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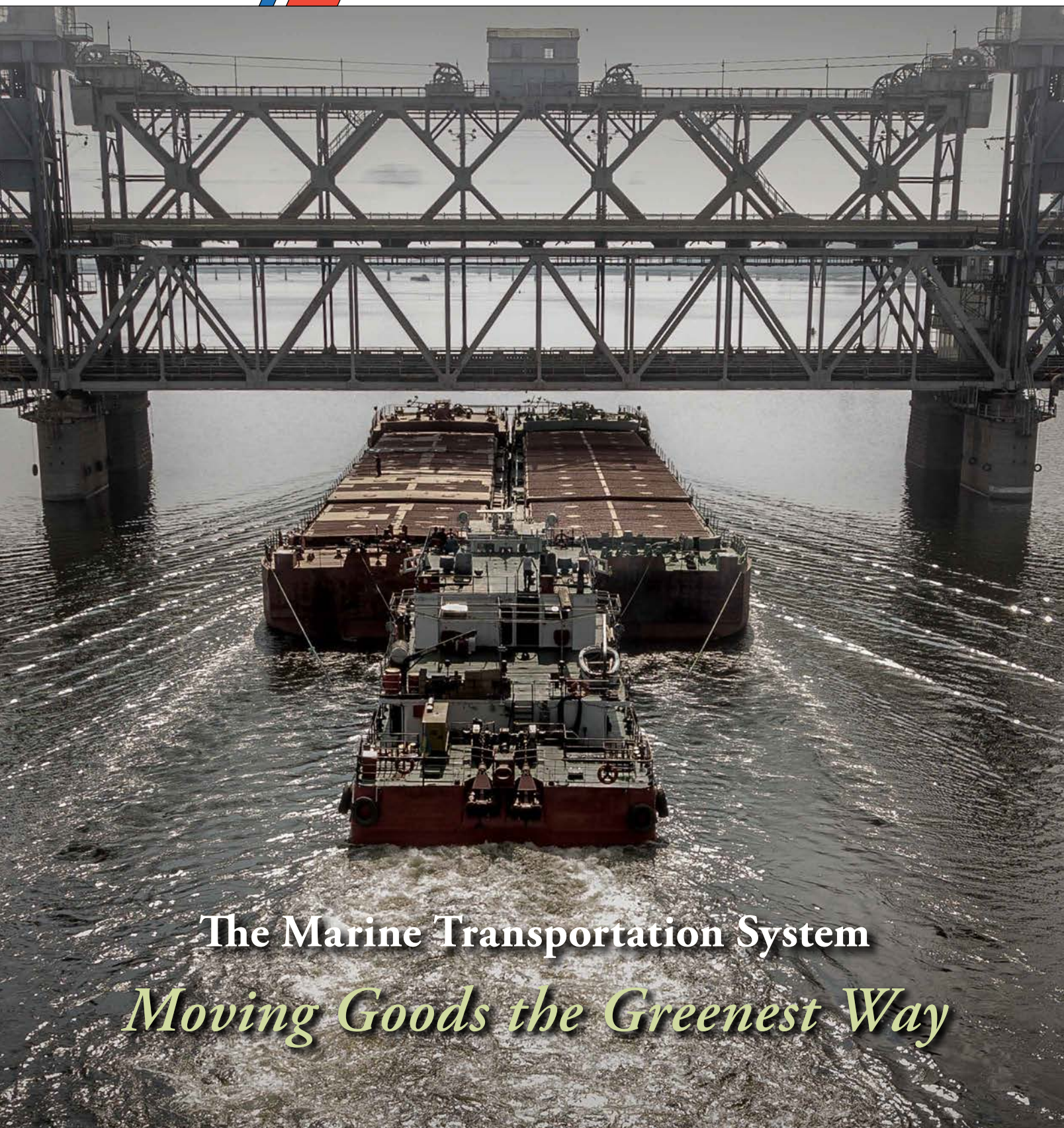

The Marine Transportation System

Moving Goods the Greenest Way

Two vessels and their barges prepare to pass through the Soo Locks en route to Lake Superior on March 24, 2021, the first day of the season. The locks, operated by the Army Corps of Engineers and located in Sault Ste. Marie, Michigan, ensure safe, economical transportation of raw materials and other goods between Lake Superior and industrial hubs such as Detroit, Cleveland, and the Chicago region along the lower Great Lakes. Coast Guard photo by Chief Petty Officer John Masson

PROCEEDINGS

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Marine Transportation System Synopsis

The Backbone of the Global Supply Chain

MTS Tech Revolution

The Greenest Mode

MTS Unity of Effort

On Deck

On the Cover: It's not easy going green, but the maritime industry is working to get to net zero carbon emissions before the half-century mark. With 40 percent of all U.S. international trade moving through the nation's ports last year, the need to reach this goal is critical for the environment and for moving the goods Americans rely on in their everyday lives.

Cover photo by DavidEdZiegler | Adobe Stock

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Editorial Contact

Email: HQS-DG-NMCProceedings@uscg.mil

Mail Commandant (CG-5PS)
ATTN: Editor, *Proceedings* Magazine
U.S. Coast Guard Stop 7509
2703 Martin Luther King Jr. Ave. S.E.
Washington, DC 20593-7509

Web: www.dco.uscg.mil/proceedings

Phone: (202) 372-2316

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Assistant Commandant's Perspective

by Rear Admiral Richard V. Timme
Assistant Commandant for Prevention Policy
U.S. Coast Guard

I am pleased to present this edition of *Proceedings* which highlights innovation and emergent technologies throughout the Marine Transportation System (MTS). As a nation, continued investment in a safe, efficient marine transportation system is crucial to ensuring economic growth. Strategic implementation of enhanced infrastructure and support of autonomous systems will ultimately boost our global environmental position, support national security interests, and ease congestion caused by land-based transportation systems.

Guided by the tenets set forth in the Coast Guard's *Maritime Commerce Strategic Outlook*, in this edition, we collaborated with academia and industry to submit articles which highlight innovations in artificial intelligence that improve delivery systems within the supply chain from factory to your door. We ask companies to discuss their implementation of fuels that are more efficient and have less negative impact on our environment. We highlight the expansion of offshore wind, as well as the implementation of autonomy to fight

Champion's Point of View

by Mr. Michael D. Emerson
Director of Marine Transportation Systems
U.S. Coast Guard

The Maritime Commerce Strategic Outlook and Implementation Plan guides Coast Guard operations as we tackle the challenges associated with governance in the maritime domain. As such, I am pleased to champion this edition of *Proceedings*, which highlights the strategic global value of the Marine Transportation System (MTS).

Marine transportation has always been the foundation of global commerce. As our economy becomes more complex, humans will continue to innovate and revolutionize the MTS to meet demands. The past year has taught us how reliant

illegal, unreported, and unregulated fishing. Regional topics include stories on the ports of Charleston and the Columbia-Snake River systems. This wide range of topics highlights the crucial role of waterway infrastructure and the impact that the MTS provides to the global economy.

Technical innovation and the constant drive towards economies of scale fuel MTS users' development of novel technology and the adaptation of enhanced technologies. These developments occur within the shared marine environment. Specifically, the development and deployment of artificial intelligence and other autonomous systems, which operate vessels and serve specific functions at waterfront facilities, has become a new reality over the last decade.

As the International Maritime Organization and stakeholder nations discuss methods of governance related to these systems, the pace of technical advancements continually shifts the goal line. Thirty years ago, autonomous technology only existed in television, movies, and science fiction novels. Autonomously operated systems are becoming increasingly feasible for waterways users.

Innovation does not come without risk, however. The introduction of new technology could disrupt vital trade activity. As such, the Coast Guard has an obligation to understand emerging technologies and clear a path towards sensible, prudent regulations ahead of global adoption. Coast Guard Captains of the Port and their waterways managers have many objectives when considering stakeholders' uses of American waterways. Foremost, they must ensure the safety, security, and environmental stewardship of their waterway.

Simultaneously, because American innovation and economic advancement are matters of national security and core objectives for other federal agencies, regulators consistently strive to facilitate America's efforts to promote our MTS to remain globally competitive. However, ports and harbors carry different risks than open oceans. To fulfill their objectives, Captains of the Port and waterways managers must have a unified vision and strategy specific to how autonomously operated systems can safely and securely operate alongside traditional waterways users. Navigation Safety Risk Assessments are critical tools to promote these strategies and to recognize and mitigate the overall risks.

I hope these articles will encourage a dialogue in support of our marine transportation system—nature's highways and the greenest mode of transportation—which is fundamental to our nation's economic growth and security.

the global supply chain is on the MTS and its relevance to worldwide trade. We are still reeling from COVID-related port delays and issues related to the recent grounding of the M/V *Ever Given* in the Suez Canal.

As the pace of innovation, emerging technologies, and the expansion of natural resource exploration and production drives the demand for increased capacity, complexity, and capability within our MTS, we have witnessed incredible advances in the system. Without this progress we would not see the $5.4 trillion in economic activity attributed to it.

Progress can bring new challenges, though. Numerous ports have begun to employ automated systems ranging from driverless vehicles to automated stacking cranes. This technology relies on information technology and cyber networks that are vulnerable to cyberattacks. While technologies increase the complexity of our operating environment, they also present great opportunities for improved safety and efficiency.

Solutions to the challenges presented by novel technology aren't simple. Often, technology is advancing faster than the regulations and infrastructure required to support it, but success in the maritime domain can be achieved through unity of effort, leveraging data to optimize resources, and capturing lessons learned as new technology comes to fruition. To continue safeguarding the MTS, the Coast Guard must continually assess and improve its readiness through prioritizing the development of standards that set expectations for safe, secure, and sustainable maritime operations.

Marine transportation systems management is a broad mission area within the Coast Guard and the carefully selected articles in this edition of *Proceedings* are just a sample of the vast innovation taking place throughout the MTS. The United States Coast Guard remains *Semper Paratus* and eager to meet the MTS challenges of tomorrow but, as we have since 1790, we will continue to adapt!

Marine Transportation System Synopsis

The Marine Transportation System and Environmental Protection

by Helen Brohl
Executive Director
Committee on the Marine Transportation System

M. Chase Long
Maritime Data Specialist
Committee on the Marine Transportation System

The marine transportation system (MTS) touches virtually every aspect of American life from the clothes we wear, to the cars and trucks we drive, to the food we eat, to the oil and natural gas used to heat and cool our homes. It is also used for recreational, scientific, and military purposes and is the primary system by which goods enter and leave the United States. Approximately 2.3 billion tons of domestic and foreign commerce are carried on U.S. inland waterways annually.[1] During 2020, waterborne trade through U.S. ports accounted for more than 40 percent of this country's international trade by value, moving $1.51 trillion worth of goods.[2]

Domestically, there are more than 25,000 miles of navigable waterways, including the Great Lakes and St. Lawrence Seaway System; inland rivers such as the Mississippi, Illinois, Ohio, and Columbia-Snake river systems; and the Atlantic and Gulf Intracoastal waterways. Navigation on these waterways is supported by systems of physical infrastructure such as canals, locks, dams, channels, harbors, and fixed and floating aids to navigation. These are augmented with informational infrastructure like nautical charts, weather and sea ice broadcasts, automatic identification system, marine safety information bulletins, local notice to mariners, and electronic aids to navigation, among others.

Protecting the Marine Environment

The federal government has addressed protection of the marine environment for decades and, in concert with states and the International Maritime Organization (IMO), engages in environment-related initiatives associated with maritime vessel operations. Some of these initiatives include ballast water management and aquatic

A commercial vessel sails past the Old Presque Isle Lighthouse on Lake Huron. Navigation of the United States' more than 25,000 miles of waterways, including the Great Lakes, is supported by systems of canals, locks, dams, channels, and harbors, as well as fixed and floating aids to navigation. Haveseen | Shuttershock.com

nuisance species, air emissions, water pollution, underwater noise generation, and ship strikes of marine mammals and other marine life. Vessel operations while in port; emissions from shore cranes and other cargo handling equipment; trucks; and rail equipment at, and adjacent to, docks, terminals, and intermodal connections can be related to cascading impacts associated with maritime transportation. International, federal, and state environmental regulations have broadened in scope; in some cases, have become more stringent, and are not always aligned across jurisdictions. For example, some states have enacted environmental requirements more stringent than federal requirements, such as California's regulation of port-related air pollution.

Environmental implications of shipping are diverse and subject to regulatory oversight at the international, national, state, and local levels. In the United States, environmental requirements are issued and enforced by various federal, state, and local agencies. Focus on new technologies for cleaner domestic and international marine transportation is growing rapidly in an effort to comply with stricter sulfur oxide and nitrogen oxide emissions requirements, in addition to concerns over greenhouse gas emissions. Prevention of, response to, and mitigation of the introduction of contaminants into the marine environment from marine transportation requires the engagement of international, national, state, and local stakeholders. Response requires a robust community with authorities to take immediate action in tandem with industry.

Marine transportation is a very efficient form of commercial transportation and the dominant mode of cargo transportation connecting the United States to the rest of the world.[3] Though the energy used and air emissions per ton-mile of freight moved are lower than combined land transport,[4] maritime transportation may pose other risks to the marine environment. Effective planning and preparation can help to mitigate such risks.

As ships transit domestic or international waters, they can be vectors for moving, depositing, and expelling contaminants into oceans, inland systems, and the air. The value of waterborne transportation to trade, national economies, and our everyday lifestyle is well-documented. And, while maritime transportation has been acknowledged as being less detrimental to the environment, international trade can have environmental impacts.

The IMO provides a global forum for member states to consider and adopt international maritime safety and environmental requirements through international treaties. The United Nations Convention on the Law of the Sea (UNCLOS) contains an over-arching framework to protect the marine environment and hold accountable ships that damage the environment. Though the United States adheres to traditional uses of the oceans, which are considered customary under international law, it is not signatory to UNCLOS.

In the federal government, various agencies, including the Environmental Protection Agency, the Coast Guard, and National Oceanic and Atmospheric Administration, develop and implement environmental requirements. As noted, state and local governments may also adopt environmental requirements that affect the MTS. This requires maritime operators to consider multiple domestic stakeholder requirements and standards which may differ from international standards established by IMO and other countries. Inconsistent standards impact types of equipment, crew requirements, speed restrictions, and other operating parameters. Improved coordination and outreach benefit the regulated community in key areas like water polluting discharges—ballast, gray, and oily waters—air pollution from main and auxiliary engines, and impacts on sensitive natural resources like marine mammals.

In order to provide effective stewardship of the maritime ecosystem, rules and requirements related to maritime transportation were enacted on international, national, and regional levels. On an international level, the International Convention for the Prevention of Pollution from Ships (MARPOL)[5] addresses these areas:

- Annex I: Regulations for the Prevention of Pollution by Oil
- Annex II: Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
- Annex III: Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form
- Annex IV: Prevention of Pollution by Sewage from Ships
- Annex V: Prevention of Pollution by Garbage from Ships
- Annex VI: Prevention of Air Pollution from Ships

In 1980, Congress enacted the Act to Prevent Pollution from Ships (APPS) [33 U.S.C. §§1905-1915], which implements MARPOL domestically,[6] forbidding or restricting the discharge of oils, noxious liquid substances, dry cargo residues, sewage, and garbage. The United States is not party to MARPOL Annex IV; therefore, sewage discharges are regulated domestically under the Clean Water Act (CWA). Vessels with installed toilets are required to be fitted with Coast Guard approved marine sanitation devices to either treat sewage to levels established by EPA as required under the CWA, or hold sewage on board for disposal at an appropriate facility. Additionally, under the CWA, states may request the establishment of vessel sewage "no-discharge zones," where the discharge of both treated and untreated sewage from vessels is prohibited. Thirty states have established these zones.

Marine Life Impacts

As ships travel, it is inevitable they will come into close proximity with sensitive natural resources such as resident or migrating sea life and coastal or near-shore ecosystems. Anthropogenic sound produced by seismic operations and ship engines, among other sources, could interfere with marine mammals' ability to use sound for everything from communications to mother-offspring bonding. Physical injury, physiological dysfunction, disturbance, and behavioral modification are just some of the adverse effects of sound on marine mammals and other species.[7]

Ship wakes can dissipate harmlessly or adversely impact shorelines. Caleb Anstey Photography | Shutterstock.com

Ship wakes are another environmental disturbance. They can dissipate harmlessly or they can adversely affect shoreline characteristics. For instance, they can cause inundation of bird nests in tidal marshes or the re-suspension of sediment in the water which allows it to be carried and deposited elsewhere. Wakes vary according to ship size, speed, direction, and water depth. Under-keel clearance is also a factor, particularly in narrow, shallow waters where a ship's handling characteristics and wake patterns are different. Reducing wake effect is best controlled through speed management, which also serves to limit mammal strikes.

Providing sufficiently deep navigation channels for large ships requires regular dredging, which disturbs benthic habitats and produces material that must be appropriately managed to protect human health and the environment. Dredged material can be appropriately disposed of in open water or on land, and some can be beneficial to building critical wetlands and providing fill material for community development.

Alternative technologies for marine fuels and energy have great potential for improving the environmental footprint of waterborne commerce. Recent international and national standards for conventional marine fuels, innovative new fuel concepts, new exhaust remediation technology, and shore-to-ship alternative powering techniques are providing policies, products, and methods to reduce emissions.

Historically, the marine industry has relied largely on carbon-based fuels—specifically heavy fuel oil—but advances in requirements, available technologies and fuels, and priorities are shifting the diversity of fuels used in the maritime sector. The existence of emission control areas provides vessel operators operating within U.S. waters additional motivation to move to less polluting fuels and mechanisms. Mandated decreases in the allowable sulfur content of fuel oil will drive continuing efforts to find and use lower sulfur fuels.

Conclusion

The MTS stretches along the nation's coastlines and into its inland waters. It will continue to be a critical link in our national supply chain and federal agencies will continue to engage industry partners to support and enhance best practices to preserve our treasured natural resources.

About the authors:

Helen Brohl is the executive director of the U.S. Committee on the Marine Transportation System, managing the interagency partnership to address our nation's waterways, ports, and intermodal connections. During her tenure, the committee has built a substantial portfolio related to navigation safety, Arctic shipping, infrastructure investment, system performance, innovative science and technologies, maritime data management, military to mariner transition, port and coastal resilience, and most recently, impacts of the COVID-19 pandemic on the MTS.

M. Chase Long joined the U.S. Committee on the Marine Transportation System in early 2020, and is the senior advisor and staff lead related to maritime data, infrastructure investment, and MTS supply chain. He earned his Bachelor of Science degree in coastal biology from the University of North Florida, and is completing a Master of Science degree in marine science with a concentration in fisheries at the Virginia Institute of Marine Science.

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The Columbia Snake River System

Keeping the Pacific Northwest green—in more ways than one

by Scott Clemans
Communications Director
Pacific Northwest Waterways Association

A friend of mine who works in the railroad industry jokes that he has seen a lot of American cities in his career, but has never been able to appreciate any of them. That is because he only ever sees the industrial areas the tracks run through. As he puts it, "No city looks green and beautiful from the tracks."

I suspect a lot of us in the maritime sector have similar experiences, but our view from the docks is as misleading as that from the tracks—maybe more so. Our maritime sector is actually the nation's "greenest" mode of commerce. Here in the Pacific Northwest, our Columbia Snake River System (CSRS) proves why in three different ways.

If you are not familiar with the Columbia River and its major tributaries, you are not alone. The Columbia often does not get as much attention as other great American rivers like the Mississippi, Colorado, Ohio, and Hudson. A lot of that is simply geographic isolation. We are pretty far from the rest of you up here in the Pacific Northwest, and you probably do not know much about us except from "Portlandia" and Seattle's '90s grunge music scene. Do not feel bad—the Columbia doesn't get the love it deserves even from a lot of us who live here. It is separated from the region's population center along Puget Sound by the Cascade Mountains and a lot of high desert and, with the exception of Portland, Oregon, it does not really run through major urban areas.

Even for those in Puget Sound who could not find it on a map, the Columbia and its tributaries truly carry the lifeblood of the Pacific Northwest. The 1,243-mile mainstem Columbia begins its course in a deep glacial valley between the Canadian Rockies and Columbia Mountains in southeastern British Columbia. It flows northwest for 200 miles, before abruptly bending south around the edge of the mountains and flowing into northeastern Washington state. There, in north-central Washington, it turns west and then south again, flowing all the way to the Oregon border before turning west and dividing the two states all the way to the Pacific Ocean.

The Columbia River accommodates deep-draft shipping from its mouth to Vancouver, Washington, 106 river miles inland. Just before Vancouver, the Willamette River flows into the Columbia at Portland, accommodating deep draft shipping 11 river miles into downtown Portland. Similarly, the Columbia and its tributary Snake River, which joins the Columbia near the tri-cities of Kennewick, Pasco, and Richland in southeastern Washington, accommodate barge traffic 360 miles from Vancouver to Lewiston, Idaho, on the Washington-Idaho border.

The Columbia, Snake, and Willamette rivers are collectively home to 23 ports, including large multiterminal import/export gateways like the Port of Portland; commercial and recreational fishing hubs like the Port of Ilwaco; and multiuse industrial facilities like the Port of Arlington.

A loaded barge is pushed up the Columbia river at the Astoria-Megler Bridge in Oregon. Barging is the most fuel efficient and lowest emission option for transporting wheat. Jonathan Lingel | Shutterstock.com

Fourteen of these ports are accessed by a system of U.S. Army Corps of Engineers dams and navigation locks, four each on the lower Columbia and Snake rivers. And what amazing locks they are! John Day Lock & Dam on the mainstem Columbia is the highest single lift lock in the nation at 113 feet, with a downstream lift gate weighing almost 2 million pounds. Most of the other locks are similarly massive.

So how is all this maritime infrastructure "green?" For starters, it generates some serious green cash for the region and nation.

Greening the Economy

The CSRS is one of the nation's largest export gateways, connecting U.S. farmers and manufacturers with overseas markets. It is the nation's single largest wheat export gateway, transporting more than 50 percent of all U.S. wheat to markets overseas. Eleven states export wheat through our rivers, which moved over 13 million metric tons in 2019.

The Columbia River is second in the nation for soy exports, with over 8 million metric tons transported in 2017. The majority of this product originates in Minnesota, Iowa, Nebraska, the Dakotas, Kansas, and Missouri, and is moved to the Lower Columbia River by rail. The beans are destined for ports in East Asia with China as the top buyer. Soy exports are expected to grow in tandem with the East Asian population.

The CSRS is also the nation's second largest corn export gateway, and the West Coast's largest wood, mineral bulks, and automotive export gateway.

