense
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- Battery Technology

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IPF 2026 – New York, NY
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DEEP DIVE
PODCAST: Underwater Vehicle Tech

02 | February 2026
Ad close Feb 4

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Tech Focus: Sonar, Telemetry & Data Processing Software

DEEP DIVE
PODCAST: Digitalization

03 | Mar/Apr 2026
Ad close Mar 21

Oceanographic Instrumentation & Sensors
- Port Security
- Offshore Energy
- Seismic & Geotechnical Surveys
- Workclass ROVs: IMR

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PODCAST: Subsea Survey Technology

05 | May/Jun 2026
Ad close May 21

Dredging Technology
- Universities Review
- Hydrographic Survey
- Scientific Deck Machinery
- Cables & Connectors

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Underwater Technology Conference – Norway
WEDA Dredging Congress & Exhibition – Montreal, Canada

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PODCAST: Dredging Technology

07 | Jul/Aug 2026
Ad close Jul 21

Autonomous Vehicle Operations
- Underwater Tools & Manipulators
- GPS, Gyro Compasses & MEMS Motion Tracking
- Deck Machinery & Cranes
- Battery Technology

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PODCAST: Subsea Defense

08 | August 2026
Ad close Aug 4

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Tech Focus: Underwater Communications

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PODCAST: Research Vessels

09 | Sep/Oct 2026
Ad close Sep 21

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11 | Nov/Dec 2026
Ad close Nov 21

Ocean Observation: Gliders, Buoys, & Sub-Surface Networks
- Instrumentation: Profilers, Samplers & Sediment Corer
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12 | December 2026
Ad close Dec 4

Subsea Vehicles
e-Magazine Edition

Tech Focus: Underwater Imaging: Lights

DEEP DIVE
PODCAST: Subsea Vehicle Technology

In Memoriam

Captain Charles Robert MacVean, USN, (Ret.), PhD

March 22, 1937 – September 10, 2025

By Kevin Hardy

The book, **Blind Man's Bluff**, describes the secret USN submarine operations known as "The Projects." It begins with the opening line, "There was something about Commander Charles R. MacVean that had a way of inspiring legend." Authors Sontag and Drew narrowed that "something" down to "his sense of humor and humanity." Even in the toughest of situations, MacVean radiated calm assurance and situational command. His sailors and divers would knowingly follow him past the Gates of Hell, and did more than once. They called him "Captain," "Skipper," "Mac," or simply "Charlie."

Captain "Charlie" MacVean passed away in the company of family in San Diego, CA, on September 10, 2025, at the age of 88. MacVean joins other stellar American submariners enshrined in history: Bushnell, Holland, Lake, Nimitz, Morton, O'Kane, Butler, and others.

Charles Robert MacVean was born in Paterson, New Jersey. Following graduation from high school in Ridgewood, New Jersey, he attended Dartmouth College as an NROTC student. He earned a Bachelor of Arts Degree, Summa Cum Laude and Phi Beta Kappa, majoring in Engineering Physics, and was commissioned in 1959. Ensign MacVean served as Communicator on board the USS FORREST SHERMAN (DD931) prior to attending Cornell University where he received a PhD in Nuclear Science and Engineering. Lieutenant MacVean then entered the Nuclear Power and Submarine Curriculum, completing courses in Bainbridge, MD, Windsor Locks, CT, and New London, CT.

Lieutenant Commander MacVean was assigned to USS TINOSA (SSN606) in 1965 where he served as the Main Propulsion Assistant and Navigator. The USS TINOSA keel was laid at Portsmouth Naval Yard 24 Nov 1959, the second in a series of fast attack submarines following USS THRESHER (SSN593) from PNY. Charlie recalled some parts of the propulsion system for the THRESHER were not available for its first voyages, so parts from TINOSA were substituted. After THRESHER's loss at sea with all hands on 10 April 1963, the now available THRESHER parts were built into TINOSA, with the serial numbers beginning with "593-". MacVean silently kept the memory of those seamen as he worked every day.

Thresher's loss was traced in part to its inability to blow its ballast tanks due to excessive moisture in the submarine's high-pressure air flasks. The moist air inside the flasks cools as it expands and flows through the valves. The cooling is localized at the point of expansion. The water vapor froze and plugged the flow paths. This was later confirmed in dockside tests on TINOSA where the flow of air lasted only a few seconds.

Following qualification as a Nuclear Propulsion Engineer, MacVean attended the SSBN Navigator course and completed four POLARIS Strategic Deterrent Patrols as Navigator of the USS GEORGE WASHINGTON (SSBN598 (Blue)), 1968-1972.