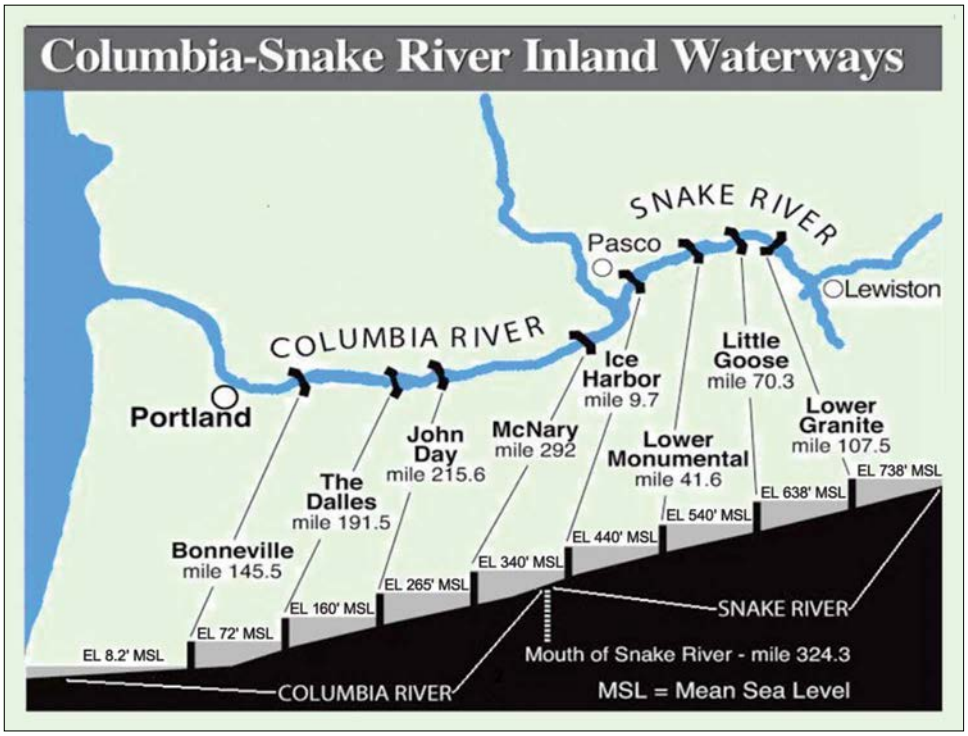
In 2018, the CSRS facilitated over 56 million tons of international trade with a cargo value of at least $21 billion. Oregon and Washington are two of the most trade-dependent states in the nation, with over 40,000 local jobs dependent upon commerce on the river. But it's not just the Pacific Northwest that depends on that trade.

"Whenever I have conversations with people at headquarters and elsewhere in the nation about the critical importance of maintaining the Columbia Snake River System's navigation infrastructure, I mention that keeping this export gateway open isn't just a U.S. economic issue," Coast Guard CAPT Jeremy Smith, Sector Columbia River commander, said. "This river feeds a lot of the world. That makes it a worldwide food security issue, and therefore a U.S. national security issue. Eyes always open wider when I talk about that."

From an irrigation perspective, the rivers have literally greened hundreds of thousands of acres of farmland, turning the Pacific Northwest into an agricultural powerhouse.

It's not part of the Columbia Snake navigation system farther downriver, but Grand Coulee Dam in northeastern Washington is the 800-pound gorilla of the region's water resources infrastructure. Almost a mile long and 550 feet high, the dam has over 5.5 million acre-feet of active storage behind it that provides irrigation water to almost 700,000 acres of land through the Columbia Basin Project (CBP).

As a result of irrigation water from the CBP and other CSRS dams, Pacific Northwest agriculture is booming. Washington's agriculture production alone topped $9.6 billion in 2018, with another $20 billion in food processing revenue. The state is among the top three producers in 15 different food categories. Oregon boasts similar statistics.



The U.S. Army Corps of Engineers monitors 14 dams on the Columbia River system, including The John Day Lock & Dam, the highest single lift lock in the United States at 113 feet. Graphic courtesy of the U.S. Army Corps of Engineers

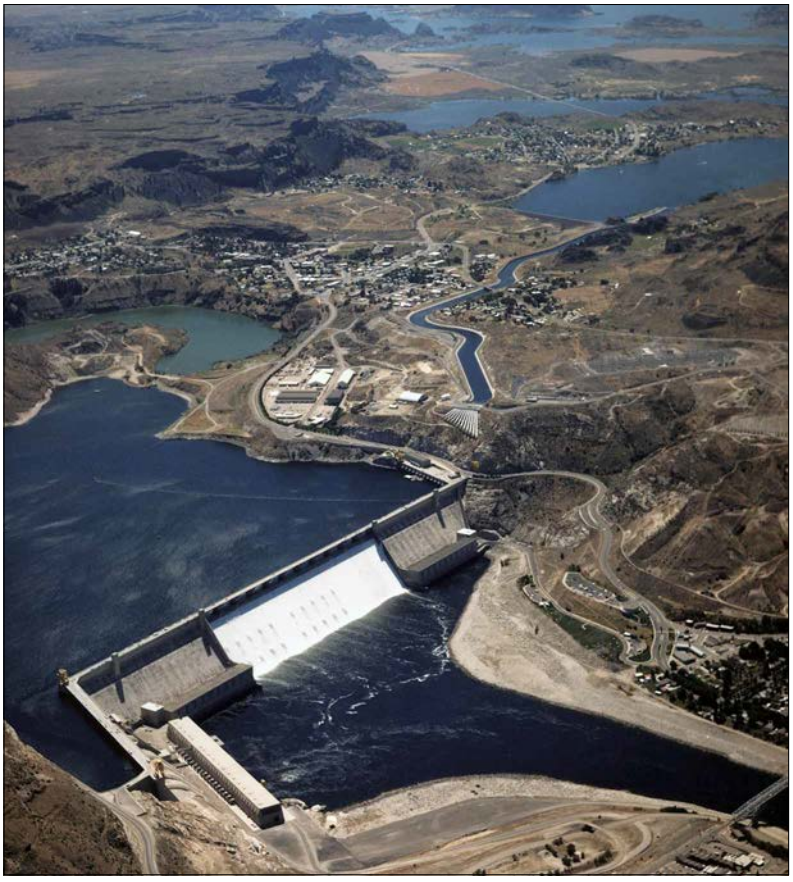
Green Transportation

From an environmental perspective, the navigation and hydropower benefits of the Columbia and Snake rivers, and other Columbia Basin tributaries, are two of the region's most important weapons to keep our planet

green in the battle against climate change. If a U.S. product is going overseas from the Pacific Northwest, it's almost certainly departing by ship from one of the region's deep draft ports. But producers have the option of truck, train, or barge for getting their goods to those ports.

With the lowest emissions and best fuel efficiency, barging is by far the most environmentally friendly of the options. Towboats are more than three times as fuel efficient as trucks and 40 percent more efficient than trains. Additionally, each four-barge tow carries as much as 538 semi-trailers or 140 train cars.

A recent study determined that eliminating barging as a transportation option in the Pacific Northwest would cause diesel fuel consumption to increase by nearly 5 million gallons per year as barges are replaced by less efficient truck-to-rail shipments. This could occur if the four lower Snake River dams are breached, as environmental extremists consistently call for. At a time when both Oregon and Washington are aggressively pursuing shutdowns of existing coal plants to help achieve ambitious carbon reduction goals, the resulting carbon emissions would be equal to those of building a new coal-fired power plant every five to six years.



Through the Grand Coulee Dam, the Columbia Basin Project is the largest water reclamation project in the United States. Water from the river is pumped and carried over 300 miles in order to irrigate over 670,000 acres through reservoirs, irrigation canals, drains, and waterways. U.S. Bureau of Reclamation photo

Even more recent research has revealed that mass die-offs of coho salmon in the Pacific Northwest and elsewhere along the West Coast can be tied to a chemical antioxidant used in tires to make them last longer. Tire treads break down over time and leave behind bits of microplastics on roads and the antioxidant in them reacts with ozone to become a different chemical byproduct that is toxic to coho salmon. Researchers found its presence in roadway runoff samples taken from across the West Coast, leading them to conclude it is likely the main cause of the population decline.

Barging on the CSRS kept over 330,000 trucks—and the toxic byproducts from their nearly 6 million tires—off Pacific Northwest roads and out of waterways in 2018 alone.

Green Power

Grand Coulee Dam is not only the centerpiece of the region's irrigated agriculture infrastructure, but also of hydropower, which is another important weapon in the battle against climate change. Capable of producing over 6,800 megawatts of clean, renewable electric power, it is the nation's largest power station, and joins other hydropower dams in providing 90 percent of the Pacific Northwest's renewable energy, and about 46 percent of its total energy.

Hydropower also provides the firm power supply needed to integrate other intermittent renewable power sources like wind and solar into the power grid. Managers can quickly adjust the amount of power dams produce to compensate for fluctuations in wind and sunlight, providing balance and stability to the region's electric supply.

So, if you ever get the chance to moor ship at one of our many ports along the Columbia Snake River System and look around, do not be deceived by what you see at the docks. You are actually looking at, and contributing to, one of the greenest commercial systems in the nation and world.

About the author:

Scott Clemans joined Pacific Northwest Waterways Association in August 2019. He has over 20 years of professional communications experience with the U.S. Army Corps of Engineers, U.S. Forest Service, and U.S. Army Reserve, as well as telecommunications and software companies. Clemans earned a master's degree from Portland State University, a bachelor's degree from Willamette University, and Public Affairs MOS qualification from the Department of Defense Information School. He lives in Vancouver, Washington, with his wife and two daughters.

The Greater Charleston Port Complex

Expanding global accessibility through capital improvements and strategic collaboration

by CDR Corydon Heard, Ph.D.
Prevention Department Head, Sector Charleston
U.S. Coast Guard

LCDR Chad Ray
Waterways Management Division Chief, Sector Charleston
U.S. Coast Guard

"The South is not a monolith. There are pockets of weirdness, awesomeness and then there's Charleston."
—Anthony Bourdain

The late chef and globetrotter summed it up well. Southern in every way, Charleston stands alone. This historic center of American maritime commerce and culture is situated on the Atlantic coast of South Carolina where the confluence of the Ashley, Cooper, and Wando rivers form an inlet intersecting with the Intracoastal Waterway.

Fondly referred to as Chucktown, a throwback to its namesake King Charles II of England, and the Holy City, for its many church spires and diverse congregations, Charleston is a "Port City" to its core. Originally named Charles Town by English colonists in 1670, the settlement was eventually relocated from Albemarle Point to Oyster Point, favoring a strategic location at the junction of the Ashley and Cooper rivers.[1] By 1740, Charles Town's bustling East Bay Street wharves became North America's principal seaport for exporting raw materials and a hub for importing European staples, garnering a reputation as the "Little London" of the American Colonies. In the late 1760s, Gadsden's Wharf was established along the same waterfront as a major destination for ships engaged in the trans-Atlantic slave trade, a role denounced by a 2018 Charleston City Council Resolution.

Nearly three centuries later, despite a storied past, the Greater Charleston Port Complex is more relevant and nationally significant than ever. An epicenter of strategic activity, Charleston balances maritime commerce—the backbone of South Carolina's economy—with military throughput to ensure transportation readiness as one of 17 strategic seaports designated by the federal government. Spanning multiple municipalities along the Cooper and Wando rivers, today's commercially driven Port Complex comprises six public terminals owned and operated by the South Carolina Ports Authority (SCPA), several independent bulk cargo and petrochemical facilities, and a large-scale repair and service shipyard. Within the same footprint exists a federal presence consisting of a Naval weapons station, a sizeable contingent of Ready Reserve Force ships, and a budding major homeport for Coast Guard cutters.

Remaining true to its maritime roots, Charleston stands at the forefront of the "big ship era" with a focus on the deep channels, advanced technology, and expanded infrastructure needed to facilitate the next-gen fleets of efficient ultra-large cargo ships and modern military vessels. In April 2020, Charleston marked 350 years since the 200-ton, triple-masted frigate *Carolina* first arrived in the natural harbor that would ultimately become the Greater Charleston Port Complex. Months later, Charleston welcomed CMA CGM *Brazil*. At almost 150,000 gross tons (GRT) and cargo capacity of more than 15,000 20-foot equivalent units (TEU), it is one of the largest ships to make a port call on the United States' East Coast.

Development of the Port Complex

The development of Charleston's Port Complex over the last 20 years has been anything but subtle. In an industry where profits are made while underway, Charleston's Port Complex takes advantage of its natural geographic layout to cater to its client's schedule with its shortest transit from sea buoy to terminal at only one hour.

Steaming inbound, SCPA's Union Pier and Columbus Street terminals stretch along Charleston's East Bay Street. Once, where wooden wharves drove out above wet marshland, supporting the export of rice, indigo, and tobacco, now sits the port's cruise ship terminal, a commercial Ro-Ro dock, and general cargo facility. Columbus Street Terminal (CST) plays a major role in the automotive trade, moving more than 220,000 vehicles in and out of the southeast corridor of the United States each year. It also handles nearly 700,000 pier tons of break bulk cargo, like metals and equipment, each year.

Zhen Hua 27 begins its approach to Port Charleston's Wando Welch Terminal to deliver two new 155-foot-tall ship-to-shore cranes. South Carolina Ports Authority photo by English Purcell

Meanwhile, adjacent to CST, Union Pier Terminal (UPT) annually hosts around 260,000 cruise ship passengers looking to indulge in Charleston's emerging culinary scene and rich American history. UPT is a Carnival Cruise Line homeport, and was the site of the 2020 State of the Coast Guard Address.

Spanning the city's skyline and dividing Charleston's lower and upper harbor, stands the Arthur Ravenel Jr. Bridge, locally known as the Ravenel or Cooper River Bridge. In 2005, a joint federal-, state-, and local-agency effort culminated with the replacement of the dilapidated John P. Grace Memorial and Silas N. Pearman bridges. In their place opened the 1,546-foot cable-stayed Ravenel Bridge, a gateway welcoming post-Panamax shipping, with its 186-foot air gap and 600-foot-wide channel. As the third longest cable-stayed bridge in the Western Hemisphere, the Ravenel Bridge provides the shipping industry's latest and largest ocean carriers access to the most recent investments the Port Complex has to offer. These investments consist of three SCPA container terminals, several independent bulk and petrochemical facilities, a shipyard, and a Naval weapons station, which all lie north along the Cooper and Wando rivers.

The Wando River, branching off from the Cooper River, leads up to SCPA's newly christened $43.2 million headquarters and its flagship Wando Welch Terminal (WWT) in Mount Pleasant, South Carolina. SCPA's $450 million investment into the 40-year-old WWT has outfitted it with upgraded internal planning, facilities, and equipment further modernizing the terminal to handle more cargo and bigger ships. By the end of 2021, WWT will be able to simultaneously work three 14,000-TEU ships employing 15 155-foot ship-to-shore cranes and 65 rubber-tired gantry cranes.

In March 2021, SCPA opened its newest container terminal, the Hugh K. Leatherman Terminal (HLT) along the Cooper River in North Charleston. HLT is the first new container terminal to open in the United States in more than a decade, and is capable of handling a 19,000-TEU vessel. The phase 1 opening provides 1,400 feet of open wharf with five 169-foot ship-to-shore cranes, 25 hybrid rubber-tired gantry cranes, and a 47-acre container yard, increasing the Port's TEU capacity by 700,000. When completed in 2033, the terminal will create an additional 2.4 million TEU capacity, doubling Charleston's current capacity.

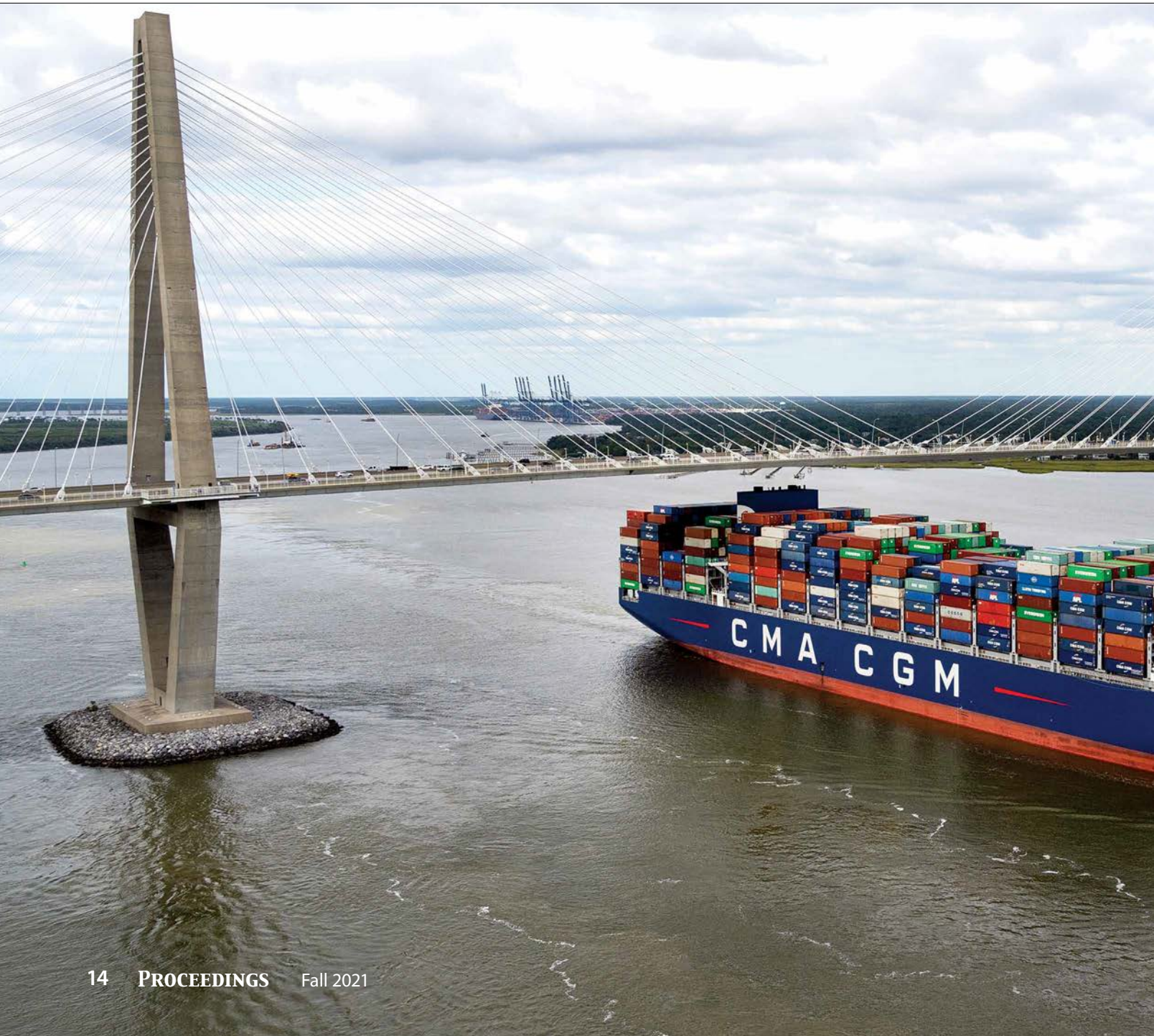
Up the Cooper River and beyond the Ravenel Bridge, lies SCPA's North Charleston Terminal (NCT). Previously

owned and operated by the U.S. Army as an embarkation terminal used to move troops and supplies bound for the European theater during World War II, NCT continues to impact international trade by directly contributing to SCPA's 2.32 million TEUs handled during FY20.

The rising tide of Charleston's container trade has undoubtedly lifted business opportunities for other markets in the area. The addition of Odfjell Terminals in 2013 and Carver Maritime in 2016 increased the Port Complex's diversity to 12 independently operated bulk cargo and petrochemical terminals. These operators account for approximately 25 percent of the port's vessel movements every year, demonstrating the variety of cargo seen on Charleston waters.

From Military to Commercial

Historically significant dates, like January 9, 1861, undoubtedly influenced the perception of Charleston as a port of military significance. That day, Southern secessionists fired on the Union merchant ship *Star of The West* as it delivered supplies to Fort Sumter, stoking the Civil War.[2] While the 21st century needs of the military largely dictated the development of the Port Complex, Charleston has shifted the focus from a history of military readiness to that of a future of continued commercial growth through capital improvements and strategic collaboration. Vessels that continue to push the envelope of size, versatility, and cutting-edge technology calling on Charleston are reflective of those efforts.



In 2020, the average size of inbound container ships was 83,000 GRT compared with 51,000 GRT in 2012. This equates to a 62.7 percent increase in cargo capacity per ship over the eight-year period.

CMA CGM *Brazil* provided the best demonstration of increased cargo and next-gen ship capacity in September 2020. The 15,072 TEU container ship was given a warm welcome at each of its prior port calls—New York/New Jersey; Norfolk, Virginia; and Savannah, Georgia—before the WWT gave it a Lowcountry welcome as the largest ship ever to make a port call on the Eastern Seaboard at the time.

As newly christened ships straight from the builder begin their trade at Charleston terminals, vessels far removed from their ceremonial launching find their place among inbound traffic. Detyens Shipyard, with its four dry docks and 8,000 feet of deep-water pier space, plays a vital role in its development. Originally established by President Theodore Roosevelt in 1902 to build and repair ships for U.S. war efforts, the Charleston Navy Yard was handed over to Detyens Shipyards in 1996. For the past 25 years Detyens has continued this mission, adding commercial and cruise ships.

The Charleston Port Complex's ability to capitalize on its rich maritime history, providing facilities, terminals, and infrastructure more than capable of catering to the shipping industry's next iteration of technology, has swiftly impacted its host city, state, and region for the better.

The 15,072-TEU CMA CGM *Brazil*, one of the largest ships to make a port call on the United States' East Coast, passes under the Arthur J. Ravenel Bridge in September 2020 as it departs the Wando Welch Terminal. South Carolina Ports Authority photo by Marion Bull

Revealing the Lowcountry

While the Lowcountry refers to a debated geographic location of South Carolina, generally between the Savannah River and Pawley's Island, to locals it is synonymous with a caliber of service, hospitality, and a way of life. For years, this lifestyle referred to the kindness of Lowcountry natives, as well as the charm of its land and city. Now Lowcountry operations have branded this manner of living and genteel hospitality to entice international partnerships toward the state … and it's working.

More than 40 major business, including General Electric, Walmart, Boeing, Samsung, and several European auto makers, rely directly on the Greater Charleston Port Complex and its distribution and logistics industry. As the southeastern United States continues its automotive and aerospace industries boom, cities like Charlotte, North Carolina; Nashville, Tennessee; and Atlanta are emerging as global business hubs. However, it is South Carolina's 41,000 miles

of state-maintained highways, 2,300 miles of rail, and the Charleston Port Complex, that connect the nation's supply chain to the rest of the world. That supply chain has proven to be not only an economic lifeblood for Charleston and its surrounding areas, but for the state, as well.

Gone are the days where the first thoughts of the Lowcountry are raised houses overlooking soft marshlands thick with cordgrass, the smell of pluff mud in the morning and shrimp-and-grits in the evening, and palmetto trees topping the skyline. In harmony, thoughts are now of deep-water channels, reliable and efficient terminal operations, and cutting-edge technology linking the Southeast Corridor to the rest of the world through just-in-time-commerce. The Greater Charleston Port Complex's mission of providing a Lowcountry experience for business partners and shipping lines carrying countless sectors' goods and products delivers real numbers for its state.

According to an SCPA study done by the University of South Carolina's Moore School of Business, port operations are responsible for one of every 10 jobs created in South Carolina. Those port jobs pay 32 percent more than the state's average annual wage. The complex's $63.4 billion annual economic impact and $1.1 billion annual generated tax revenue has increased the quality of life for locals. In a 2019, pre-COVID-19 smartasset.com study of "Top Boomtowns in America," North Charleston, Charleston, and Mount Pleasant topped the list boasting, among other gains, a 23.59 percent increase in household income growth.

The number of households are growing, as well. A 2003 Clemson University study predicted the Charleston area's population could hit 800,000 by 2030, a number Charleston exceeded in 2019—11 years early. To accommodate the rapid growth, local officials have approved plans for nearly 105,000 new homes throughout the area, which will be necessarily accompanied by retail and service providers, schools, and hospitals. At the heart of this growth is the strategic planning, efforts, and candid coordination between members of the marine transportation system and Charleston officials.

Fundamental to Nation's Success

The federal government has long seen the importance of the Port of Charleston in terms of military necessity. So much so that the Maritime Administration's National Port Readiness Network identified Charleston as one of 17 commercial strategic seaports capable of coordinating quick response to military requests in times of emergency while balancing commercial traffic.

To keep pace, in 2011, the U.S. Army Corps of Engineers began working alongside the SCPA and port partners on the "Charleston Harbor Post 45 Deepening Project," also referred to as "Post 45." This project, one of the first expedited under President Barack Obama's "We Can't Wait" critical infrastructure projects, is deepening the harbor and surrounding rivers from 45 to 52 feet, as well as widening sections of the Wando River. Scheduled for completion in 2022, the 2020 budget's allocation of $138 million ensures an on-time completion.

Post 45 has laid the bedrock for Charleston's Port Complex as it anticipates handling neo-Panamax ships. Upon completion, Charleston will be one of the deepest ports on the East Coast, allowing the world's largest vessels to transit without navigational restrictions, providing more than $169 million in average annual benefit, and solidifying the Charleston Port Complex's future.

Looking to the future, the Commandant of the Coast Guard, Admiral Karl Shultz, highlighted in his 2020 State of the Coast Guard address the role Charleston will play in the service's evolution. He identified the city as a "future Coast Guard operational center of gravity" with "the potential to grow into the largest concentration of assets and people in the Coast Guard."

In 1996, the Navy pulled out of the Lowcountry, creating a vacuum largely filled by the vigor of Charleston's maritime industry. Twenty-five years later, the Coast Guard is now ready to invest in additional infrastructure to support the growth of assets and personnel. The Coast Guard's close work with the Department of Homeland Security and SCPA to secure land in the port will shuffle the service's footprint into a consolidated, efficient operation similar to that of the Navy in San Diego or Norfolk, Virginia.

This growth includes plans to homeport five national security cutters (NSC) and a future compliment of offshore patrol cutters (OPC). Such a move is a further endorsement of Charleston's continued strategic importance dating back to the revenue cutter *South Carolina*, one of the original 10 cutters called for by Treasury Secretary Alexander Hamilton in 1790. Replacing an aging fleet of high and medium endurance cutters dating back to the 1960s, the NSC and OPC fleets are the newest, most capable, and most technologically sophisticated platforms the service has to offer. To date, nine NSCs have been delivered and the lead OPC, *Argus*, is scheduled for delivery in 2022. These new classes of cutters are designed to execute the most challenging operations in the most demanding environments for maritime homeland security and defense missions.

Port Coordination and Interagency Relationships

In shared waters where one operation directly impacts another, the ability to recognize port safety, mobility, and environmental protection issues are vital. Harbor safety committees, marine exchanges, maritime transportation system committees all seek the same goal of

transparent coordination in the name of safe, sound operations. These local bodies are found in each and every one of the nation's major ports, and the Charleston Port Complex is no different.

Whether commercial or governmental, the professionals at the helm of this gateway linking the Lowcountry to the rest of the world, are as diverse, experienced, and forward-looking as one would expect from a port like Charleston. This becomes most evident between June 1 and November 30, as the entirety of Charleston turns an eye toward hurricane alley. The Heavy Weather Advisory Group, a function of the Charleston Area Harbor Safety Committee, delivers real-time input on local operations and coordination for overall port well-being in response to severe weather events.

This coordination does not end with the hurricane season. In fact, as demonstrated in March 2020, it remains very much alive and ready for any type of disruption, casualty, or other large-scale event. COVID-19 has been an "all-hands on deck" event and the Charleston Port Complex's early identification of this allowed it to maintain a supply chain throughout 2020 that met not only the needs of South Carolina, but the nation. Highlighting the port's ability to deliver during the demanding circumstances of 2020, SCPA reported its strongest December on record, surpassing TEUs handled, pier container moves, and vehicle movements from one year prior.

Expansion and Future Plans of the South Carolina Ports Authority

As the southeast continues to attract new residents and businesses, SCPA has strategically planned to accommodate future growth. SCPA is investing more than $2 billion to build timely, world-class infrastructure, ensuring ample capacity and big-ship capabilities for decades to come.

In 2021, SCPA opened the Hugh K. Leatherman Terminal and further enhanced Wando Welch Terminal. The container terminal investments will enable SCPA to handle a total of four 14,000-TEU vessels simultaneously, greatly enhancing the port's capabilities and global competitiveness. Once completed in 2022, the Post 45 project will provide a deeper Charleston Harbor, allowing mega container ships to call on SCPA any time, any tide—an attractive asset to ocean carriers.

SCPA is also working to expand its rail-served Inland Port Greer near Greenville, South Carolina, as well as further develop the state's rail networks and intermodal hubs. As a top 10 U.S. container port, it is imperative that SCPA invests in infrastructure and grows above the market. SCPA has doubled cargo volumes over the past decade, and looks to continue this growth by diversifying its cargo base, particularly by moving goods for large retailers and e-commerce sites. Walmart is currently building a nearly 3-million-square-foot distribution center on port-owned land in Dorchester County, South Carolina, which will boost port volumes by 5 percent. As SCPA works to grow retail imports, the port also looks to increase exports with agricultural, forest, and refrigerated goods, among other cargo.

Future of the Charleston Port Complex

Excitement in South Carolina's "Port City" builds year after year, as the Charleston Port Complex positions itself for long-standing success. Stories of marquee collaborations, ground-breakings for state-of-the-art facilities, and record-setting cargo movements have become a frequent feature of local news outlets.

With the development of the Charleston Port Complex, the quaint, southern town has meshed with a metropolitan environment reflective of its expanding business and global presence. The counties of Charleston, Dorchester, and Berkeley that make up the greater Charleston area have all seen an increase in population. Their explosion of the 2003 Clemson University predictions for 2030, and a 2.5 percent annual population increase puts the Charleston area on track for over 1 million people by 2028. How these numbers will be impacted by Americans ditching the mega-cities for suburban life in response to COVID-19, only time will tell.

What is known today is that the Greater Charleston Port Complex, while remaining true to its maritime roots, is ready to assume its national role. This once fledgling colonial port has evolved into a dynamic complex, impressing leaders as an epicenter of strategic activity as it welcomes the next-gen fleet of efficient, ultra-large cargo ships and modern military vessels.

About the Authors:

CDR Corydon Heard is the prevention department head at Sector Charleston. He has served in the Office of Budget and Programs, as well as the Office of Commercial Vessel Compliance, at Coast Guard Headquarters. Prior field assignments include Marine Safety Unit Texas City, Activities Europe, and Sector Baltimore. He is a graduate of the U.S. Merchant Marine Academy, holds an unlimited U.S. Merchant Marine Officer endorsement, and has earned a master's degree as well as a doctorate in business administration.

LCDR Chad Ray is the Waterways Management division chief at Sector Charleston. Prior field tours include Sector New York, Sector San Diego, and USCGC Hamilton *(WHEC-715). He is a graduate of the U.S. Merchant Marine Academy and holds an unlimited U.S. Merchant Marine Officer endorsement.*

Endnotes:

1. Having been previously incorporated as Charles City and Port in 1722, Charleston adopted its present spelling when it was reincorporated as a city in 1783 at the end of the Revolutionary War.
2. The first naval shot of the Civil War is considered to have been fired on April 12, 1861, by the revenue cutter *Harriet Lane* across the bow of the steamer *Nashville* approaching Charleston Harbor.

Modernizing the Global Supply Chain

Lessons learned from a pandemic

by Lori Ann LaRocco
Senior Editor
CNBC Business News

Nick Vyas
Executive Director
Marshall Center for Global Supply Chain Management
University of Southern California

Amid all the tumult unleashed by COVID-19 and the social media turf wars, what has gone unnoticed is that the sands of the global supply chain landscape are shifting. It began about halfway through the Sino-American trade conflict, which started nearly a decade ago but accelerated during the previous administration.

The trade war put pressure on multinational corporations to move manufacturing out of China. To avoid tariffs that President Donald Trump placed on $360 billion worth of Chinese goods, companies like Samsung, Nike, Nintendo, and Williams-Sonoma moved partially, or entirely, to Germany and Vietnam, causing U.S. trade with China to fall sharply. As a result, countries like Vietnam, Taiwan, and Mexico benefitted.

Engines of Change

China's manufacturing dominance was driven by providing the lowest acquisition cost producers could find anywhere in the world. China consistently provided mass quantities of goods produced at the cheapest rates, at scale. All this was supported by a massive infrastructure, a relaxed regulatory atmosphere, and incentives offered to manufacturers to set up locally. This increased the world's appetite for this cheap source of goods and influenced consumer behavior in the West.

Now, companies hammered by the twin impacts of the trade war and the pandemic are forced to look for alternatives. In a survey conducted in February and March 2020, Gartner Inc. found that one-third of global supply chain organizations have either moved, or plan to move, their sourcing and manufacturing activities out of China in the next two to three years. A quarter of respondents indicated they have already regionalized their supply chains.

This, however, comes at a cost. Companies are discovering that China is the only country that can provide the same cost structure, velocity, and scale. Moving all export-related manufacturing not intended for Chinese consumption out of the country could cost firms $1 trillion over the next five years, according to new Bank of America research.

Digitalize or Perish

The COVID-19 pandemic has revealed the glaring need for supply chain resiliency. The muscles supporting the global value chains were violently ripped away by the drastic imbalance of supply and demand, revealing countless fractures. The processes in the manufacturing and logistics of goods were shattered, and the stability was gone.

The need for control is a fundamental trait that influences human behavior. The pandemic eviscerated that sense of well-being. Supply chain visibility became opaque as manufacturers were shuttered and vessels were canceled, but consumer demand soared.

Now on the other side of the pandemic where commerce is moving once again, we are reading more about the benefits of supply chain digitalization and the acceleration of its implementation. For the good of humanity, to achieve this, every facet that is instrumental in the flow of trade—manufacturers, logistics, carriers, ports, and warehouses—need to approach and employ these ideas and technologies with a scalpel, not a hatchet.

The world we live in is far too interconnected to be ripped apart and begun anew. Given that more than 90 percent of world trade moves on water, the solution to streamlining trade lies in improving the performance metrics of intermodal logistics.

According to MarineTraffic automatic identification system data, more than 22 percent of commercial vessels arrive at their destination a day later than planned. Fifteen percent of vessels are also making additional stops en route to their destination, which impacts efficiency.

A series of crises like U.S. port strikes, the pandemic, and the Beirut port explosion have wreaked havoc with the maritime logistics sector's service reliability and

increased the demand for improved visibility.

"Our forecast ETA calculations and metrics on waiting times have long been pieces of information most requested by the logistics and supply chain sectors," said Daniel Shirley, senior product manager at MarineTraffic. "We're currently seeing a big rise in requests for information on both vessel whereabouts and potential delays. These inquiries are from people looking to get ahead of the game and understand the potential impact the COVID-19 pandemic will have on their supply chain. This is a spike in demand for improved shipping visibility rather than a fresh need for information."

Removing in-transit uncertainty by monitoring a vessel's journey end-to-end through digitalization can inject more stability and control in this new normal where manufacturing is an amalgamation of global companies. The trouble is, the maritime industry is not ready for a digital transformation. Containerized shipping is still heavily reliant on paperwork and personal interactions, further hampered by lockdown restrictions during the pandemic. According to the World Economic Forum, 20 percent of the cost of shipping goods is administrative paperwork expenses.

Even the ports are far from prepared. To illustrate, to date, only 49 of the 174 member states of the International Maritime Organization have functioning port community systems (PCS). PCS are interorganizational software platforms that enable information exchange and are crucial to the digitalization of ports.

Digitization of paperwork will not only benefit ocean freight, but it will also help boost international trade. According to the U.N., a complete digitalization of shipping trade paperwork in the Asia Pacific region alone could raise yearly exports by $257 billion, a massive boost for regional exporters.

Sector stakeholders are, of course, acutely aware of the need for digitalization. In June 2020, several prominent industry associations jointly launched a call to action to accelerate the digitalization of maritime trade and logistics. Co-signees included the International Association of Ports and Harbors, BIMCO, the International Cargo Handling Coordination Association, the International Chamber of Shipping, the International Harbor Masters' Association, the International Maritime Pilots Association, and the International Port Community Systems Association. With the trade patterns shifting from traditional monolithic supply chains to near-shored, decoupled trade networks, companies need to be willing to embrace automation and digitalization to survive.

BIMCO is the world's largest direct-membership organization for shipowners, charterers, shipbrokers, and agents.

Another example of the interdependence of value chains is the assembly of automobiles. The American Automobile Labeling Act of 1992 mandates that only 55 percent of all car components need to be made in America to be labeled "American Made," meaning the U.S. automobile includes many foreign parts. According to Cars.com's American-Made Index, the Ford Ranger can claim being the most American made vehicle in 2020 with 70 percent domestic parts.

Digitalization is needed so the sum of all product segments can be efficiently produced, tracked, and transported. This can feed the sense of control humanity is so desperately seeking. Unfortunately, you have parts of the world that are still pushing paper because of digital disparity. Therefore precision, like a trained surgeon using a scalpel, is needed when constructing a proper digital supply chain that is interoperable. Building various platforms that cannot talk to each other, leaving critical components out of such communication, uses the equivalent of a hatchet to make a delicate incision.

Visibility Saves Lives

A real-world example of digitalization deployment is the timeline to source and transport personal protective equipment (PPE) to the state of Minnesota during the pandemic. The timeline began in mid-March when Governor Tim Walz created an economic council with partners from both the public and private sectors with the mission of securing badly needed PPE as quickly as possible. C.H. Robinson was one of the companies asked to help.

The PPE procurement involved fulfillment during the immediate surge in demand. But the surge was just one obstacle. Minnesota was up against significant competition from other states and federal agencies vying for the same product and inbound quality checks to vet fakes and bad quality PPE added time to the delivery. It also faced medical protectionism and U.S. Customs and Chinese regulations changes.

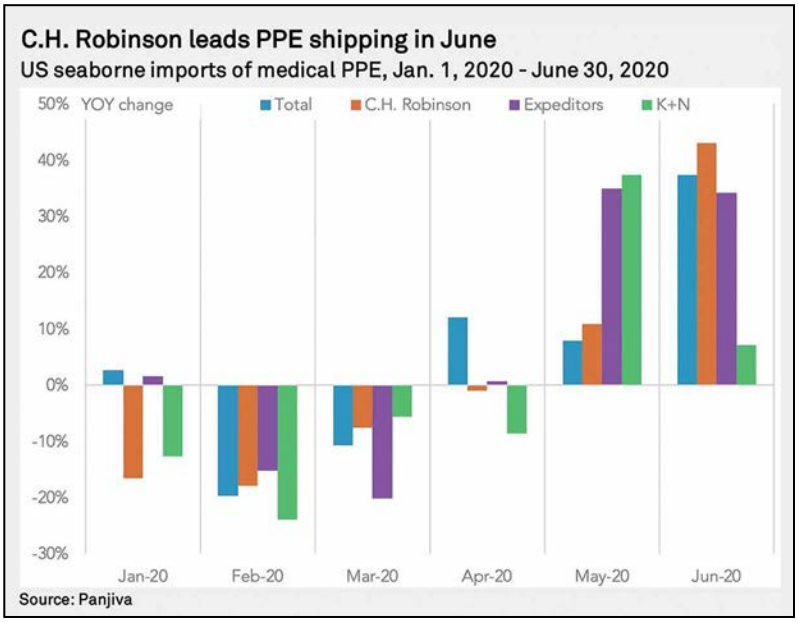
"We originally reached out to our contacts and resources in Wuhan, China, to help locate new suppliers for the state," said Mac Pinkerton, C.H. Robinson's North American Surface Transportation division. "While we were successful in moving product out of China, we also provided additional routes. Digitalization enabled us to quickly identify the bottlenecks in the supply chain and identify other areas of opportunity."

One example was the decision to use the 'fast boat' over air freight to deliver an order of surgical gowns. In

times of crisis, real-time visibility is vital.

"As the number 1 [non-vessel operating common carrier] from China to the United States, we have insights into a range of shipments in Asia, including those from less sophisticated manufacturers who might still rely on paper and phone calls," said Mike Neill, chief technology officer at C.H. Robinson.

"The past six months have reinforced how we invest in technology to continue to solve the real problems facing companies and, with our tech capabilities, we've been able to empower our people and, in turn, our customers, to make smart decisions throughout the crisis," Pinkerton, president of North American surface transportation operations for C.H. Robinson, said. "We have been able to build supply chain resiliency for our customers, which has always been thought of as important but has never been tested like it was this year." Over 72 million pieces of PPE were procured.



Graphic courtesy of Panjiva, S&P Global Market Intelligence

Interoperability Equals Less Siloed Friction

The success of an efficient supply chain relies on the relationships of all those involved within a supply chain. A deep understanding of all participants' strengths and weaknesses is needed so the flow of trade can move as efficiently and cost-effectively as possible. This provides an opportunity for other parts of the supply chain to lean in.

"We have pockets around the world in inner China, Asia, and Eastern Europe, where they are not digital at all and are still pushing paper," Pinkerton said. "They lack the digital technology to be efficient."

Niell said that this is where companies like C.H. Robinson are stepping in as an equalizer. "There is a play for intermediaries to help less sophisticated manufacturers interact with companies that are digital and meet their supply chain," he said. "Digitalization is enhancing the human element by using that digital connection to allow people to work together and solve problems."

Interoperability in the technology base is also necessary. Every leg of the supply chain needs to have the ability to be tracked in real time. The relationships and trust between participants are paramount. If not done correctly with precision, personalization and isolation can result, but the development of such digital infrastructure takes time.

The Port of Los Angeles is a good example of deep public and private sector cooperation. It recently released its digitalization offering, Signal, which provides its users a three-week look at cargo arriving into the port. The information, broken down by the type of container, volume of shipments, and method of transportation, gives users the ability to plan.

"Digitalizing the supply chain takes people," said Gene Seroka, executive director of the Port of Los Angeles, and chief logistics officer of the City of Los Angeles. "We initially started with roundtable discussions five years ago. Data sharing agreements, standards of best practices—all of this is necessary to achieve the goal in supply chain visibility and security."

Knowing how the container is being transported, for instance on a dock or off dock, gives truckers, railroads, and chassis providers the visibility to prepare for the incoming volumes. Because of the fragmented nature of the supply chain and its dynamic breath, digitalization creates a community within the chain. "Technology is the only way to bring the many stakeholders together to move cargo efficiently and transparently," said Weston LaBar, CEO of the Harbor Trucking Association. "The adoption of the carrier alliances, coupled with eCommerce demand, requires better planning and the ability to be more adaptive in real-time."

Unlike a neat, precise cut of a scalpel, the strike of a hatchet, while it can be controlled, is still deep, jagged, and wide. If done correctly, digitalization is precise. If not, the result is gaping voids of inefficiency with countless "best in breed" technologies and existing digital platforms already in use. The democratization of supply chain technology and visibility would help better meet consumer demand. "There are too many antiquated legacy systems that can't properly handle the volume of data being generated," LaBar said. "We have also seen pushback from stakeholders who have already invested in systems and don't want to be forced to conform to new

standards. Finally, there are some companies that profit off the inefficiencies in the system. They don't want that brought to light by transparency."

With supply chain digitalization in the United States still in the early stages, Seroka hopes Signal could be the catalyst to start a discussion on a single standardized digital data set for the country. This is not a pie in the sky concept.

In 2014, the Port Call Optimization Taskforce was created out of Holland's Port of Rotterdam with the sole purpose of encouraging the creation of a single standardized digital dataset. Implementing the same International Organization of Standardization standards used in both the maritime and logistics sectors would create greater efficiency, predictability, and a tighter turnaround of goods being offloaded at the port. The digital black holes of inefficiencies would collapse.

"Even if our eight to 12 participants each gain one percent efficiency, that's a total gain of 8–12 percent," Seroka said. "This is just the beginning. Imagine if we had a nationwide port community system? Digitalization would provide visibility for its users and competitiveness for the nation's ports. Unfortunately, what stops this implementation is personality and politics."

The New Supply Chains

The lean inventory of the manufacturing sector associated with the modern ways of supply chain management is not working in a pandemic age. The numerous stories on the shortage of toilet paper and other products could fill the empty shelves at retailers worldwide. This change in consumer behavior for essential items shows no signs of slowing. At the Port of Los Angeles, cleaning product imports were up 256 percent from January to August 2020.

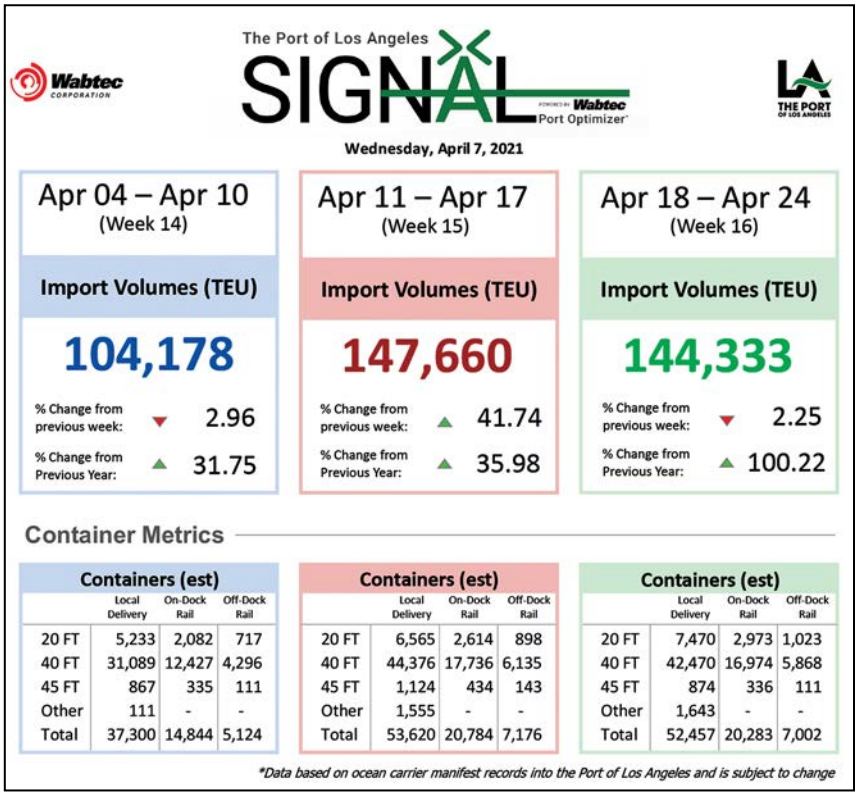
"For the longest time, we have designed our supply chains for responsiveness and how you would fill that demand," said Ashfaque Chowdhury, president of Supply Chain, Americas, and Asia Pacific at XPO Logistics. "Now we have to reimagine the supply chain, so it's not only resilient but sustainable. The right levels of inventory need to have a balance."

Optimizing Infrastructure and Use

In addition to data sharing environments, upgrading processes, and the potential in using predictive data to make those smart decisions, there is one critical piece to this digital puzzle—people. XPO has a facility in Wuhan, and understood other companies might not realize the seriousness of the disease, Chowdhury said. "In mid-February, we convened our business continuity team on best practices. Our pandemic business approach was very similar to how we plan for storms," he said. "XPO has spent $49 million in COVID measures in Q2 2020 alone. Logistics is an important business. For trade to move, you need to make sure the people within the supply chain are safe.… But most importantly, you need to make sure your employees are engaged."

Across the trade spectrum, digitalization will influence how each facet of the supply chain will impact both society and the environment. The benefits include enhanced trade compliance, efficient energy use, waste emissions, services traceability, and labor compliance. However, advances in technology, such as those involved in digital transformation, have a history of inflicting pain and distress in the form of technological unemployment. A Keynesian phrase, technological unemployment means a loss of jobs caused by automation. At the very least, the fourth industrial revolution is a big displacer of jobs. A Mckinsey report found that automation could displace 15 percent of the global workforce, or about 400 million workers, by 2030. At the fastest rate of automation, like that seen during the pandemic, that figure could rise to 30 percent of the global workforce.