Photograph courtesy of John Freeman

Capt. Charlie MacVean with some of his USS SEAWOLF (SSN575) divers.

From 1972 until 1975, Commander MacVean served as the Commissioning Executive Officer of the USS PARCHE (SSN683). PARCHE became the most highly decorated ship in U.S. Navy history, mainly for missions that remain classified to this day.

He reported for duty as the Commanding Officer of USS SEAWOLF (SSN575) in 1975. During his three years in command, USS SEAWOLF conducted extensive classified operations in the Pacific.

MacVean had a close intellectual and personal relationship with Adm. Hyman G. Rickover, Father of the Nuclear Navy, which he recounted on occasion with stories, including a presentation for the Naval Submarine League, "Admiral Rickover-Up Close and Personal." Once, while commanding a classified mission on SEAWOLF, a rack of electronics in a power panel failed spectacularly. To repair it, the submarine surfaced in a fog bank, spare parts were substituted and tested, the reactor restarted, and the ship submerged. USN protocol required SEAWOLF to return to port. MacVean, however, assembled his officers in the mess, discussed the matter, expressed his confidence in the repair and testing, and suggested they complete the mission. The officers unanimously agreed. The mission was completed, and they returned to port. On the return trip, he sent the message "Mission Completed." And a second, "btw, we had a fire in the reactor compartment." The Navy was not amused. On the brink of court martial, Rickover intervened, writing,

Captain Charlie MacVean and wife, Ellen, at the NSLPACSW luncheon, February 2020.

"Leave SEAWOLF alone. They did exactly what we trained them to do." MacVean reflected, "Rickover saved my career."

In 1978, Captain MacVean assumed command of Submarine Development Group ONE. This Group contained seventeen ships and units and was the sole Navy activity responsible for deep ocean search, location and recovery. Captain MacVean retired from active Naval Service in October, 1981.

Captain MacVean's awards include two Distinguished Service Medals, the highest award for non-combat service, requiring Presidential review and approval. He also received the Legion of Merit, the Joint Service Commendation Medal, and the Navy Commendation Medal.

MacVean always spoke of his wife, Ellen, with tremendous affection and admiration. They met as juniors in high school, and were married after his graduation from Dartmouth. When Charlie's submarine, SEAWOLF, set a submerged record of 89-days, it was Ellen who looked after the wives and families at home, a U.S. Navy extended family, helping solve daily problems, occasionally handling far worse. One new mother lost her child just a day or two after giving birth. Ellen stepped in to help with arrangements and grief. She recalls, "I went to the naval hospital in Oakland to be with her. She was amazingly strong. She waited for her husband to come home to have a burial. It was one of the hardest days I had as the CO's wife." The word was passed to Charlie at sea, who broke the news to the young father under his command. Ellen added, "Because of how terribly the CO of the George Washington had handled telling Charlie his brother was killed in Viet Nam, he was very compassionate with informing a crew member of a tragedy at home." His crew knew their captain's personal interest in each of them, and he saw an inspiring example of dedication in them.

Following his Naval service, Dr. MacVean held numerous positions in industry, including Honeywell/Hydro Products, eventually becoming Vice President and General Manager. In 1989, Dr. MacVean became the Vice President for Business Development at Horizons Technology, a San Diego company developing and providing mission planning software for the U.S. Navy, U.S. Marine Corps, and overseas allies.

MacVean authored an engaging autobiography, "Down Deep," with the help of friends John Freeman and Gresham Bayne, available on Amazon. One SEAWOLF crewman wrote, "Great book. Felt like I was alongside the CO again. Nice feeling. I was a nuke, so there were long hours, and very tough times. Not always fun. But as was stated throughout the book, you always busted your ass. Not because you feared Mac, but because you never wanted to let the Old Man down. That's a quality that a fine leader has. Mac had it in spades."

MacVean is survived by his wife and two children, Amy Perez of La Habra Heights in Los Angeles County, CA and David MacVean of Southport, NC. A third child, Lynne MacVean, passed away in February 2025 in Newport Beach, CA.

A Memorial was planned for November 1, 2025, in Point Loma, CA. Ellen picked the date. "Charlie took command of SEAWOLF on November 1, 1975 so his memorial will be on the exact 50th anniversary. I think he would like the date we have chosen to honor and remember him."

A memorial page for Charlie may be found at **https://sites.google.com/view/charlesrmacvean/home**. Your memories and photos of Charlie are welcome. In lieu of flowers, the family has provided links to two non-profits Charlie felt strongly about.

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