American workers will be among the most affected



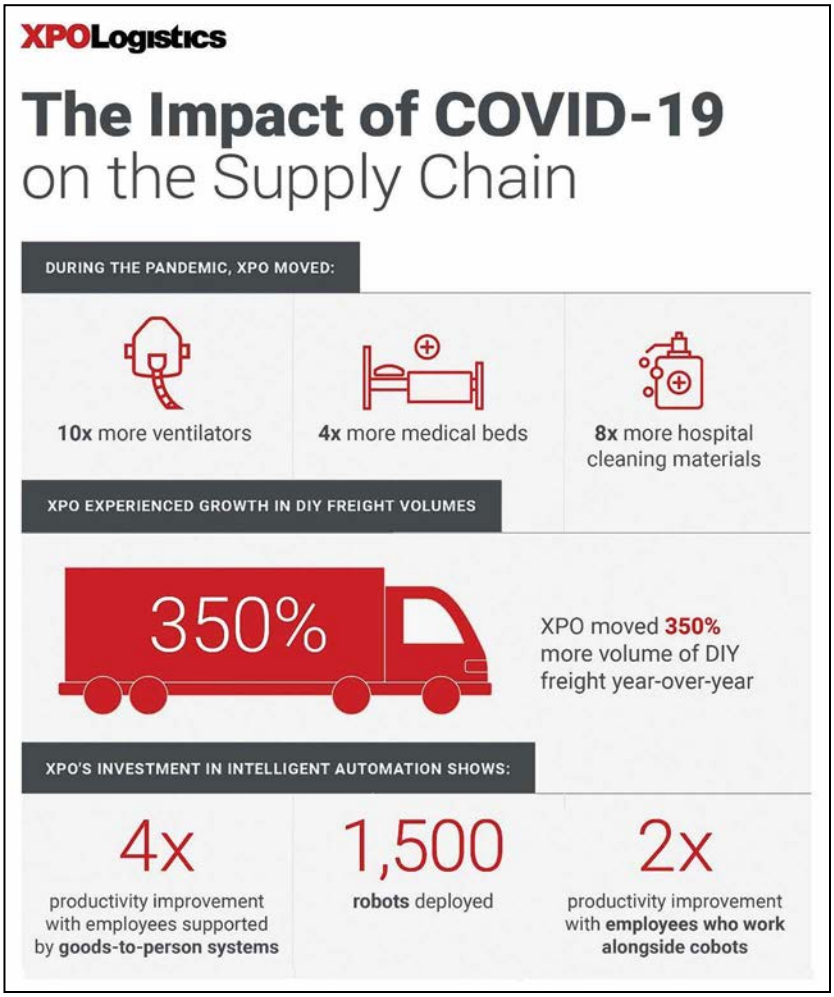
Graphic courtesy of the Port of Los Angeles

countries in such a scenario. The automation potential—the percentage of jobs that could be replaced by automation in the United States—is a disquieting 46 percent, representing 60.6 million employees. Retail trade, manufacturing, and transportation and warehousing jobs are the most susceptible of all sectors. In transportation and warehousing, close to 60 percent of jobs are automatable, implying a job displacement for 3 million workers, according to 2017 figures.

Technological unemployment caused by digital transformation, of which automation is an integral feature, will not be restricted to blue-collar workers. It will impact jobs across the spectrum, especially white-collar professionals whose work involves data processing and collection. The first industrial revolution replaced agricultural occupations and increased urbanization on a large scale which, in an unprepared world, spawned absolutist ideologies that destabilized whole populations and economies.

That need not be the case for the fourth industrial revolution. Today, many improvement strategies are available to corporations and governments, and some of these measures have been implemented with demonstrable success, like Denmark's flexicurity—both flexible and secure—which solves two of the most significant challenges at once. It helps employers deal with disruptions, like the pandemic, by giving them a free hand to reconfigure the workforce. At the same time, it provides generous unemployment benefits and retraining opportunities to workers to help with the transition.

It has been demonstrated that, even in developing countries, policies supporting and cushioning labor mobility reduce poverty and increase the participation of women in the workforce



Graphic courtesy of XPO Logistics

Conclusion

In the end, no matter how compelling the data is in support of digital supply chains, the successful evolution of global value chains hinges on mankind, and the willingness to work together. If we do not, we will end up with numerous "best of breed" technologies that are only "best" in their tiny cyber universe. The tech isolations will result in incomplete information, just like in the child's game of telephone.

As exciting as the supply chains of the post-COVID world look from where we stand, we must approach it with a sense of cautious optimism. Digitalization will impact the developed world and the developing world with equal force. While the developed world has evolved through its share of crises and disruptions to create safety nets like social security, universal healthcare, and wage insurance, the developing world, which comprises 80 percent of the world's population, is mostly unprepared for the change.

About the authors:

Lori Ann LaRocco is senior editor of guests for CNBC Business News. *She coordinates high-profile political titans of industry interviews and special multi-million dollar, on-location productions for all shows on the network. She is a maritime trade columnist for* American Shipper *and the author of several books including "Trade War: Containers Don't Lie, Navigating the Bluster" and "Dynasties of the Sea: The Untold Stories of the Postwar Shipping Pioneers, both published by Marine Money Inc, among others.*

Nick Vyas, Ed.D., is an educator, thought leader, internationally recognized author, keynote speaker, ASQ Fellow, chair of the ASQ Lean Division, and advisor to leaders in the worlds of supply chain practice and policy. As the executive director and founder of Center for Global Supply Chain Management (CGSCM), and academic director of the University of Southern California's Marshall MS GSCM program, Vyas educates the next generation of business leaders.

The Backbone of the Global Supply Chain

The Port Authority of New York and New Jersey

Infrastructure improvements deliver benefits via land and sea

by Amanda Kwan
Senior Public Information Officer
The Port Authority of New York and New Jersey

When it was built 90 years ago, The Port Authority of New York and New Jersey's Bayonne Bridge made history as the world's largest steel arch bridge. It made New York maritime history again in September 2020 when the CMA CGM *Brazil* became the largest container vessel to call on the East Coast and sailed underneath to dock at the Elizabeth-Port Authority Marine Terminal.

The CMA CGM *Brazil*, with a maximum capacity of 15,072 twenty-foot equivalent units (TEUs), carried food, pharmaceuticals, winter clothing, and other goods to the APM Terminal as a result of an increase in demand on

The CMA CGM *Brazil*, the largest container ship to call on the East Coast to date, sails under the Bayonne Bridge in September 2020. Photo courtesy of the Port Authority of New York and New Jersey

CMA CGM's Columbus JAX service route. But the ability of any ultra-large container ship like the *Brazil* to serve most facilities in the Port of New York and New Jersey at all was a result of global perspective, forward-thinking capital planning, and infrastructure investments that were almost a decade in the making.

"We have all arrived at this historic moment together, thanks to continued and dedicated investments in our infrastructure, our partnership with APM Terminals and the CMA CGM Group, and the waterfront workforce who keep the region supplied with all the critical goods that keep us fed, clean and healthy," said Port Director Sam Ruda of the Port Authority. "In the midst of the global pandemic, this moment shows the importance of the Port and supply chain to our regional economy."

The Port Authority began planning for the rise of ultra-large container ships as the expansions of both the Suez and Panama canals were underway. The Panama Canal project expanded capacity for ships up to 14,000 TEUs, while the Suez Canal expansion now accommodates two-way traffic. Both projects were completed in 2016.

Shipping companies expected to take advantage of the capacity improvements by deploying larger ships. This meant something needed to be done about the vertical clearance of the Bayonne Bridge, as it limited ships serving most facilities in the Port of New York and New Jersey to those with a maximum capacity of 9,800 TEUs.

With larger ships on the horizon, the Port Authority began the Bayonne Bridge Navigational Clearance Project to raise navigational clearance from 151 feet to 215 feet in 2011. Upon completion, it would allow ships greater than 18,000 TEUs to sail underneath. Work began in 2013 after the project received a fast-tracked environmental review status and a federal permit from the U.S. Coast Guard.

Known internally as "Raise the Roadway," the $1.7 billion project was undertaken as a joint venture by Skanska Koch/Kiewit Infrastructure Co. and was historic in its own right. Engineers were tasked with constructing a new bridge roadway above the original span that remained open to vehicular traffic. The new design maintained the 1,675-foot steel arch that made the Bayonne Bridge a civil engineering landmark, yet created a safer, wider, more modern roadway with 12-foot lanes, new shoulders, a median divider, and a 12-foot-wide shared bike and pedestrian walkway.

The Bayonne Bridge spans the Kill van Kull, a 3-mile long, 1,000-foot-wide navigational channel, at a diagonal angle to the water, linking New York City's Staten Island with the New Jersey city of Bayonne. This orientation not only joined existing streets at either end of the bridge, it also created a more dramatic and pleasing profile, according to its original groundbreaking designer and engineer, Othmar Amman. The Kill van Kull provides passage to the Port Authority's Port Newark-Elizabeth Marine Terminal in New Jersey, the Howland Hook Maritime Terminal on Staten Island, and dozens of privately owned and operated port facilities.

Among the engineering feats and technology employed to construct a roadway above the existing—and operational—roadway on the Bayonne Bridge were a pair of massive mechanical gantry cranes, parked on either side of the Kill van Kull. Each 500-foot-long, custom-made gantry crane weighed 1 million pounds and precisely moved 70-ton concrete roadway segments so workers could bind them with steel, epoxy, and more concrete. The cranes operated mostly during overnights when the bridge was closed to traffic.

The elevated roadway and its accompanying infrastructure were completed in February 2017, and the old roadway was removed to create the higher navigational clearance. Four months later, the Coast Guard certified the bridge's new navigational clearance at 215 feet, and the project was declared complete.

Within three months of the Bayonne Bridge project's 2017 completion, the Port of New York and New Jersey welcomed the 14,414-TEU cargo vessel *T. Roosevelt*, the largest container ship to call at the seaport at that time. Just days before its September 2017 arrival, the *T. Roosevelt*

This undated file photo shows three dredges working to deepen the Kill Van Kull, a 3-mile long, 1,000-foot-wide navigational channel that's part of the New York and New Jersey Harbor. U.S. Army Corps of Engineers photo

set another record when it became the largest ship to use the expanded Panama Canal as it sailed from Asia.

"We knew this important infrastructure project would yield tangible results as soon as it was completed, and we've seen those predictions realized in the first year," Port Authority Chairman Kevin O'Toole said in 2017. "The port already supports 400,000 jobs and $25.7 billion in personal income wages, and we expect those numbers to grow as bigger ships and more cargo come here thanks to the benefits from this project."

Coast Guard crew members enforce a safety zone in September 2017 as the CMA CGM *T. Roosevelt* sails under the recently elevated Bayonne Bridge. At the time, the *T. Roosevelt* was the largest container ship to transit under the Port Authority of New York & New Jersey's Bayonne Bridge since a four-year navigational clearance project completion. Coast Guard photo by Petty Officer 1st Class Sabrina Clarke

A year after project completion, the Port of New York and New Jersey saw record cargo volumes exceeding those at other U.S. ports. With this growth came a dramatic increase in the size of ships calling on the port and additional new cargo services making the New York/New Jersey port their first stop on the East Coast. With both greater container capacity and newer, more sustainable technology, the larger ships are more environmentally friendly than their smaller, older counterparts.

"The raising of the Bayonne Bridge was an impressive engineering achievement that showcased the Port Authority's ability to build great, challenging projects," said Port Authority Executive Director Rick Cotton. "It cemented our port as the most attractive East Coast option for international shippers, and based on early returns, shippers agree and are bringing their cargo here in record volumes."

In 2017, just 30 ultra-large vessels—ships carrying more than 10,000 TEUs—called on the Port of New York and New Jersey. The following year, that number more than doubled to 77. In 2019, that number again nearly doubled to 143 ultra-large vessels. In spite of the global pandemic and dozens of voyages being cancelled, the Port handled an impressive 174 ultra-large container ships through July 2020.

Other infrastructure investments helped the seaport become the nation's second busiest container port in 2019 and further strengthened its position as the busiest on the East Coast. These investments included:

- a concurrent $2.1 billion U.S. Army Corps of Engineers and Port Authority project to deepen the navigational channel to 50 feet
- $600 million in investments in on-dock intermodal projects
- billions of dollars in portside investments by private terminal operators that lease space at Port of New York and New Jersey

"Deepening our port, expanding our capacity for trade, and raising the Bayonne Bridge took years of cooperation between many local, state, and federal players," U.S. Senator Bob Menendez said, at the bridge's rededication in 2019. Part of the congressional delegation that helped expedite the project, he said it was about raising the economic prospects of the state and region. "When we invest in infrastructure, we build a stronger economy for all of us," he added.

As global shipping trends continue to shift, particularly as e-commerce increases consumer demand amid the coronavirus pandemic, larger container ships are still to come. The Port Authority is again thinking ahead to that future. It is currently turning its attention to accommodating ships with a maximum capacity of 24,000 TEUs by working with the Army Corps of Engineers on a new navigation study, and planning a long-term berth and wharf replacement project.

About the author:

Amanda Kwan is a New York City-based senior public information officer at The Port Authority of New York and New Jersey focusing on the bistate agency's six tolled crossings and its seaport. She previously was a spokesperson for the Metropolitan Transportation Authority of New York, and a news editor at Reuters News, *and the* Associated Press.

NOAA's Strategic Plan to Power the American Blue Economy

by Rear Admiral Tim Gallaudet, Ph.D.
U.S. Navy (ret.)
Former Assistant Secretary of Commerce for Oceans and Atmosphere
Former Deputy NOAA Administrator

Alexandra Skrivanek, Ph.D.
Associate Program Officer
Ocean Studies Board
National Academies of Sciences, Engineering, and Medicine

With 95,471 miles of shoreline and an exclusive economic zone (EEZ) among the largest in the world, the strength of the U.S. economy is reliant on the understanding, health, and sustainable use of ocean, coastal, and Great Lakes resources.[1] U.S. coastal and Great Lakes economies provide valuable goods and services to the nation, and contribute to the U.S. gross domestic product (GDP) through diverse and dynamic activities including:

- tourism and recreation
- national defense and public administration
- offshore mineral exploration
- shipping and transportation
- commercial fishing and aquaculture
- ship building
- offshore power generation
- research and education

Over the last two decades, the American Marine—or Blue—Economy has seen tremendous growth.[2,3] From 2014 to 2015, Blue Economy sectors expanded by 5.7 percent, more than twice that of the U.S. economy as a whole. From 2017 to 2018, the Blue Economy increased by 7.5 percent, again eclipsing national economic growth averaged at 6.1 percent. Between 2014 and 2018, the economic activity from America's seaports alone grew by 17 percent to $5.4 trillion, comprising nearly 26 percent of the nation's $20.5 trillion gross domestic product. In 2018, the U.S. Blue Economy, including goods and services, contributed approximately $373 billion to the nation's GDP and supported 2.3 million jobs. Such activities also contribute to the global marine economy, which is expected to double in value to $3 trillion over the next decade.[4]

The populations of coastal communities are similarly large in scale. While coastal areas account for less than 10 percent of the total land in the contiguous United States, an estimated 127 million people, or 40 percent of the U.S. population, live in coastal counties.[5] If these coastal counties were an individual country, they would rank third in the world in GDP, surpassed only by the United States and China. Despite the challenges posed by the COVID-19 pandemic, American seaports are adding coastal infrastructure, including terminals and piers. Demand for maritime commerce is expected to double by 2025, and triple by 2030.[6]

In summary, the United States is an ocean nation, with a growing Blue Economy that is inextricably linked to national prosperity and marine resource conservation. The Blue Economy also benefits national security—a connection that is demonstrated by the inclusion of promoting the domestic economy as the second pillar in the 2017 National Security Strategy.[7]

It is for these reasons that the National Oceanic and Atmospheric Administration (NOAA) has supported advancing the American Blue Economy as a top budget and outreach priority since 2017. The agency has led the nation in implementing a number of initiatives, from the National Ocean Policy of 2018[8] and the 2018 National Strategic Plan for STEM Education,[9] to the 2019 Presidential Memorandum on Mapping the U.S. EEZ and Shoreline and Nearshore of Alaska.[10] This includes the 2020 National Strategy for Mapping, Exploring, and Characterizing the U.S. Exclusive Economic Zone (NOMEC),[11] the 2020 Executive Order on Promoting Seafood Competitiveness and Economic Growth,[12] and the 2020 U.S. Federal Strategy for Addressing the Global Challenge of Marine Litter.[13] It has also implemented several agency strategies to advance resource conservation, S&T,[14] and mapping, such as the 2020 NOAA Office of Coast Survey National Ocean Mapping Strategy.[15]

An important milestone in advancing this cross-cutting priority area was the November 2019 White House Summit on Ocean Science & Technology (S&T) Partnerships,[16] where the agency arranged over a dozen ocean S&T partnerships to advance American competitiveness, security, and prosperity. Through implementing national ocean policy and achieving its mission, NOAA has worked to advance the U.S. Blue Economy, and prepare the nation for both a national and global economy that is becoming increasingly dependent on

data and technology.

Advancing the U.S. Blue Economy

As the nation's leading marine science agency, NOAA provides data, tools, and services that support coastal economies and positively impact every American life, every day. In keeping with its core mission of science, service, and stewardship to the nation, NOAA expands and strengthens the American Blue Economy by leading agency-wide initiatives in the marine transportation, ocean exploration, seafood competitiveness, tourism and recreation, and coastal resilience sectors.

In January 2021, after a year of mounting need for national economic relief due to compounding effects of the COVID-19 pandemic, NOAA formalized these initiatives in a NOAA Blue Economy Strategic Plan.[17] This plan organizes efforts across the agency that are either planned or already in progress from 2021–2025. In addition to providing a framework for agency-wide contributions to the five pillars of NOAA's Blue Economy initiative, it outlines actions to maximize agency capacity to contribute data and services and engage with multisector partners. These goals are achieved by improving cross-cutting internal focus areas and leveraging external opportunities, respectively, across a number of areas via the United Nations Decade of Ocean Science for Sustainable Development. These areas include:

- strategic communications
- partnership agreements
- finance and business development
- education
- S&T transitioning and applications
- workforce development
- policy and legislation
- socioeconomic evaluations
- international engagement

Through these actions, NOAA aims to strengthen and improve its data, services, and technological resources that contribute to the American Blue Economy. It will also continue to collaborate with partners to support the growth of American business and entrepreneurship that contributes to the development and sustainability of Blue Economy sectors. In achieving these goals, we identify and support the growth of sectors of the Blue Economy that will help to accelerate the nation's economic recovery.

NOAA Blue Economy Initiatives

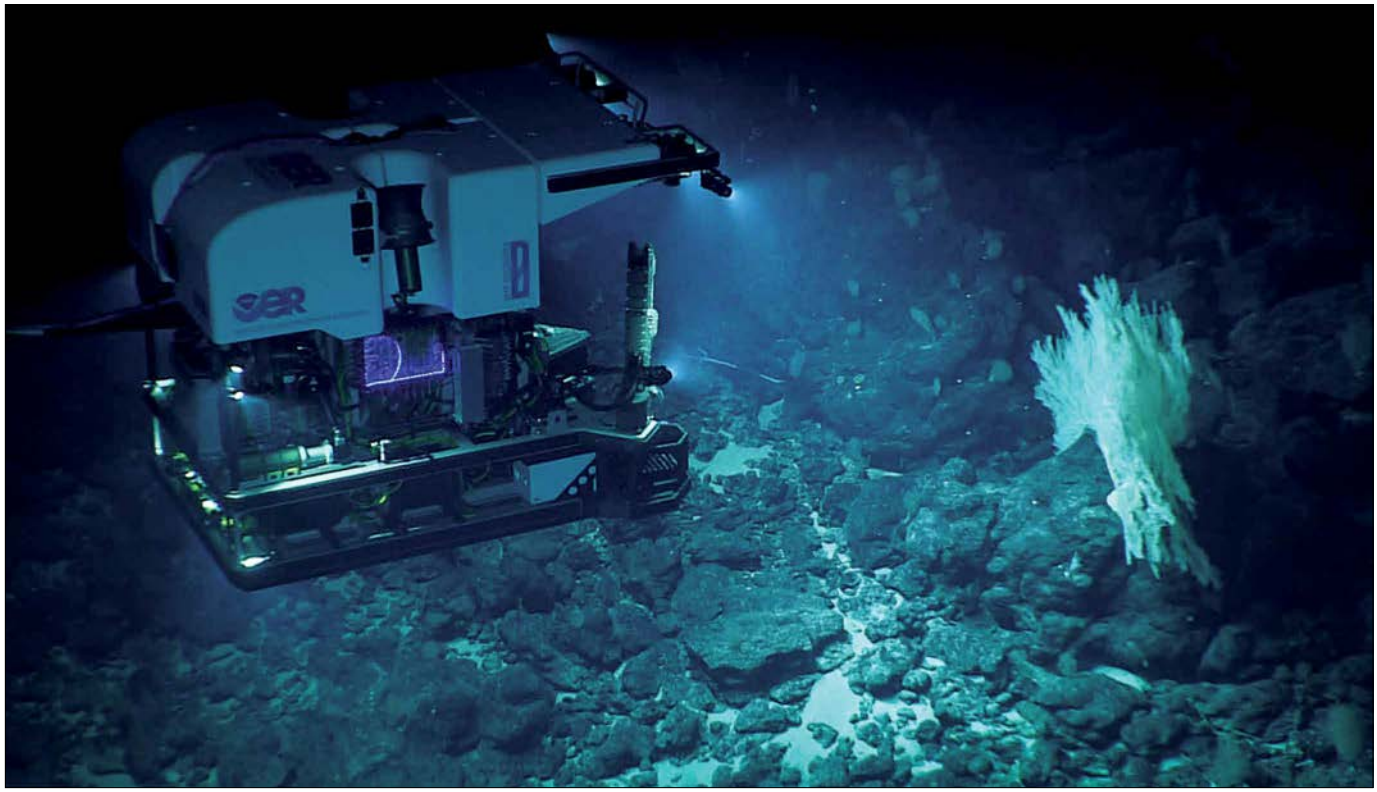
The NOAA Blue Economy Strategic Plan provides concrete examples of how NOAA's people, policies, products, and services intersect to support Blue Economy growth in a sustainable and responsible manner. Additionally, the plan highlights how the agency leverages private sector capabilities and applies emergent science and technology to further innovation in all Blue Economy sectors. This approach has been instrumental in the continuation of ocean science operations and other efforts to adapt activities in support of the nation following the onset of COVID-19. Here, we describe some of the many ways in which NOAA is powering the American Blue Economy.

Marine Transportation

NOAA products and services drive the marine transportation sector, which produced $59 billion gross in 2018, accounting for 10 percent of the total U.S. marine economy.[18] The NOAA Physical Oceanographic Real-Time System, or PORTS, partnership program[19,20] for instance, provides real-time information to mariners to improve the efficiency of U.S. ports and harbors, promote navigation safety, and enhance the protection of coastal marine resources. PORTS, which currently serves about one-third of the 175 major seaports in the United States, recently upgraded Houston, Mobile Bay, Corpus Christi, New York and New Jersey, and Cape Cod, and expanded with new systems in Portsmouth, New Hampshire; Valdez, Alaska; and King's Bay, Georgia; in 2020.[21]

NOAA distributes precision marine navigation data,

A container ship enters the Port of Miami's shipping channel where vessel pilots now have access to real-time current information to help guide them safely into port through the Physical Oceanographic Real-Time System, or PORTS. This program is used in a growing number of U.S. ports for environmental data such as water levels, currents, waves, salinity, bridge clearance (air gap), winds, air and water temperature, and visibility. Photo courtesy of the National Oceanic and Atmospheric Administration



The National Oceanic and Atmospheric Administration office of Ocean Exploration and Research's remotely operated vehicle, *Deep Discoverer*, documents the benthic communities at Paganini Seamount in the north-central Pacific Ocean. Photo courtesy of the National Oceanic and Atmospheric Administration

such as surface current forecasts, marine weather hazards, and high-resolution bathymetry, to help mariners make better decisions, and refines the National Spatial Reference System to improve positioning accuracy. The agency is working to develop products that enhance the safety of marine transportation and commercial shipping by providing critical environmental information, such as the location of icebergs, wind patterns, and operational marine weather forecasts. The Economics National Ocean Watch dataset provides economic time series data on the marine transportation sector for use by public audiences and stakeholders. These are a few of many ongoing efforts to optimize the safety and utility of the nation's marine highway infrastructure, improve marine navigation, and characterize marine commerce for industry partners.

Ocean Exploration

The U.S. EEZ covers 3.4 million square nautical miles of ocean, and is larger than the land area of all 50 states combined, yet only 40 percent of it is mapped.[22] In response to this gap in our understanding of the EEZ, NOAA is leading the implementation of the 2019 Presidential Memorandum on Mapping the EEZ and Shoreline and Nearshore of Alaska.[23] Since 2019, the agency has worked with partners to develop the 2020 NOMEC Strategy[24] to coordinate interagency efforts and resources, setting a goal to map and characterize the EEZ by 2030. Subsequent interagency collaborations include the 2020 Alaska Coastal Mapping Strategy,[25] and the Implementation Plan to Improve the Permitting Process for Mapping, Characterizing, and Exploring the EEZ.[26]

Ongoing efforts include coordinating and executing ocean mapping campaigns with public and private sector partners and meeting established standards and protocols. Through a series of public-private partnerships, NOAA has continued to engage in both mapping and exploration using marine robotics, collecting data that provides insight into sustainable energy development, new marine species, fisheries, minerals, and pharmaceutical development, as well as ocean/weather forecasts, conservation, and ocean health.

In addition to coordinating and executing mapping expeditions, and performing ocean exploration and characterization operations, the agency is dedicated to archiving, inventorying, and making accessible expedition data to the public in a timely manner. Furthermore, the agency is developing data collection and quality standards for ocean exploration and characterization to produce robust datasets that can be used for multiple objectives across sectors. Applications of artificial intelligence (AI) and uncrewed systems (UxS), and the use of innovative methods like telepresence to support this area are highlighted in six NOAA S&T Focus Area

Implementation Plans. Such methods have been critical to continuing ocean operations in accordance with Centers for Disease Control Guidelines during the COVID-19 pandemic limiting ship capacity and crew size.

Lastly, NOAA supports efforts to facilitate permitting for ocean mapping and exploration projects. NOAA offices are increasing the clarity and consistency of federal compliance processes, promoting efficiency through systematic federal approaches, and integrating new and emerging science and technology in permitting and authorization processes.

National Oceanic and Atmospheric Administration ship *Ferninand R. Hassler* is the newest state-of-the-art coastal mapping vessel designed to detect and monitor changes to the sea floor. Data collected by the ship will be used to update nautical charts, detect potential hazards to navigation, and further enhance our understanding of the ever-changing marine environment. Photo courtesy of the National Oceanic and Atmospheric Administration

Seafood Competitiveness

In 2017, commercial and recreational fishing industries combined generated $244 billion in annual sales, contributing $111 billion to the gross domestic product and supporting 1.74 million jobs; all increases over the previous year.[27,28] NOAA played a leading role in the implementation of the 2020 Executive Order on Seafood Competitiveness and Economic Growth.[29] Key lines of effort include reducing barriers to U.S. fisherman, implementing aquaculture opportunity areas (AOAs), streamlining aquaculture permitting, and combating illegal, unreported, and unregulated (IUU) fishing.

A diver explores the Flower Garden Banks National Marine Sanctuary, one of the locations the National Oceanic and Atmospheric Administration protects in an effort to conserve special coastal and marine sites for future generations. Photo courtesy of the National Oceanic and Atmospheric Administration

NOAA offices are engaged in a variety of specific activities to promote U.S. seafood competitiveness and economic growth. NOAA Fisheries reflect the gold standard in sustainable fisheries management, with 47 rebuilt stocks since 2000. Of 321 stocks with known overfishing status in 2019, 93 percent are no longer subject to overfishing, and 81 percent of those with known overfished status are no longer overfished.[30] Underpinned by the best available science, NOAA is supporting efforts that streamline fisheries regulation to provide more access for fishermen without depleting stocks. This includes leveraging citizen science data and networks to inform decision-making and advocacy, and advancing ecosystem-based fisheries management through widespread adoption of UxS, 'omics, cloud computing, big data and citizen science in fisheries surveys.

In 2020, NOAA Fisheries announced the selection of southern California and the Gulf of Mexico as the first regions for focused study to identify AOAs. Through spatial analyses, modeling, and stakeholder engagement, the agency hopes to determine the potential suitability of these areas for commercial aquaculture to expand domestic production and economic opportunities for coastal communities.

IUU Fishing is an internationally recognized problem that has far-reaching consequences for national security and marine fisheries. This issue is of particular concern in the Indo-Pacific region, and significantly undermines the economies of our Pacific Island Partners. Chinese vessels regularly make incursions into the EEZs of other nations, routinely fishing without permission and overfishing licensing agreements. In contrast, NOAA is working with interagency and international partners and developing new technologies to ensure that sustainable and legal fishing practices counter this activity.

Tourism and Recreation

The largest sector in the U.S. Blue Economy is tourism and recreation—coastal and offshore—which grossed $227 billion in 2018.[31] Furthermore, this sector accounted for 38.3 percent, or $143 billion of the $373 billion, in value added to the ocean economy in 2018, and demonstrated the largest amount of sales growth—$14 billion—over the previous year.[32] NOAA supports the outdoor recreation economy, which was recently highlighted in the Great American Outdoors Act.[33] It has contributed to the tourism and recreation sector in sustainable, and powerful ways, such as the designation and expansion of National Marine Sanctuaries.

NOAA designated the new Mallows Bay-Potomac River National Marine Sanctuary in 2019, and is working to finalize two shipwreck sanctuaries in Wisconsin and Lake Ontario. Additionally, the agency is working to expand the Monitor and Flower Garden Banks National Marine Sanctuaries. Our national marine sanctuaries generate $8 billion annually for local coastal economies from activities including commercial fishing, research, recreation, and tourism activities.[34]

What are 'Omics?

"'Omics" encompasses genomics, transcriptomics, proteomics, and metabolomics. Combined, these represent science of cell structure, function, and dynamics.

NOAA personnel are actively engaged in efforts to increase options and access for sustainable, safe tourism and recreation activities; improve ocean health; and understand and communicate the economic value of this

National Oceanic and Atmospheric Administration Fisheries announced federal waters off southern California and in the Gulf of Mexico as the first two regions to host Aquaculture Opportunity Areas (AOA) in August 2020. AOAs are small, defined geographic areas that have been evaluated to determine potential suitability for commercial aquaculture. Photo courtesy of the National Oceanic and Atmospheric Administration

sector to the public. From improving weather forecasts, conserving coral reefs, removing marine debris, restoring habitats, and protecting endangered species, to preparing the nation to respond to oil spills, NOAA data and services inform diverse areas within this sector.

For instance, the NOAA Coral Reef Conservation Program works to assess, restore, and protect U.S. reef systems, which provide essential services for all seven U.S. coral reef jurisdictions that have an estimated total economic value of $3.4 billion per year.[35] NOAA is executing the 2018 NOAA Coral Reef Conservation Program Strategic Plan,[36] producing reef status reports to monitor reef health, trends, and human impacts, as well as leading restoration planning and developing partnerships to restore Florida's coral reef.

The agency will also be implementing the 2020 NOAA Strategy for Stony Coral Tissue Loss Disease Response and Prevention. In collaboration with federal, state, and private partners, the strategy supports timely, efficient, and effective action to match agency capacity with critical research and response needs and slow the outbreak of this devastating disease across Florida and Caribbean reefs. It also identifies opportunities to prevent and prepare for the possible spread of the disease to the Pacific region.[37] Protecting America's coral reefs not only benefits the sustainable tourism and recreation sector, but supports fisheries and builds coastal resilience through powerful shoreline protection preventing an estimated $94 million in flood damages every year.[38]

Marine debris is another critical area where NOAA data, services, and tools impact the tourism and recreation sector. Following the 2020 U.S. Federal Strategy for Addressing the Global Challenge of Marine Litter, the agency is working with federal partners to identify actions to address marine debris and its impacts on ocean health.[39] The NOAA Marine Debris Program is authorized by Congress to continue NOAA's leadership in marine debris removal and prevention through the Save Our Seas 2.0 Act.[40]

Coastal Resilience

Increasing coastal hazards are a major threat from climate change, the impacts of which can vary significantly along the nation's coastline. In 2020, the United States experienced 22 weather and climate disasters with damages exceeding $1 billion each and totaling approximately $95 billion for all 22 events.[41] The active 2020 Atlantic hurricane season produced an unprecedented 30 named storms, including seven billion-dollar tropical cyclones that resulted in a total of $42 billion in damages to coastal communities.

NOAA is providing critical data to monitor and predict coastal hazards across the nation, and to understand how global and regional changes are affecting coastal communities. It is engaged in a wide range of activities shaping coastal resilience, such as generating hurricane and storm surge predictions, developing climate assessments, and providing data to coastal managers through programs such as NOAA's Digital Coast.[42] The

The National Oceanic and Atmospheric Administration Center for Operational Oceanographic Products and Services National Current Observation Program conduct tidal current surveys. Data has been collected in southeast Alaska since 2001 to help update tidal current predictions critical to safe navigation and other applications that are published annually in the U.S. Tidal Current Tables. Photo courtesy of the National Oceanic and Atmospheric Administration

agency is also actively expanding data-comparison tools and services that may inform the public about coastal changes, direct resilience planning to protect jobs, identify vulnerable economic sectors, and describe economic impacts of hazards.

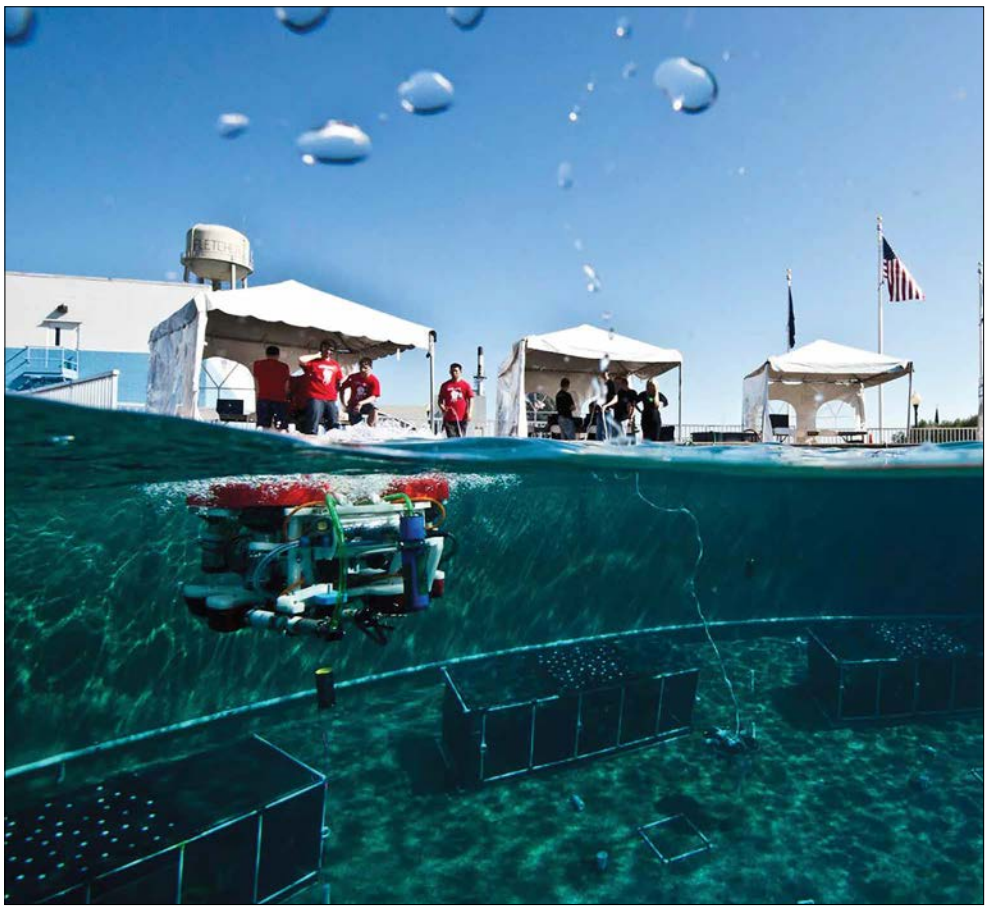
Because partnerships are invaluable in this effort, NOAA works with public and federal partners to build resilience to coastal hazards through the National Coastal Resilience Fund.[43] This national program invests in conservation projects that increase and strengthen natural infrastructure to protect coastal communities from the impacts of storms and other naturally occurring events while creating or expanding habitats for fish and wildlife.

Agency personnel engage in habitat restoration projects across the nation, from marshes in Louisiana and oyster beds in the Chesapeake, to coral reefs in Puerto Rico, and are looking to identify new opportunities for increasing coastal resilience. They also work to develop tools and training to prepare for coastal disasters and to work with partners to respond to events like marine oil spills through the Disaster Preparedness Program. This initiative is designed to strengthen existing operational capabilities to ensure the agency and its partners can effectively plan for and respond to hazards, and to accelerate the recovery of commerce, communities, and natural resources. By upgrading our global weather forecast model and supercomputing capacity in 2019, NOAA has made remarkable improvements in weather forecasting that better prepare the nation to respond to coastal disasters.

The Way Ahead

Instrumental to the success of NOAA's Blue Economy initiatives are dynamic public-private partnerships, transformative technologies, and innovative STEM education and outreach that can monitor and maximize sustainable economic contributions of ocean, coastal, and Great Lakes resources. Partnerships developed since the 2019 White House Summit stem from government, philanthropic and non-governmental organizations, academia, and the private sector. NOAA is implementing six S&T strategies—AI UxS, cloud computing, data, 'omics, and citizen science—to promote transformational improvements in performance and efficiency across the agency's mission areas. NOAA also played a leadership role in the development and implementation of the White House STEM Education Strategy. Both STEM education and outreach are key to enabling U.S. Blue Economy and Blue Tech leadership, as are talent acquisition and workforce development to foster innovation throughout the agency and beyond.

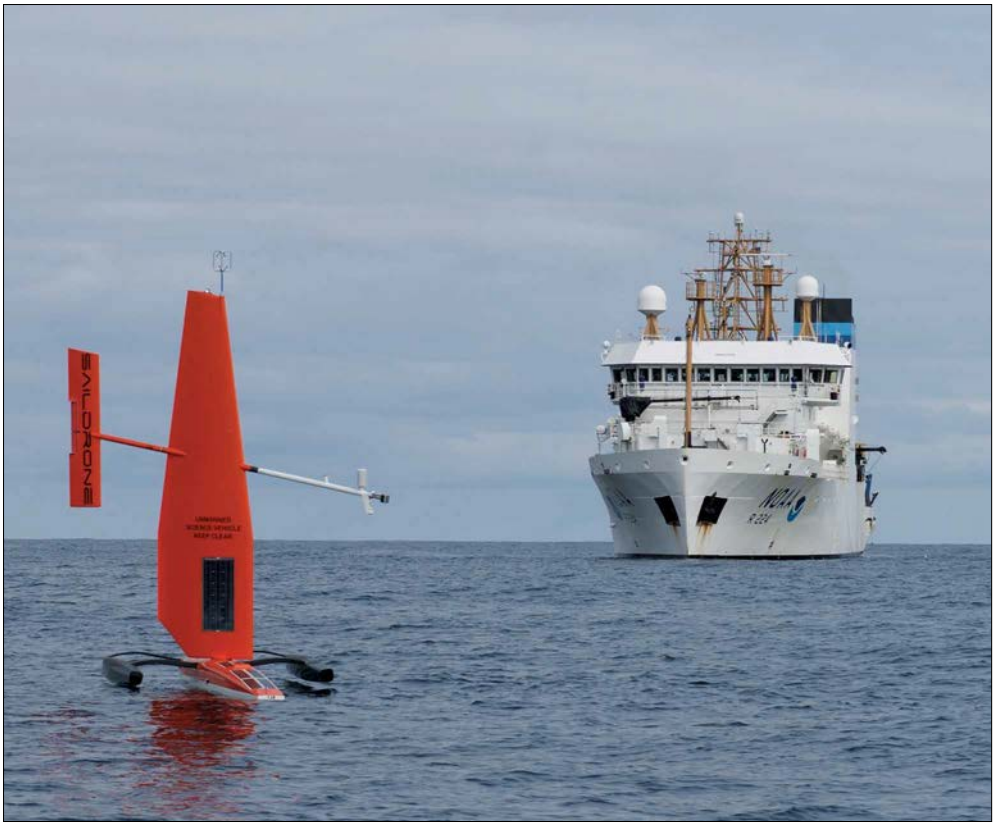
In 2020, for example, NOAA published a strategy to guide advancements in UxS applications and increase the use of these systems across NOAA mission areas. Shortly thereafter, the agency collaborated with partners to use UxS to adapt research operations, exploration, and fisheries management to the restrictions imposed by the COVID-19 pandemic and mitigate impacts to operations to ensure the timely delivery of critical data and services. NOAA deployed uncrewed surface vessels to perform stock assessments for pollock, and produce updated



Students at the Marine Advanced Technology Education International Remotely Operated Vehicle Competition held at the Thunder Bay National Marine Sanctuary test their remotely operated vehicles in the sanctuary's dive tank. Building these vehicles introduces students to new marine technology career pathways. Photo courtesy of the National Oceanic and Atmospheric Administration

nautical charts ensuring safe passage of commercial vessels. Underwater gliders were also deployed along the U.S. Gulf of Mexico and South Atlantic Coast to provide sustained ocean temperature profiles to improve 2020 hurricane forecasts.

These examples illustrate how augmenting seagoing operations with emerging tech can transform a single NOAA vessel into a virtual fleet, and are a sign of what is to come. NOAA will continue to develop integrative solutions to support mission areas essential to the nation.



Saildrone vessels deployed to Alaska in early 2020 to support winter stock assessments of Pollock fish during the COVID-19 pandemic. Photo courtesy of the National Oceanic and Atmospheric Administration

There is much more work to be done to contribute to the development and sustainability of the Blue Economy. Supporting sustainable global maritime transportation is a key component of the agency's approach to achieving this goal, which may benefit from combined applications of emerging S&T. For example, sustainable maritime transport will require the design, development, and implementation of zero emission energy technology for propulsion. Other technologies, like AI, can be employed to further increase efficiency. The integration of AI and highly precise weather forecasting has the potential to optimize fuel efficiency for shipping and transportation processes. Maritime transport and operations relying on or incorporating autonomous systems can work toward zero-waste transportation. Additionally, AI, optical, and acoustic sensing can ensure marine mammal avoidance. The NOAA Blue Economy Strategic Plan aims to accelerate and grow such contributions Additionally it demonstrates the strength of combining partnerships, emerging S&T, and internal and external outreach with sound ocean science in powering the nation's economic recovery in the wake of the COVID-19 pandemic. NOAA has prioritized accelerating these advances to empower our American economic recovery, and to guide a clear, sustainable path forward to assure American security and prosperity today and throughout the 21st century.

About the Authors:

Retired Navy Rear Admiral Tim Gallaudet, Ph.D., is the former assistant secretary of Commerce for Oceans and Atmosphere and deputy administrator of NOAA, and served as the acting undersecretary of Commerce for Oceans and Atmosphere and NOAA administrator from 2017 -2019. Rear Admiral Gallaudet completed 32 years of service in the Navy in 2017 as Oceanographer of the Navy. He has a bachelor's degree from the U.S. Naval Academy, and master's and doctorate degrees from Scripps Institution of Oceanography.

Dr. Alexandra Skrivanek is an Associate Program Officer on the National Academies Ocean Studies Board. Previously, she was a policy analyst and Sea Grant Knauss Marine Policy Fellow in the NOAA Office of the Assistant Secretary of Commerce for Oceans and Atmosphere, advancing initiatives on ocean health and the blue economy. Dr. Skrivanek earned a bachelor's degree in earth science at the University of Michigan, and a Ph.D. in geology at the University of Florida.

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Lifting the Ban on Crude Oil Exports

Implications for spill preparedness and the environment

by Valerie Cleland
Oceans Advocate, Nature Program
Natural Resources Defense Council

Mary Baker, Ph.D.
Environmental Scientist, Office of Response and Restoration
National Oceanic and Atmospheric Administration

You could call it a black gold rush. The United States has a long love affair with oil, and this relationship has led us to begin looking for oil in new places, and finding new ways to extract it. Even in the face of horrific environmental disasters like the *Exxon Valdez* and *Deepwater Horizon* oil spills, we are not deterred in our quest for this lucrative substance.

Today, as melting sea ice makes oil more accessible, the risk of a spill is moving north into Arctic territories. If a significant spill was to occur in the Arctic, the unforgiving weather and lack of major ports nearby would make response much more difficult, not to mention the devastation to a delicate, and already stressed, ecosystem. As we've seen time and time again, oil spills have devastating impacts on the environment, wildlife, and local communities, and the effects linger long after the cleanup crews have gone home.

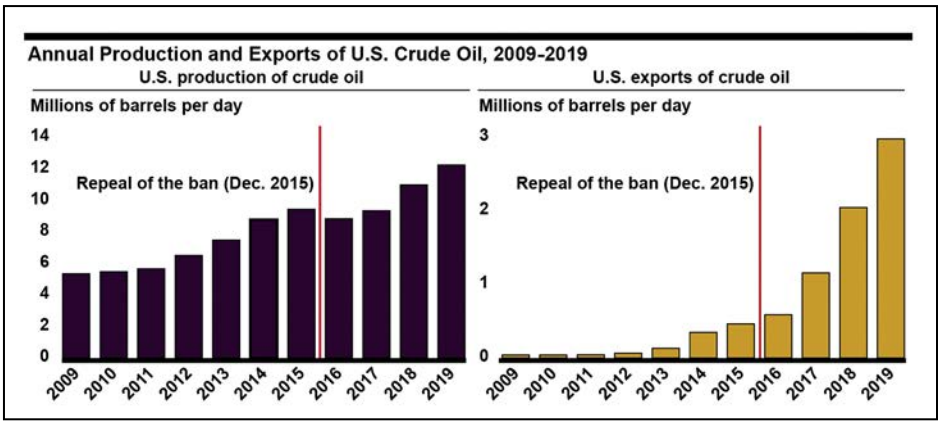
Technological advances, like hydraulic fracking, have made harvesting oil more profitable and thus changed the global petroleum market. For decades the United States was dependent on oil imports and banned crude oil exports to protect domestic reserves. This all changed in 2015, when the 40-year crude oil export embargo was lifted as the result of political pressure, giving the domestic oil industry access to the global crude oil market.

Now, six years later, it is no surprise that the repeal of the export ban has resulted in increased crude oil exports. The winners of this policy change? The crude oil producers. The losers in this situation? That is a more complicated answer, but the losers include the domestic oil refiners, domestic ship builders, and arguably our environment as the risk of oil spills rises and we continue to increase our production of fossil fuels despite climate change.

Though the United States now exports more crude oil than we import, we are still importing significant amounts of crude oil from other countries.[1] After the repeal of the crude oil export ban, there was decline in demand for U.S. tankers, often known as Jones Act tankers, that are used to move crude oil between domestic ports. Due to the relative price increase of domestic crude oil, some U.S. refineries may have chosen to use foreign crude oil instead according to interviews conducted by the Government Accountability Office. Foreign oil is usually transported by foreign tankers, thus reducing the demand for U.S.-built tankers.[2]

While the United States has been increasing its crude oil exports since 2015, changes in the market can disrupt the demand for these resources very quickly. In April, due to the COVID-19 pandemic, total U.S. demand for petroleum products fell about 30 percent from the preceding months, likely due to travel restrictions. It fell for months after a high in February.[3]

With the United States now the third largest crude oil exporter, demand for U.S. oil seems to be increasing. Crude exports have climbed from an average of nearly 465,000 barrels per day in 2015 to almost 3 million barrels per day in 2019, according to the U.S. Energy Information Administration.[4] Much attention has been given to the economic implications of this massive shift, without as



U.S. Government Accountability Office graphic

much thought to implications of potential changes in oil transportation.

In 2019, the United States exported petroleum to about 190 countries with the largest amounts going to Canada, South Korea, the Netherlands, India, and the United Kingdom. That same year, the U.S. briefly overtook Saudi Arabia as the largest crude oil exporter in the world. This dramatic increase in oil exports from the United States has implications for regional and national oil spill prevention and preparedness.

Traditionally, agencies that deal with crude oil exports almost exclusively look at changes from a national perspective. However, risks and benefits of transporting crude oil are not shared equally and emergency preparedness personnel face varying challenges across regions. This makes it imperative to understand the impacts of increasing oil exports so as to properly allocate preparedness and response assets.

Research at the School of Marine and Environmental Affairs

To address changes in crude oil transportation, in 2018 at the University of Washington School of Marine and Environmental Affairs, we took a two-pronged approach. First, we developed a survey that aimed to measure the human perception of changes resulting from the export ban lift and oil-spill risk. This 21-question survey was sent to people across the industry to get an idea of how stakeholders perceived implications of lifting the export embargo. Second, we paired this data with crude oil export data from the International Trade Commission. While this data is primarily collected for tax purposes, it provides a regional and national snapshot of oil movement and gives a quantitative indication of the significance of changes to oil export routes.

From the survey, we learned that approximately 80 percent of participants had seen no changes in policy or oil spill prevention practices since the crude oil export ban was lifted in 2015. Assuming an increase in exports, 60 percent were generally worried about increased risk of oil spills and others worried about public backlash due to concern, new shipping patterns, and unknown risks. While 42 percent thought that changing patterns in shipping may increase the chance of an oil spill, 25 percent disagreed. About 50 percent of respondents were unsure about the future of increasing exports, indicating uncertainty about what changes may take place.

In the 2018 survey, with regards to the Trans Mountain Pipeline Expansion Project, 63 percent believe that an expansion may increase oil spill risk in the Salish Sea region. At the time of this article, despite the current pandemic, the pipeline expansion appears to be on schedule.

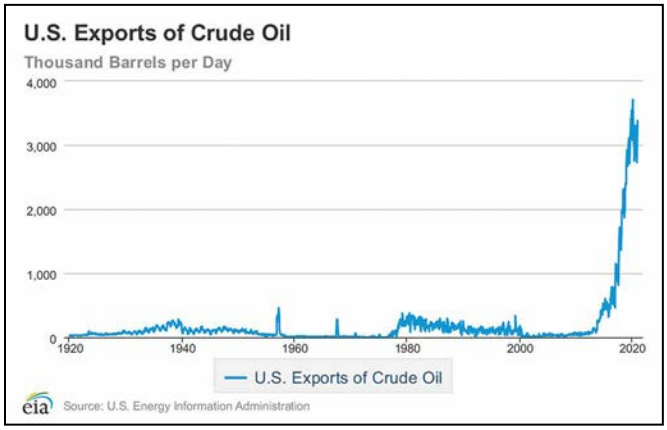
Beyond the proposed Kinder Morgan/Trans Mountain pipeline, people were concerned about future Arctic shipping and the transport of crude oil by rail. "Crude by rail exports could derail in difficult-to-respond-to locations and cause significant impacts to waters of the State [of Washington]," according to the survey. People shared ideas on how to mitigate oil spill risk in the region with suggestions like, "continuous improvement of measures already in place. Many improvements have been made in the past 25 years. We need to ensure we never ever become complacent and we [need to make] make further appropriate cost beneficial improvements when identified."

From the crude oil export data, we learned that the majority of crude oil exports—66 percent—leave from the Gulf of Mexico region. The smallest proportion—1 percent—comes from the West Coast. While less so than other regions, the West Coast region exports are increasing at a rate of one million barrels a year since 2013.

When we isolated the specific routes exports take leaving the West Coast, no particular route stands out as more significant. Exports from the West Coast at this point seem random and are likely opportunistic or exploratory. Time and experience will reveal the most profitable routes for West Coast exports. However,

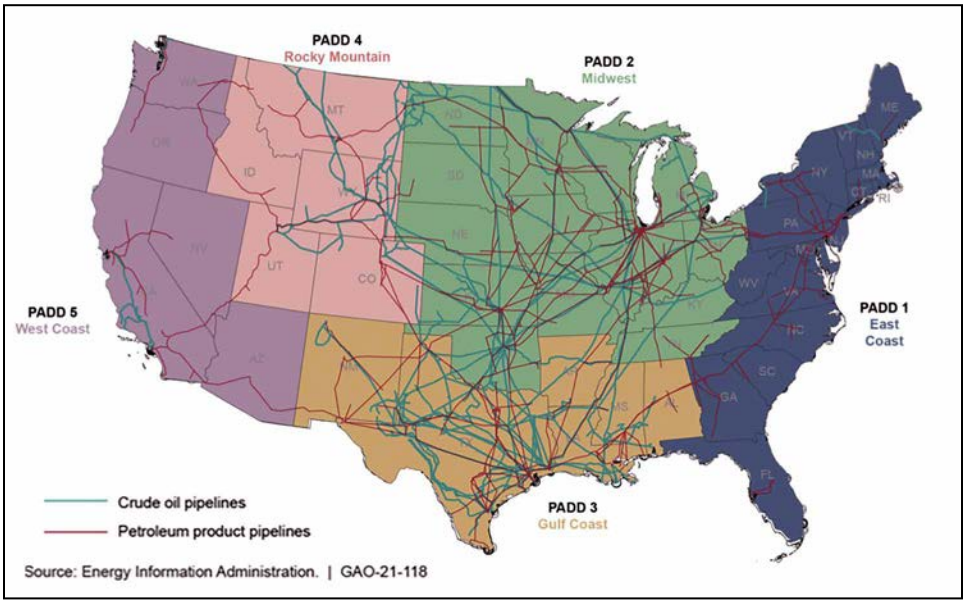
Trans Mountain Pipeline Expansion Project

The Trans Mountain Pipeline Expansion Project is a proposed extension to the existing Kinder Morgan pipeline, which carries crude and refined oil from Alberta, Canada, to the West Coast of British Columbia.



U.S. Energy Information Administration graphic

barring any unforeseen changes in the supply or price of oil, the upward trend in export volume can be expected to continue. With a growth in U.S. exports, along with the Trans Mountain pipeline in British Columbia, Canada, oil spill preparedness and response must adapt.



U.S. Government Accountability Office graphic

Regional Recommendations

It is not a matter of if there will be another oil spill, just a question of when and where. The more we understand about how oil spill risk is changing on a regional scale, the better prepared we can be to ensure that preparedness is aligned with current crude oil transportation modes and routes. Continuing to examine, monitor, and assess changes in export and transportation patterns is essential to understanding how oil spill risk may be changing, and to providing us the information to work to prevent an oil spill rather than clean one up.

We recommend that a high level of attention is maintained in the Salish Sea region, due to potential changes in both the United States and Canada that would increase oil spill risk in this area. The development of the Trans Mountain pipeline has increased the risk of land-based spills of blended bitumen oil from Alberta, which presents cleanup challenges when compared to lighter crude oils. Improving response plans for diluted bitumen oil, whether it is transported by pipeline, rail, or tanker, will reduce and mitigate risk. The Coast Guard recently undertook an assessment of response to oil sands products, including transport by pipeline and rail. Recommendations included adding considerations for sinking oil in response plans and capabilities; requiring more information to be provided regarding the diluent used in bitumen oils; and improving equipment and training for detecting and recovering sinking oils from the environment.[5]

Increased attention should also be given to the Aleutian Islands since they are particularly sensitive to oil spills and situated along a major transportation corridor. The great circle route—the shortest distance on the globe—between the Pacific Northwest and Asia passes through the Aleutians and is the most frequented part of the Arctic region. As this area is already dense with shipping traffic, any increases in crude oil tankers, makes the region more vulnerable to oil spills. While no crude oil is currently being shipped via this route, an upward trend in West Coast exports increases the future possibility of crude oil tankers using this route.

Like the rest of the Arctic, any crude oil tanker spill in the Aleutians would be catastrophic because it is remote, lacking in response infrastructure, environmentally sensitive, with harsh weather that makes cleanup difficult. In addition to monitoring changes, further investment in infrastructure and response planning for the Aleutians is necessary. For example, in 2020, the Government Accountability Office (GAO) recommended improvements in the Coast Guard's vessel response plan (VRP) review procedures,[6] noting that:

- a relatively small number—71 of more than 3,000 VRPs—of verifications of salvage and marine firefighting response capabilities were conducted
- there is limited availability of reliable data on the location of oil spill and marine firefighting response capabilities
- limited availability of resource providers to respond to an incident

GAO recommended that the Coast Guard analyze incidents of activating VRPs to determine if the plans were implemented effectively and that they establish a working group to suggest other improvements. In Alaska, alternative planning criteria for VRPs are used by members of the Alaska Maritime Prevention and Response Network to streamline preparedness and improve response capabilities. Including network responses in the follow-up to the GAO report will ensure that enforcement and outcomes are consistent with best practices. This review should also highlight any regional challenges with activating VRPs.

The cost of preventing and preparing for a disaster is a small price to pay when compared with the cost of a large oil spill and its long-lasting, catastrophic

ramifications.

Energy Policy Implications

As the new administration gets to work, they are faced with incredible challenges from the pandemic, the economy, and the promise to protect our climate. Continuing to invest in fossil fuel extraction does not help us curb greenhouse gas emissions and reach the climate goals outlined in the Paris Agreement. The Paris Agreement is a legally binding international treaty on climate change that more than 190 countries adopted in 2015 with a key goal of limiting global warming, and reducing greenhouse gas emissions.

A recent report found that reinstating the U.S. crude oil export ban could lead to reductions in global carbon emissions by as much as 73 to 165 million metric tons of CO_2-equivalent every year. This range of carbon emissions reductions is the equivalent of closing between 19 and 42 coal plants.[6] Furthermore, it would also provide support for continued development of domestic energy alternatives and indicate that the dominance of the fossil fuel industry is coming to an end.

The change in policy to begin exporting crude oil has only increased our domestic oil production. President Joseph R. Biden has committed to addressing climate change, and some have called on him to reinstate the ban on crude oil exports. Senator Edward Markey of Massachusetts introduced a bill in the last session of Congress calling on then-President Donald J. Trump to reinstate the crude oil export ban.[7] This is likely not the last time this issue will be raised.

Conclusion

The United States should increase efforts to incentivize the transition to clean energy. While offshore wind and ocean energy facilities bring their own challenges to the maritime industry, we simply cannot continue to increase crude oil production in the face of the climate crisis.

The current COVID-19 pandemic has temporarily reduced demand for crude oil, creating an opportunity to rethink our commitment to a fossil-fuel-laden "all of the above" energy policy. If an oil export ban is not reinstated, the pandemic also provides us with additional time to prepare for the implications of increased oil spill risk. We know what to do, we just need the imperative to act.

Authors' note: *The information in this paper reflects the views of the authors, and does not necessarily reflect the official positions or policies of that of the Natural Resources Defense Council, NOAA, or the Department of Commerce.*

About the authors:

Valerie Cleland works at the Natural Resources Defense Council where she advocates for policies that protect and restore our oceans. She got her master's degree from the University of Washington School of Marine and Environmental Affairs.

Dr. Mary Baker currently serves as an environmental scientist with National Oceanic and Atmospheric Administration's Office of Response and Restoration, with expertise in natural resource damage assessment after oil spills—including work on the Deepwater Horizon *and the Enbridge Pipeline Dilbit spills—and at urban hazardous waste sites. She is also an affiliate professor at the University of Washington School of Marine and Environmental Affairs.*

Special thanks to LCDR Ian Hanna who worked on this initial project in 2018 while at the University of Washington, and Doug Helton of NOAA's Office of Response and Restoration.

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Illegal, Unreported, and Unregulated Fishing

Supporting the Coast Guard's efforts to combat this global security threat

by Scott Craig
Air and Systems Domain Lead
Office of Research, Development, Test & Evaluation and Innovation
U.S. Coast Guard

Loretta Haring
Communications Manager
Acquisition Directorate
U.S. Coast Guard

CDR Blair Sweigart
Chief, Modeling, Simulation and Analysis Branch
Research and Development Center
U.S. Coast Guard

A bountiful catch requires more than a strong net and the proper bait, it also requires ensuring the global fishing supply. This is a complex, multi-faceted challenge, especially as illegal, unreported, and unregulated (IUU) fishing has surpassed piracy as the leading global maritime security threat. IUU fishing not only endangers the economic security of many nations, including the United States, and affects the livelihoods of those fishing legally, unchecked activity threatens global food security.

The statistics are staggering. The *U.S. Coast Guard Illegal, Unreported, and Unregulated Fishing Strategic Outlook* reports that one in five fish caught around the world is believed to have originated from IUU fishing. About half of the world's population relies on fish for 20 percent of its animal protein, yet 93 percent of the world's major marine fish stocks are considered fully exploited, over-exploited, or significantly depleted, according to the United Nations' Food and Agriculture Organization. IUU fishing cuts access to this important protein source, as well as affecting legal fisheries' revenue.

The Coast Guard has a leading role in providing for the safety, security, and stewardship of the planet's precious ocean, bay, and river resources that in turn support America's status as a maritime nation and its prosperity. Additionally, the Coast Guard has pledged to be a global leader in the fight against IUU fishing. One line of effort to accomplish this is targeted, effective, intelligence-driven enforcement operations, but the question of how to achieve effective enforcement in the vast open spaces affected by IUU

U.S. Navy Gunner's Mate 2nd Class Thomas Quinlan launches a RQ-20B Puma Unmanned Aerial System in January 2021 from the U.S. Coast Guard Cutter *Oliver Henry* in the Philippine Sea. This integrated operation enhances maritime domain awareness in order to detect, deter, and disrupt illegal, unregulated, and unreported fishing throughout the Western Pacific. Coast Guard photo by Petty Officer 3rd Class Brent Lagarde

fishing remains.

The Coast Guard's Research, Development, Test & Evaluation and Innovation Program is working to determine whether autonomous or unmanned systems might help in the fight. The program's Research and Development Center (RDC) is evaluating the ability of low-cost, unmanned surface vehicles to provide maritime domain awareness (MDA), with a primary focus on combatting IUU fishing.

Impact on Coast Guard Operations and American Maritime Economy

In 2018, Congress directed the Coast Guard to conduct a pilot study and assessment of low-cost, commercially available technologies that might enhance MDA in remote Pacific regions. The Coast Guard indicated the detection of IUU fishing as one major concern in this region. According to Scot Tripp, RDC researcher and project manager for the pilot study, this accounts for billions of dollars lost annually in the global fishing industry.

Another concern was a lack of actionable data available to Coast Guard operators. To facilitate information sharing with Pacific Island partners, any data sharing solutions needed to be unclassified, Tripp said. The RDC took a two-pronged approach; establish a memorandum of understanding (MOU) with Global Fishing Watch (GFW) for tracking IUU activity and then issue a request for information to better understand the current state of persistent MDA collection technology.

Laying the Groundwork

The purpose of the MOU was to promote a partnership for increasing transparency of the global commercial fishing enterprise and advance the detection, deterrence, and knowledge of IUU fishing through research and development activities. It resulted in the establishment of an integrated product team at Coast Guard Headquarters to incorporate GFW's established worldwide monitoring of fishing fleets and its data processing system to help determine potential illegal activity. At this time, the technology is being used as an aid to patrol planning, but it has the potential to be used as a monitoring and/or alert system of illegal activity, providing actionable data automatically.

An evaluation of the request for information responses indicated that an autonomous USV solution, with its low cost and small logistical footprint, would be the best fit. A request for proposal was issued requiring systems to detect surrounding vessels and provide actionable alerts over a 30-day demonstration period in an area off the shore of Oahu, Hawaii. This location was selected over the remote Pacific to better manage costs. The contracting approach was very broad in scope to allow industry to propose solutions and the government to award to multiple contracts. Among the requirements:

- ability to operate 30 consecutive days without refueling
- ability to detect other vessels within a minimum of 1 nautical mile of the USV
- ability to provide notification of other vessel detection within 6 hours of initial detection
- ability to operate in moderate seas and survive in rough seas
- ability to operate independently beyond line of sight communications

Partnerships and Contract Awards

Two contracts were awarded on February 7, 2020, one to Spatial Integrated Systems Inc.

BTCOE Serves as Tech Scouting Arm for Coast Guard

The Blue Technology Center of Expertise (BTCOE) acts as a conduit between the Coast Guard and the technology sector.

BTCOE is designed to educate industry, academic, non-profit, and government partners about Coast Guard missions and technology requirements, and to identify and facilitate technology solutions in support of the service's operational mission needs.

The Coast Guard has a strategic interest in advancements that will not only enhance its current capabilities, but also prepare the service for the future of maritime operations, including:

- advanced computing capabilities
- next generation domain awareness
- mobility solutions for operations and support activities
- technologies that can increase operator safety and security

Launched in 2020, BTCOE has its origins in the Save Our Seas Act of 2018, which authorized the Coast Guard to establish the center. It is located on the campus of the Scripps Institution of Oceanography in La Jolla, California.

If you have a promising technology that could aid Coast Guard operations, reach out to BTCOE at BlueTech@uscg.mil and check out the website at www.dcms.uscg.mil/acquisition/bluetechcoe.

(SIS) based in Virginia Beach, Virginia, and the other to Saildrone of Alameda, California. On-water demonstrations were scheduled to begin in July, but COVID-19 travel restrictions forced them to be rescheduled for October 7 through November 5, 2020.

To perform the demonstration, SIS developed Watcher, based on a Coast Guard small boat platform modified with solar arrays, an MDA sensor suite, and autonomy controls. To ensure the boat would meet the 30-day endurance requirement, a reserve fuel tank was added beneath the deck structure. To fulfill the requirement of detecting another vessel, Watcher was configured with a commercial radar dome and a pan-tilt-zoom electro-optical/infrared (EO/IR) camera. Once a radar target is detected, the EO/IR camera automatically pans to the target and takes an image that is sent back to the control station via satellite communications. Watcher is also capable of being launched and recovered via trailer, davit, or crane.

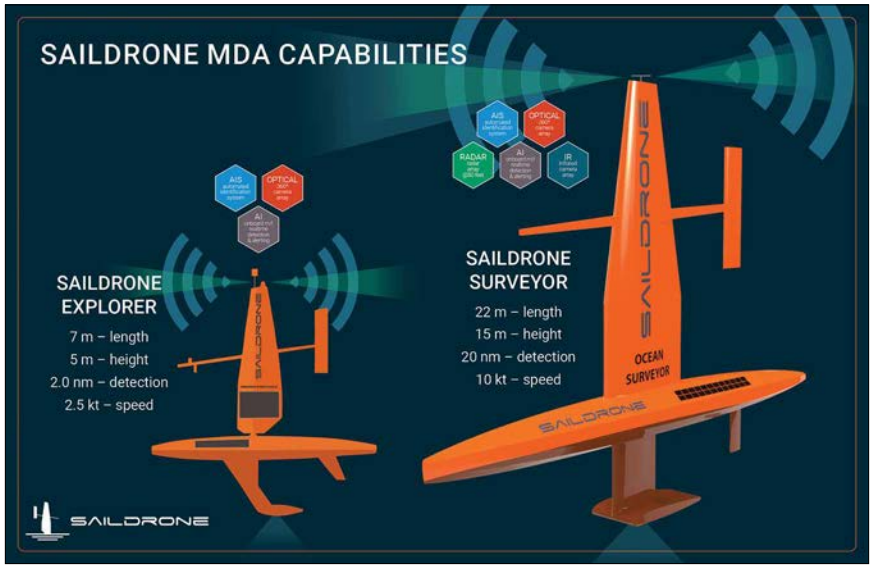
The Watcher is a Coast Guard cutter boat-large platform developed by Spatial Integrated Systems Inc. with solar arrays, a maritime domain awareness suite, and autonomy controls. This unmanned service vehicle was successfully tested in late 2020, and is a potential tool in the fight against illegal, unregulated, and unreported fishing in remote ocean areas. Coast Guard photo

Over the course of the demonstration, Watcher demonstrated its ability to maintain position within the operation box and provided alerts every hour when another vessel had been detected. Additionally, it was designed to be capable of both manned and unmanned operations for increased versatility. If manned operations are required, Watcher can still be operated from the helm and host up to two operators.

Saildrone performed the demonstration using six Generation 6 saildrones; 23-foot-long fiberglass sailing vessels with a 15-foot fiberglass airfoil sail, referred to as the wing. These USVs, normally referred to as drones, use wind for propulsion while their onboard electronics are powered by solar arrays affixed to the wing and deck. They are capable of transiting at 2–3 knots or slightly more in favorable wind conditions, operate with an average power consumption of 10 watts, and are capable of being launched and recovered via davit or crane.

All saildrones were controlled via an internet-accessible web portal, which superimposed the location of each drone at its current position, tracking history of vessels it detected, and maintaining historical tracking data for each drone. The portal also organized imagery and tracking data from each detection, allowing the user to see a time lapse of maritime activity around the saildrones. Additionally, the portal was used to retask the drones as they conducted a multitude of missions including search pattern execution, picket line formations, station keeping, and other MDA activities.

Saildrone's USV also included its proprietary artificial intelligence (AI) software, which has been trained on vessel detection. Upon the AI determining a vessel has been detected, the drone sends the image, with a line of bearing to the detected vessel, as an alert to the end user and the Saildrone command centers. To conserve satellite bandwidth



Saildrones' Generation 6 USVs are 23-foot long fiberglass sailing vessels with 15-foot fiberglass airfoil sails and feature onboard proprietary artificial intelligence software trained in vessel detection. Six of them participated in a 30-day maritime domain awareness demonstration period in late 2020. Graphic courtesy of Saildrone, Inc.

The 29RDC, a 29-foot autonomous vessel, conducts an autonomous mission off the Honolulu coast in November 2020. The USV was controlled by a laptop, but was also successfully remotely operated by Research and Development Center watchstanders in New London, Connecticut, 5,000 miles away. Coast Guard photo

and ensure the command center is not inundated with alerts, the AI is configured to send only the clearest images approximately every 15–20 minutes. All other images are saved onboard and can be accessed later.

Both contractor-owned/contractor-operated autonomous USVs were tasked with detecting and alerting Coast Guard watchstanders to ship activity in the operational area.

In an effort to better understand the efficacy of a government-owned/government-operated USV, the RDC purchased the 29RDC, a 29-foot autonomous vessel, from Metal Shark of Jeanerette, Louisiana, with a SM300 autonomy control system from Sea Machines based in Boston. The SM300 system was designed to allow a vessel to be remotely or autonomously controlled, however, the vessel's wheel and throttle remain fully functional, allowing an operator, if present, to take control at the helm if desired. The USV was controlled by a laptop running Sea Machines' user interface. To support unmanned operations the vessel was configured with cameras off the bow, stern, and within the cabin for situational awareness. The RDC successfully completed dozens of autonomous navigation, search pattern, collision avoidance, and remote-control operations. Additionally, the 29RDC was operated multiple times by RDC watchstanders in New London, Connecticut, which demonstrated the vessel's ability to be controlled from 5,000 miles away using cellular service.

Lessons Learned

Overall, the demonstration showed that commercially available USVs are capable of performing some level of daytime MDA missions of up to 30 days. Each USV proved its capability to detect other vessels in excess of a mile, and in certain situations, in excess of 4 miles.

The 29RDC also provided valuable insight to the demonstration, as it allowed the operational Coast Guard a first-hand glimpse into currently available USV technologies and allowed for interactive planning and execution of its own missions in real time. These demonstrations provided exceptional feedback regarding potential operations using USVs in concert with cutters and other boats as a force multiplier; performance of reconnaissance missions; search and rescue augmentation through autonomously executed search patterns; and screening recreational and commercial vessel traffic. The 29RDC was not constrained by SIS or Saildrone requirements, which allowed the RDC and other demonstration participants an in-person experience of how these vessels operate and their potential for future operations.

This demonstration also highlighted the importance of the development and incorporation of AI and machine learning into future USVs. For the purpose of this demonstration, the MDA sensors used were all capable of capturing significant amounts of data, and did so. To speed processing and limit expensive bandwidth consumption, it is invaluable for the USV to conduct onboard

processing to the greatest possible extent, limiting transmitted data to only that which is actionable to operators. This ability is dependent on the platform's AI, and is critical to USVs' success in long endurance and MDA missions.

Researchers also determined that using autonomous USVs for persistent MDA efforts likely will require a layered solution. "USVs like saildrone are capable of performing MDA missions for up to a year without maintenance, but their low transit speed does not allow them to pursue a target of opportunity to collect more information," said Tripp. He added that, in contrast, Watcher is only capable of 30 days endurance, but has the capability of traveling at speeds over 30 knots. Upon detection, it can also be instructed to pursue a target for better imagery. "A system where these USVs worked together could prove to be a valuable tool for future MDA capabilities," Tripp said.

The demonstration helped the Coast Guard understand what these technologies current capabilities. The results of the study will help shape how the Coast Guard, and its partners, incorporate USVs into future operations.

Conclusion

On the global stage, the importance of being mission capable in a variety of ways, even via USV, is crucially important, a fact Coast Guard Commandant ADM Karl L. Schultz highlighted in the 2020 *U.S. Coast Guard Illegal, Unreported, and Unregulated, Fishing Strategic Outlook*.

"The 2017 United States National Security Strategy outlines the impacts of these global threats, highlighting the importance of the rule of law, respect for sovereignty, and freedom of the seas to ensure the security of the United States and like-minded partners."

With enhanced capability like the Low Cost Maritime Domain Awareness program, the Coast Guard is envisioned to support maritime safety in diverse areas. While ADM Schultz said the Coast Guard is prepared to take a greater leadership role in this effort, he acknowledges the success won't be achieved alone. In this case, technology is being proven a strategic partner in maritime security success.

About the authors:

Scott Craig is the Air and Systems Domain lead for the Coast Guard's Research, Development, Test & Evaluation (RDT&E) program. In this role, he manages all aspects of the Coast Guard's aviation and unmanned systems RDT&E projects. A retired Coast Guard captain and pilot, he flew the HH-65A, HH-60J, and HC-130J. He is a 1988 graduate of Norwich University and a 2002 graduate of Purdue University's Krannert Graduate School of Management.

CDR Blair Sweigart serves as chief of Modeling, Simulation and Analysis at the Coast Guard Research and Development Center, and the demonstration director of the Low Cost Maritime Domain Awareness. He previously served as the enforcement chief in Sector Puget Sound, focused on increasing MDA for improved port, national, and border security alongside domestic and international partners. A 2004 graduate of the Coast Guard Academy, he holds a master's degree in computer science and a Ph.D. in applied mathematics from the College of William & Mary.

Loretta Haring is the communications manager for the Coast Guard Research, Development, Test & Evaluation and Innovation Program. A member of the Office of Strategic Planning and Communication within the Coast Guard Acquisition Directorate, she also works with the contracting and procurement enterprise, the Office of International Acquisition and the aviation domain. She has a degree in journalism/mass communications and worked in the newspaper industry before coming to the Coast Guard.

Coast Guard CDR Leo Danaher operates the 29RDC via radio-controlled belt pack. Unmanned service vehicles have a promising future as part of the maritime domain awareness mission. Coast Guard photo

For more information

Low Cost Maritime Domain Awareness Pilot Study Quick Look Report

www.dcms.uscg.mil/Portals/10/CG-9/Acquisition%20PDFs/LCMDA_QuickLook_NOV2020.pdf?ver=CkydXfLO--ouAfjVwjjFDA%3d%3d

U.S. Coast Guard Illegal, Unreported, and Unregulated, Fishing Strategic Outlook

www.uscg.mil/Portals/0/Images/iuu/IUU_Strategic_Outlook_2020_FINAL.pdf

Research, Development, Test & Evaluation and Innovation Program

www.dcms.uscg.mil/Our-Organization/Assistant-Commandant-for-Acquisitions-CG-9/Research-Development-Test-and-Evaluation/

Urban Freight Innovation

Leading-edge strategies for smart cities

by Bill Keough
Managing Director
Supply Chain Transportation
& Logistics Master's Program
University of Washington

Anne Goodchild, Ph.D.
Founding Director
Supply Chain Transportation & Logistics Center
and the Urban Freight Lab
University of Washington

Giacomo Dalla Chiara, Ph.D.
Research Associate
Supply Chain Transportation
& Logistics Center
University of Washington

Consumers have become accustomed to having the products they order delivered faster than ever. Using innovative techniques to securely deliver goods wherever and whenever the customer requests them, delivery companies are advancing to meet this demand.

Competition throughout the supply chain is steadily growing. Companies need to devise innovative methods for the transportation of goods from raw materials all the way to the final consumer. From concept to practice, it can be challenging to identify affordable solutions.

This article will highlight recent research conducted by the University of Washington's Urban Freight Lab. It will also detail work the lab has conducted with its strategic partners to explore new methods to reduce transportation costs, improve the customer experience, reduce carbon footprint, and reduce urban congestion after goods leave the shipping docks.

Customer Expectations in a World of eCommerce

Think of the first time you ordered something from Amazon, and the fulfillment experience when your product finally arrived. My first Amazon order in 1999 was for a newly released Tom Waits album. At the time I was working as a technology consultant for IBM and it seemed appropriate to try this out, especially since I was telling clients all about the business revolution internet commerce would soon create. I remember entering my credit card information with a little trepidation as I recalled an IBM security consultant telling me that he actually used a separate credit card for internet ordering due to the risks.

I liked the fact that Amazon immediately told me when my order would arrive. I think their projection was probably 5 days, which was fine since I didn't need to do anything except be patient. I remember walking to my mailbox two days after placing the order and there was my CD. I guess Amazon's thinking was to underpromise and over-deliver. It seems odd now, but I was really impressed.

That was a long time ago. Amazon now offers free delivery with its Prime program, and even two-hour delivery for some products in large metro areas. We all know how this has changed consumer expectations. As the pandemic began, I recall ordering a lawn spreader and I was particularly aggravated when Amazon indicated that I would need to wait a week to receive my item and I actually ended up buying it from Walmart because they could deliver in two days.

Consumers now expect to have an enormous catalog of products to choose from, and they expect the delivery to be on-time, in-full, undamaged, and with accurate documentation—a phenomenon called "perfect order." On top of that, they also expect their deliveries to be free.

Although the pandemic has lengthened the amount of time consumers are willing to wait for a delivery, and increased their willingness to pay for expedited delivery, it seems reasonable that consumer expectations will return to pre-pandemic levels once the worst subsides. Adjusted consumer expectations during the COVID-19 outbreak have provided a brief respite for less capable ecommerce shippers, but this respite won't last. Based on a number of research studies, delivery excellence is a key factor in a consumer's perception of the brand. I know that I have stopped buying from merchants who were unable to meet their delivery commitments.

Contemporary Challenges in eCommerce Logistics

For most of us, when we shop online we expect to find exactly what we want—immediately available inventory,

the most competitive prices, and complete, fast, free delivery. Amazon has taught us that this is what consumers should expect.

At this point in online retail, these abilities could almost be considered table stakes. But as any supply chain person will tell you, the operational, technological, and logistical challenges that are required to pull this off are gargantuan. Likewise, the pricing pressure exerted on logistics providers in this new competitive environment are unprecedented. To remain competitive, transportation providers must design and adopt innovative solutions that will fundamentally change the way products are delivered.

While logistics providers face a host of challenges in meeting these new service level requirements, one of the largest areas of opportunity is in optimizing delivery in what is termed the "last mile." In logistics, the term last mile means the last step of the delivery process from a warehouse or distribution center to the end customer. Depending on the nature of the delivery, last mile transportation can actually encompass the 50 miles or more it takes to get the product to the final consumer's door.

Last mile logistics is in fact the most expensive part of the delivery process. Most transportation providers are now focused on optimizing this part of the delivery process as new efficiencies can contribute very significantly to corporate profits, especially at a time when the shipping volumes and negotiating power of companies like Amazon and Walmart are exerting such downward pressure on shipping costs.

Downtown deliveries are rapidly increasing and causing traffic congestion as drivers park wherever they find space, including occasionally on the sidewalk. Technology is being piloted to optimize this "last 50 feet," of the delivery process, which will have positive impacts on the environment and profits. rblfmr | Shutterstock.com

Going Beyond the Last Mile

Addressing the last mile problem is challenging. But the researchers at the Supply Chain Transportation & Logistics Center (SCTL) have analyzed this problem in depth and isolated what is, in fact, the most challenging and costly portion of the last mile—coining the term "The Final 50 Feet."

The final 50 feet is the distance a package must travel to go from the delivery truck into the hands of the final consumer. For several years, the Urban Freight Lab at the University of Washington has been studying this problem and working with key stakeholders to devise, test, and implement innovative, real-world solutions to address what is probably the most daunting problem in the world of urban freight.

When I drive down the streets of downtown Seattle, the effects of the final 50 feet problem are painfully clear. As the number of deliveries being made downtown increases exponentially, Seattle's already-challenging traffic situation is becoming untenable. The increasing traffic congestion is due in large part to trucks parked on the sidewalk, in alleys, or sometimes in the middle of the road.

The SCTL Urban Freight Lab (UFL) at the University of Washington has partnered with the Department of Energy, the Seattle Department of Transportation, and the Pacific Northwest National Laboratory (PNNL) on a pilot project to address the final 50 feet challenge. Our research considers leveraging contemporary sensor technology, machine learning, and new processes for accomplishing this delivery challenge.

Through the Department of Energy's Office of Energy Efficiency and Renewable Energy, the Vehicle Technologies Office is funding the three-year, $1.5 million pilot project in Seattle and Bellevue, Washington, to:

- Reduce parking seeking behavior by approximately 20 percent in a pilot test area
- Reduce parcel truck dwell time by approximately 30 percent
- Increase business efficiency by increasing turnover in load/unload spaces

Project Approach

The UFL is taking a two-pronged approach by deploying centralized delivery lockers and collecting real-time data about parking behaviors and availability, then employing machine learning to predict the availability of parking at any moment in time. Both of these initiatives are focused on accelerating the delivery process to reduce urban congestion.

Accelerating the Delivery Process

Common carrier locker

The UFL partnered with the Seattle Department of Transportation to establish what are called common carrier delivery lockers in high-density population areas. Common carrier lockers are secure, automated, self-service storage systems designed to accommodate deliveries from multiple transportation providers delivering a range of parcel sizes. If you've ever had an Amazon package delivered to a locker you understand the idea. However, unlike Amazon lockers, these lockers are "common," in that any carrier can use them to make deliveries. Such common carrier lockers create what is called delivery density, enabling many trucks to transport many packages to a single stop, rather than all those vehicles having to make multiple stops to accomplish the

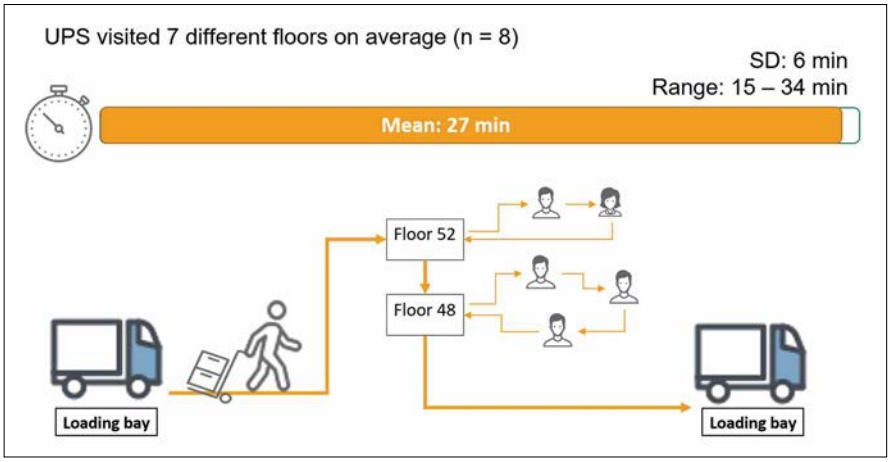
The Urban Freight Lab at the University of Washington partnered with the Seattle Department of Transportation to install common carrier delivery lockers in high-density population areas. Common carrier lockers are designed to store deliveries from multiple carriers delivering a range of parcel sizes. Photo courtesy of the Urban Freight Lab at the University of Washington

same task. This new approach reduces both dwell time and failed first deliveries, both of which produce congestion, unwanted emissions, and increased cost. Each is described below.

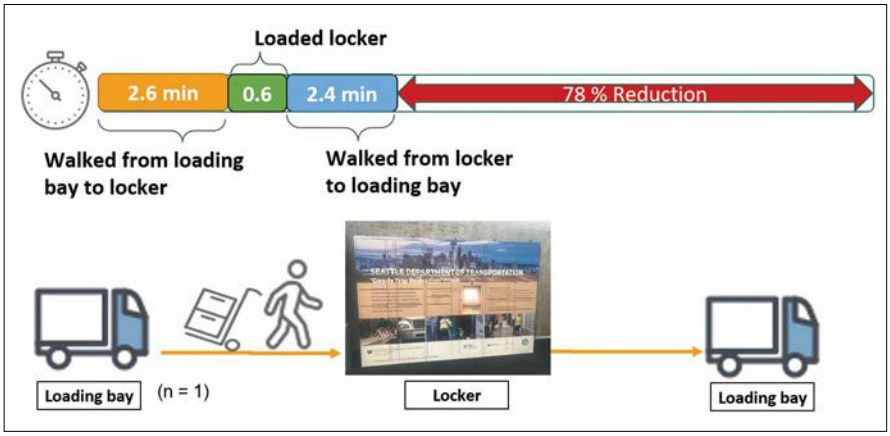
Reducing failed deliveries

Failed deliveries are a significant problem for delivery firms like UPS and DHL. A failed delivery occurs when the delivery driver is unable to get the package into the hands of the final consumer for any number of reasons. The most common reason for final delivery failure is that the consumer isn't home and there is no safe place to leave the package so it doesn't get stolen. Failed deliveries, which must be redelivered the next day, further increase congestion and pollution in urban areas. And they impact profits. Clearly, having to deliver a package twice instead of once makes that delivery that much less profitable.

Common carrier lockers essentially solve the failed delivery problem, not just for one carrier but for all of them. Fewer failed deliveries mean fewer delivery trucks downtown, so there's less congestion and more available short-term parking. More parking means fewer delivery vehicles circling the block looking for somewhere to stop, or pulled up on the sidewalk.



Without access to common carrier lockers, the average delivery time to seven different floors in a downtown Seattle building was 27 minutes. Graphic courtesy of the Urban Freight Lab at the University of Washington



Common carrier lockers reduce the last 50-foot average delivery time by nearly 80% to only 5.6 minutes. This reduces road congestion and enables delivery companies to conduct more profitable operations. Graphic courtesy of the Urban Freight Lab at the University of Washington

Reducing dwell time

One of the important efficiency metrics for delivery vehicles is dwell time. Dwell time is the time that a vehicle spends at a scheduled stop without moving, in our case when the driver is making deliveries. Obviously, the shorter the dwell time the better. To quantify the benefits that this approach can provide, the UFL observed and timed actual urban deliveries. The conclusions were compelling. Using the traditional delivery approach without access to common carrier lockers, the average delivery time to deliver packages on seven different floors in a building in downtown Seattle was 27 minutes. With common carrier lockers, the average last 50-foot delivery time collapsed to only 5.6 minutes—a reduction of nearly 80 percent! Not surprisingly, this reduced truck dwell time by nearly the same amount. As a result, far more vehicles can use the same parking space, meaning fewer trucks blocking the alleys, on sidewalks, and less need for city planners to devise ways to create more truck parking.

This reduction not only reduces congestion, but it also enables delivery firms to conduct more profitable operations, since faster deliveries require fewer trucks and less labor. Property managers have also embraced this solution. It enhances building security since there are no longer unknown individuals inside the buildings they manage. It is also more environmentally friendly, as it saves fuel and reduces emissions.

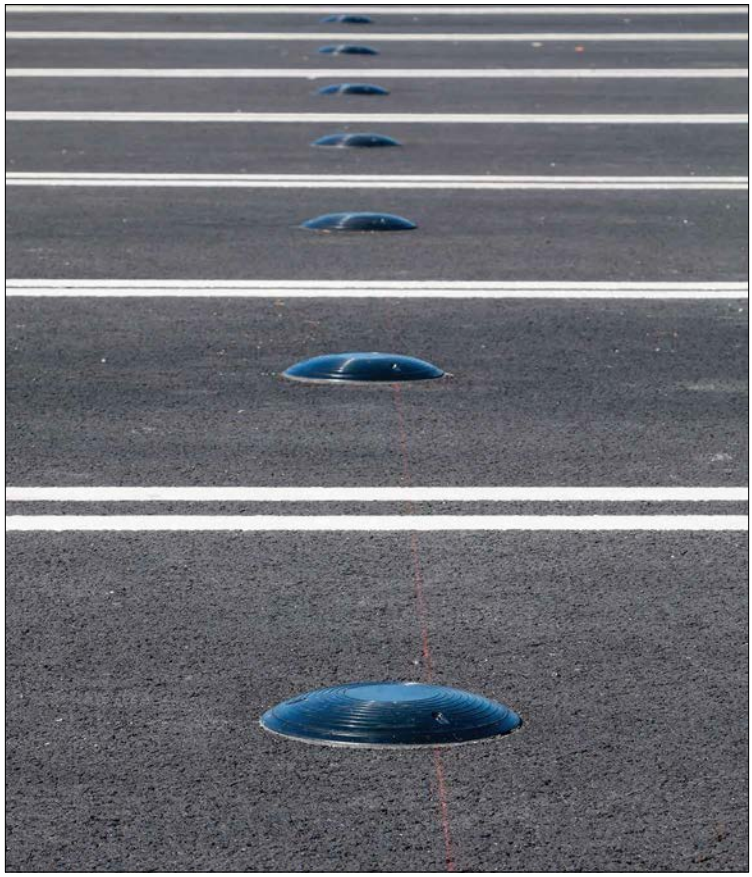
Real-time Data Detection and Analysis

The first step in understanding the real-time availability of commercial parking accessible to delivery drivers is to know whether a parking space will be available when the driver arrives. There are a number of commercially available solutions for collecting this information, but most of them function in a similar manner. To support the considerable data integration, management,

and analysis requirements of this effort, UFL has partnered with Pacific Northwest National Laboratory (PNNL).

A sensor that looks like a hockey puck is installed in the ground below a particular parking location. When a space becomes unoccupied, the sensor communicates this information to a vendor-specific data collection device. Depending on the device and the degree of connectivity, this data might either be stored on the collection device for a batch upload or streamed in real time. Ultimately, the data is sent to a server at the University of Washington and pushed to a server at PNNL through an application programming interface (API) for analysis using artificial intelligence capabilities built into the PNNL system.

The PNNL system will predict in real time which parking spots may be available when the driver arrives and where they are located, thereby dramatically reducing the amount of time drivers spend driving around looking for an available parking space. These sensors are relatively inexpensive, and the information they collect is binary—either a space is occupied or it is not. Obviously, gathering other data points besides vacancy status, like what type of vehicle is occupying the parking space at any given time, would be immensely useful in this effort, for example to ascertain the actual dimension of space occupied. However, at the current time only three data points—the location of the hockey puck and spaces, time of day, and vacancy status—are captured and communicated. Personally identifying information about people or vehicles is never gathered.



The Urban Freight Lab at the University of Washington and the Pacific Northwest National Laboratory have partnered to study parking availability for delivery drivers. Sensor technology, similar to that in the photo, is being implemented in order to monitor real-time availability of commercial parking. Pierre-Olivier | Shutterstock.com

Rich Data

Several vendors have developed solutions that can provide additional data. Companies like Cleverciti and Verizon offer solutions that provide a wealth of additional data that is invaluable for this type of effort. These technologies capture and interpret far more detailed data about parking availability and usage.

These commercial solutions can capture real-time video of a particular urban location, stream that information to a server with software designed to interpret the video stream. They can also capture and analyze pedestrian traffic, automatically interpreting various attributes of the data it has collected. Likewise, such a system can be taught to recognize different types of delivery vehicles by color and shape, which companies the vehicles are affiliated with, what type of building they are visiting, license plate numbers, etc. Additionally, information about dwell times, occupancy, the routes vehicles take through a particular urban area at a particular time of the day, and other factors can be captured and analyzed. However, none of these data streams are made available to PNNL, only the occupancy status is provided through the API.

PNNL's machine learning capabilities use only the parking space and occupancy history as model inputs to recognize patterns that are difficult for humans to discern, and then predict parking availability, based on the historical space occupancy information. Availability predictions will be accessible via a mobile device, enabling drivers to consider predicted parking availability in their decision making as they seek a suitable unoccupied parking spot. Even with these near real-time predictions, there are no guarantees a spot will remain open until the driver arrives to claim it. As the system learns, however, the predictions will increase in accuracy, delivering a far more powerful prediction solution.

Machine Learning

Once the occupancy data arrives at PNNL's servers, the prediction models are generated, exploring parking behaviors across different parking spaces, as well as looking into parameters like the time of day and day

of the week. Although it is beyond the project's current scope, future improvements could explore contextual data sources, like weather or economic indicators, that influence congestion patterns to make even more intelligent decisions and projections.

Ultimately, this data will be available in a free mobile application that drivers can employ to locate parking locations that are currently empty. The currently deployed version of the app allows drivers to define the length of their vehicle, view current occupancy, and determine if any applicable spaces are predicted to become available within a selected timeframe.

Future enhancements would be expected to improve the systems prediction accuracies. UFL member companies, like UPS, who will be using the app, will have the option to provide data like:

- vehicle length
- time of day when seeking parking
- the number of packages being delivered at each stop
- type of commodity being delivered—a single box or "big and heavy"

Drivers will also be able to select parking preferences. For example, a driver could indicate that they only want to be notified of spaces on the end of the block and not in the middle, because it is easier to maneuver.

To access the V2+ mobile application developed by PNNL, the users are required to provide an email address, which can be anonymous. Any additional data provided by the user to the application is used locally by the application and is not collected by or stored at PNNL. Such additional input data can direct drivers to available parking spots that meet their specific requirements. This information will also help drivers make more informed decisions about parking selection. In an ideal world, drivers with the app who are searching for a space would provide feedback if the space they were directed to is actually occupied at that particular moment. This is the sort of outcome-based data that helps the system "learn" to make more accurate predictions.

Other Outcomes

Removing waste and creating new business models and profit sources

While this research will unquestionably improve the efficiency and cost-effectiveness of delivery over the last 50 feet, this new real-time visibility will also create new business models and profit sources for resources that are currently either undervalued or entirely wasted. Similar examples of how technology is being employed to capture new value and remove waste in industries such as agriculture, where imperfect produce is now being sold to consumers rather than being discarded by farmers, is currently available.

Within the network of parking spaces available to delivery drivers, a significant percentage are privately-owned. At certain times these spots are vacant, even though there may be a lack of public parking options available to delivery drivers who may not want to pay for a space.

Once real-time information about parking accessibility is available, there is a foreseeable market for available private parking spots with prices that vary with demand, much like the way the price of an Uber fluctuates depending on demand.

Such a marketplace would remove waste from the system, creating a new profit-source for the owners of these private spaces while also providing a cost-effective solution for delivery drivers, who otherwise might be left to circle the block for 15 minutes seeking an available space.

Such innovations are what will contribute to the creation of "smart cities," which deploy and integrate new technologies to improve urban services like utilities and transportation to reduce waste, the consumption of resources, and costs. In doing this, these innovations will also make cities more climate-friendly, more efficient, and, ultimately, more livable.

About the authors:

Bill Keough is the managing director of the Supply Chain Transportation and Logistics master's program at the University of Washington. He also teaches in the program. His 20 years of consulting experience includes work at IBM, CSC, and with his own supply chain consulting firm, Keough Associates, helping private equity firms improve the performance of their portfolio companies. Mr. Keough holds degrees from Cornell University and the University of Houston.

Anne Goodchild is a professor of civil and environmental engineering at the University of Washington, and serves as founding director of both the supply chain transportation and logistics online master's degree program and the Supply Chain Transportation & Logistics Center. The latter is home to the Urban Freight Lab, a public-private research consortium. She holds both a doctorate and a master's degree from University of California, Berkeley, and a bachelor's degree from University of California, Davis.

Giacomo Dalla Chiara, Ph.D. is a postdoctoral research associate at the University of Washington's Urban Freight Lab. Before moving to Seattle, he was a research fellow at the Singapore University of Technology and Design in 2018 and a visiting scholar at the Massachusetts Institute of Technology in 2017. He holds a Ph.D. in engineering systems from the Singapore University of Technology and Design, an M.Sc. in statistics from ETH Zurich in Switzerland, and a B.Sc. in economics from LUISS University in Italy.

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Using AI Technologies for Dynamic Risk Management

by Bahadir Inozu, Ph.D.
Chief Executive Officer
Sharp Focus Inc.

Curtis Doucette
Chief Strategy and Innovation Officer
Sharp Focus Inc.

In hindsight, professional accident investigators find every adverse event produces tell-tale warning signs prior to the incident. These signs will be scattered across voluminous reports, emails, data silos, handwritten forms, and device data. In the maritime environment, connecting the dots to identify emerging risks in time to act has been very challenging, if not impossible, until now. The emergence of advanced technologies like Artificial Intelligence (AI) and Natural Language Processing (NLP), can now empower decision makers to make better choices in near-real time. They are able to detect and respond to anomalies, see emerging trends dynamically, and take action to stop the initiation or propagation of an adverse event. In addition, through better planning and simulation of adverse scenarios, every organization can become more resilient.

Ensuring Sustainability Against Increasing Complexity and Environmental Harm

On top of the impending risks inherent to the introduction of more automation, new, often invisible or unknown risk types like cyber threats and pandemic diseases, are being introduced. In addition, sensitivity to environmental harm is increasing as manifested by the United Nation's (U.N.) 2030 Agenda for Sustainable Development, which included 17 sustainable development goals (SDGs) and 169 related targets.[1] As a whole, the SDGs offer the maritime industry the chance to gain recognition by contributing with a broad consortium of stakeholders towards a set of high-profile, well-defined, measurable goals. It also provides opportunities for the International Maritime Organization (IMO) to strengthen and prioritize its efforts to contribute to sustainable development in a measurable manner and make the maritime industry's contribution to sustainable development more visible.

The 17 U.N. SDGs are integrated, requiring a balancing act among social, economic, and environmental sustainability. Two are directly linked to safety. SDG 3 addresses vessel related pollution and can also be linked to the occupational health and safety of the seafarer. On the other hand, SDG 8 addresses the seafarers' welfare on issues such as safety and fatigue, as well as promoting a safe and secure working environment for all seafarers. While reaching these SDGs is critical for sustainability, the additional administrative burden imposed by compliance is expected to be substantial.

As a result of the shifting regulatory and technology landscape, ensuring safety and financial viability becomes increasingly difficult. This requires a much more proactive approach which makes use of all available data and facilitates understanding with the effective fusion of algorithms and expert knowledge. Identifying negative and positive risks, or opportunities, and then acting upon them in a time-sensitive and agile manner are critical steps. These enable the transformation of ordinary organizations into fast-learning organizations and drive the required cultural change. In a world as digitally enabled as ours is becoming, resiliency is best achieved by building upon a platform that has proven effective under highly dynamic circumstances. Using existing data, high reliability organization (HRO) methodology has seen great success in a number of cases.[2] HRO has been used very successfully to transform organizations, changing behavior by instilling people with values and principles that result in the adoption of a culture of safety in high-risk environments. Combining

The emergence of advanced technologies, like natural language processing, or NLP, is helping decision makers to make better choices in near-real time. Funtap | Adobe Stock

In the maritime industry, high reliability organization was first implemented on board the USS *Carl Vinson*. Navy photo by Petty Officer 3rd Class Devin M. Monroe

this proven methodology with advanced technologies, like AI, will significantly ease change management and allow the results to be repeatable and scalable across many organizations. In other words, consuming the outputs of AI algorithms within the framework of an HRO amplifies the impact of the intelligence by making the operationalization of AI support seamless and incorporating it into a well-defined organizational process.

Principles of High Reliability Organizing

High reliability organizations are known to respond to crisis, chaos, and adversity with dramatically better results than other risk management and agility techniques. HRO gives leadership, management, and all levels of an organization a way to process challenges and overcome them as a single unit. HRO can help large teams adapt to potentially threatening and time-sensitive situations while they are still developing. It has literally been a lifesaver for those trapped in chaotic environments. Following naval aviation, other high-risk industries like civil aviation, chemicals, manufacturing, defense, and energy, among others have embraced the principles of HRO.[3]

These industries all function in environments where failure is catastrophic and, in many cases, puts human lives in danger. They also all rely on every individual to prevent catastrophic failure. From this perspective, we can readily see that all members of an HRO must maintain vigilance for anything that might cause a failure. When an organizational member observes an early sign of a failure, that member will engage the situation and articulate it to the team as clearly and concisely as possible. That person will subsequently be supported by the entire system and organization. From this concept emerge the five principles Weick and Sutcliffe presented in their book, *Managing the Unexpected*.[4]

1. Preoccupation with failure: Vigilance toward system vulnerability; early engagement of problems
2. Reluctance to simplify: The complexity of multiple interactions at the local level; the organization is reluctant to simplify or to keep simple in order to capture this complexity
3. Sensitivity to operations: The priority of local discrepancies, disturbances, and interruptions while maintaining strategic operations
4. Deference to expertise: The importance of local knowledge from interacting with the situation
5. Commitment to resilience: Support of the open-ended working of a problem until resolution

Because HRO supports the rapid expansion of a system during a crisis, it must accommodate the routine

operations immediately before the event. There is no confusion about when to shift operational methods from routine to crisis. Daily activities, in effect, become regular practice exercises for an emergency and the team, whatever that team may be, will then be better prepared to respond appropriately when a situation does escalate.

Six values enable an HRO to perform and are shared with its members through acculturation. These values are dignity, honesty, humility, empathy, duty, and resilience or perseverance. It is believed that a combination of these values and the above five principles make HRO a perfect candidate to drive the cultural change required in using near-miss reports and related data towards creating a safer more sustainable world.

Implementing HRO in the Maritime Industry

HRO has its roots in the maritime industry, beginning on the USS *Carl Vinson*. Some implementations have now been reported in the offshore industry, as with Chevron or Equinor, formerly Statoil, and in the U.S. nuclear submarine force. HRO principles are not widely embraced by the maritime industry as a whole yet, despite some of the principles being sparsely implemented.[5,6]

> *"Important to the true performance in what is now called HRO was the style and philosophy of leadership and management throughout the ship. The chief petty officers, whose authority crosses lines of command, have an important role in creating and maintaining the climate of HRO. There is the belief that you are always training your own relief and moving up. The record is based on many lessons and from previous experience. These lessons were learned in blood in the 1950s and 1960s; the crew must always remember that. There is attention to small detail in the belief that anyone can stop the operation if they observe something they believe is significant."* —Thomas A. Mercer, RADM, USN (retired)

Preoccupation with Failure

Ship crews are surrounded with systems that generate tremendous amounts of information. This information can provide the clues we need in order to be able to prevent a risk from developing into an adverse event. This is why the first principle of HRO is "preoccupation with failure." It is about recognizing anomalies. Even though the majority of them may be innocuous, we must not miss the fraction that represents an emergent threat so that we can intervene before it is too late.

We encourage organizations to consider any lapse in performance a potentially serious consequence. People watch for, and respond to, the weakest signals of failure. Rather than viewing outliers as random, independent events that one can ignore because of their rarity or disregard because of their disconnection to the system, we view the outlier as an early sign or representation of what is possible. Ignoring small failures leads to larger cascading failures and possibly catastrophic events. This approach enables forward-looking, preoccupation with failure, resulting in heightened vigilance toward system vulnerability, as well as earlier, and much more dynamic, engagement of problems than other safety management systems available in the market.

Applying Advanced Technology to Near-Miss Reporting

"Share your story, save the next shift" is the motto of firefighters' near-miss reporting system.[7] They have developed this culture over many years with the understanding that sharing information is the best way to enhance the common understanding of an emerging situation and solve issues proactively. This concept applies very well to ship near misses as well, but our observations indicate that this type of data collection is generally considered a bureaucratic requirement. Therefore, the quality and completeness of these reports, as well as how they are then consumed to drive change, are in need of significant improvement.

Our team has been working on improving near-miss data collection and analysis, primarily for maritime shipping and civil aviation, using NLP/machine learning (ML) methods applied on structured and unstructured data. This approach builds on our team's system reliability improvement experience and depth in HRO over the last 30 years. We have already reviewed and analyzed tens of thousands of ship incident reports that have been provided by more than a dozen organizations. We have also been developing and experimenting with the latest supervised—text classification—and unsupervised—text clustering and topic modeling—NLP/ML techniques to find patterns and automate analyses.

Buried in the haystacks, are golden needles, or free lessons learned, in the form of key bits of information contained in near-miss reports. If these reports are carefully filed and processed in a timely manner, they can become an invaluable source for detection of vulnerabilities and can be used proactively to prevent

Aviation Safety Reporting System

The Aviation Safety Reporting System allows two analysts to review incoming reports within three to five days of receipt and pass on time-critical information to the proper authorities. It can take up to four years to act on vulnerabilities in near-miss maritime events.

risks from evolving into accidents. We have focused on analyzing reports to determine whether a problem requires intervention. In order to achieve the ideal state of zero accidents in a dynamic environment, technology enabled vigilance is a critical requirement. We have been informed that sometimes it takes up to four years to act on a vulnerability detected during a near miss. The situation in civil aviation on the other hand is markedly better. The industry has a reporting system called the Aviation Safety Reporting System (ASRS) that allows pilots and other professionals to confidentially report near miss and close calls events. Typically, two analysts review incoming reports within three to five days of receipt, often less, and time-critical information is disseminated to the proper authority. Clearly, there are best practices to be applied across industries to drive safety and sustainability for all.

Our comparison of incident reports submitted to ASRS run by NASA for the FAA versus the ship incident reports in our database showed stark differences. In addition to some flight condition data, airplane pilots are asked to describe the event/situation in a free text field, keeping in mind the chain of events and human performance considerations. They are asked to discuss those which they feel are relevant and anything else they think is important and include what they believe really caused the problem.

Details of the following are also requested:

- What can be done to prevent a recurrence or correct the situation (ASRS)?
- How the problem arose and contributing factors?
- How was it discovered?
- What corrective actions can be taken?
- What are the human performance considerations: perceptions, judgements, decisions, and factors affecting the quality of human performance and actions or inactions?

On the other hand, IMO guidance on near-miss reporting as well as ASTM-F3256 state that, at a minimum, the following information should be gathered about any near-miss:[8,9]

1. Who and what was involved?
2. What happened, where, when, and in what sequence?
3. What were the potential losses and their potential severity?
4. What was the likelihood of a loss being realized?
5. What is the likelihood of a recurrence of the chain of events and/or conditions that led to the near miss?

Our review of near-miss reports from multiple international shipping companies showed that the overwhelming majority of ship near-miss reports do not contain the answers to these questions as opposed to ASRS reports, which are much more comprehensive. However, ASRS has the resources to call back the report provider to gather the missing information until sufficient information is captured. In general shipping companies do not have sufficient resources to do this.

When there are no labels applied to the unstructured text data that impute categories or when labels have a high degree of inaccuracy, like probable root causes, then supervised learning methods are not usable. For such cases, topic modeling can provide useful insights. For example, in some machine learning tasks, known as supervised learning models, and the training dataset fed to the algorithm includes the desired solutions, called "labels." For instance, if we want to develop a spam filter application, the algorithm needs to be trained on a training data which contains mail contents and corresponding label for each mail. The label for such an application would be "spam" and "ham (not spam)." If we consider another example like Root Cause Classification, then labels for each report (text) would be "Physical/Physiological Stress," "Lack of Competence," "Inadequate Tool/Equipment/Machinery/Device," etc. These label examples were selected from DNV GL—Marine Systematic Cause Analysis Technique M-SCAT8.2.

Topic modeling has previously been applied in the transportation domain with great success. Francisco C. Pereira et al previously used topic modeling to study ground traffic incidents.[10] Dr. Kenneth D. Kuhn used topic modeling to identify themes in ASRS text data and developed two prototype web-based applications about air traffic and weather conditions in the New York area. The results demonstrate that structural topic modeling and other methods applied are able to identify known issues. These methods are also able to uncover some issues that have not been previously reported. However, subject matter expertise is required to assign intuitive meanings to topics that are generated algorithmically and to otherwise interpret the results of topic modeling results.[11] An example of our analysis identifying 11 clusters of corrective actions is shown in the graphic to the

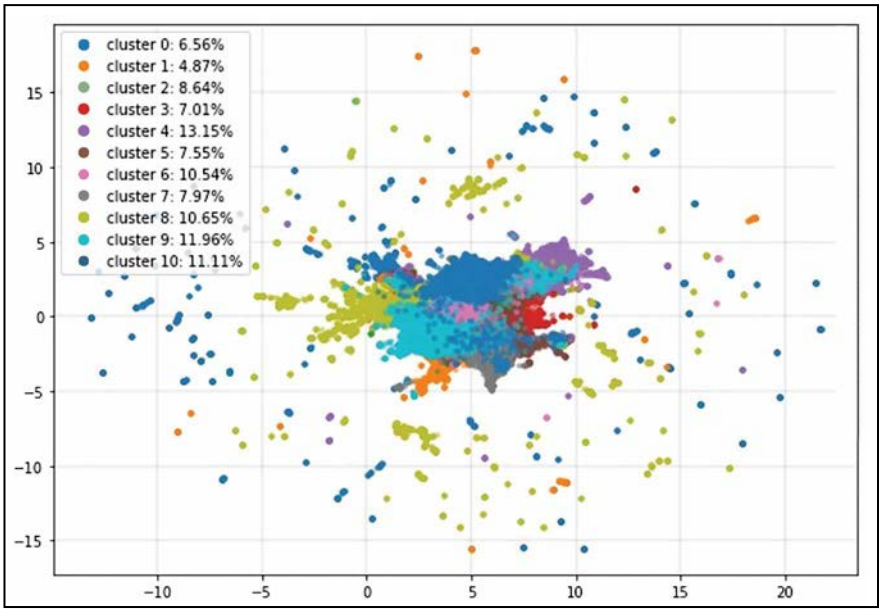
Standards Organizations

ASTM International, formerly known as American Society for Testing and Materials, is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services.

ASTM F3256-17 is the Standard Guide for Reporting and Recording of Near-Misses for Maritime Industry.

right. Each cluster represents a topic/incident mentioned in the dataset. For instance, when we look at the shining words and phrases in the extracted clusters, we observe that "cluster 4" is about PPE/safety wear. On the other hand, our analysis shows that "cluster 9" mainly contains the incidents that happened due to the lack of situational awareness. Actually, every cluster represents some other topic, and these are some examples regarding what these clusters mean in our analysis.[12]

Clusters of Topic Modeling



Graphic courtesy of Sharp Focus Inc.

Getting Good Data: Necessary but Not Sufficient

Too often, we see data collection systems that do not facilitate the early identification of emerging issues that will support timely downstream intervention because the analyses fall short as a result of inconsistent data that was poorly collected in the first place. Sometimes data can be corrected after the fact even though it can be tedious and time consuming. Other times, the data may be collected consistently but reports still lack the detail to narrow the analysis down to a useful degree. Considering the rate at which the environment is increasing in complexity and causing new threats to emerge, our means to process information must at the very least keep pace. Furthermore, even when data is extensively and sufficiently collected, available technology is not sufficiently used to derive insights from the data and those insights are not operationalized to drive the expected outcomes.

If you do not have the data collected consistently and sufficiently, you will not be able to generate actions accurately or expeditiously. If you do not have the right culture or employ the right methodology, you will not realize the expected benefits. Increasing technological intensity together with innovative application of HRO will allow us to prevent avoidable accidents, saving both lives and assets. Successfully leveraging these factors will also move us towards achievement of key sustainable development goals. The trick is to view these not as disparate efforts but as one integrated, end-to-end effort that earns the necessary buy-in from each stakeholder in order to achieve safety and sustainability for all.

About the authors:

Bahadir Inozu, Ph.D. is a graduate of the University of Michigan. He served as the chairman of School of Naval Architecture and Marine Engineering at University of New Orleans. Currently, he is the co-founder and CEO of Sharp Focus Inc. in Los Angeles. He also teaches project management at University of Southern California and Engineering Management at University of New Orleans. He is the author of two books.

Curtis Doucette is a graduate from the University of British Columbia Sauder School of Business. He is experienced in the tech start-up and venture capital space, and is the co-founder and chief strategy and innovation officer at Sharp Focus Inc., where his focus is on improving operational outcomes by combining cutting edge management with technological sciences.

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The Greenest Mode

The Case for Offshore Wind

Offshore wind and the U.S. Coast Guard Maritime Commerce Strategic Outlook

by Edward G. LeBlanc
Northeast U.S. Marine Affairs Manager
Ørsted Offshore North America

Today, few of us would dispute the need, or at least the desire, for clean renewable energy. Wind, particularly offshore wind, is a dominant source of clean renewable energy. Europe has nearly 100 utility-scale offshore wind farms powered by more than 5,000 offshore wind turbines, many of which have been in operation for decades.

The United States has zero.

Correct, the United States does not yet have an operational utility-scale offshore wind farm,[1] and the U.S. government has been reluctant to issue permits authorizing such wind farms in federal waters. That is about to change.

President Joseph R. Biden's declarations and commitments regarding renewable energy and the ambitious goals of several East Coast states, relative specifically to offshore wind, suggest a potential for rapid growth of this new-to-the-U.S. maritime industry. Such growth may challenge the Coast Guard's vision outlined in its *Maritime Commerce Strategic Outlook*,[2] but more likely it will offer significant opportunities to achieve the objectives detailed therein. This article discusses offshore wind in the context of challenges and opportunities relative to the Coast Guard's vision and objectives.

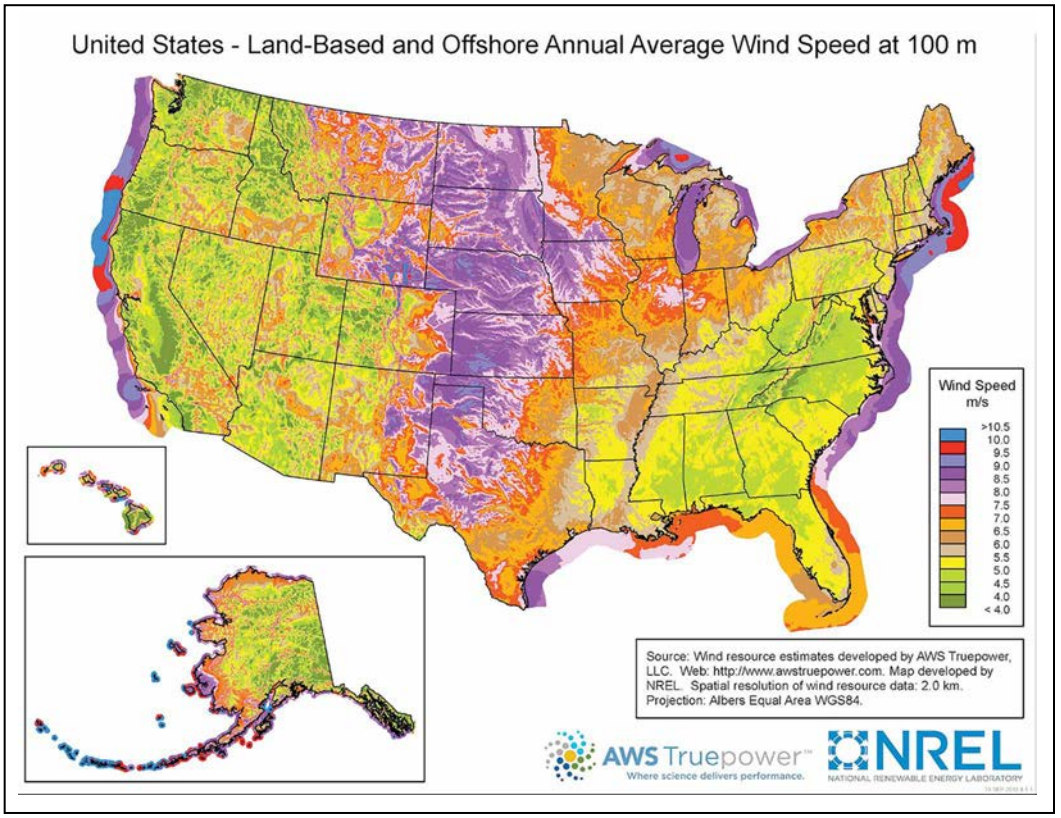
About Ørsted

Ørsted is the world leader in offshore wind development, operating 26 wind farms with more than 1,500 turbines generating power around the globe. In the United States, Ørsted owns and operates the 30-megawatt (MW) Block Island Wind Farm in Rhode Island state waters and has power purchase agreements (PPAs) in place to build and operate five utility-scale facilities with a combined nameplate capacity[3] of nearly 3,000 MW. To support these PPAs and future demands for renewable power to meet various states' renewable energy goals, Ørsted has over 600,000 acres, or more than 900 square miles, of Atlantic coast Outer Continental Shelf (OCS) currently under lease from the Bureau of Ocean Energy Management (BOEM).

Ørsted, and others in the offshore wind industry, will play a significant role in U.S. maritime commerce in the coming years and decades. Traditionally, "maritime commerce" is thought of primarily as commercial shipping.

A scaled image from a full-size bridge simulation model of Ørsted's Revolution wind farm shows how vessel traffic would appear in a 1 nautical mile by 1 nautical mile area. Note there are multiple vessels in the image—including the largest container ship in the world—all within the 1 nautical mile width between turbines. Graphic courtesy of the U.S. Maritime Resource Center

Offshore wind's presence in the maritime environment, and that of the offshore wind industry in general, is critical to providing renewable energy to the U.S. electrical grid. As it has already begun to do, offshore wind will continue to add a new and vital dimension to maritime commerce.



U.S. Department of Energy graphic

A Short History of the U.S. Offshore Wind Industry

As you will see, there can be no long history.

In 2001, Cape Wind submitted the first proposal for an offshore wind farm in U.S. waters—a planned 134-tower farm in Massachusetts' Nantucket Sound.

After more than a decade of what can only be described as a tortuous path through federal, state, and local permitting hurdles, and a heap of legal litigation, Cape Wind dropped its proposal. In 2010, Rhode Island approved an application for a five-tower, demonstration-scale wind farm in state waters, off the coast of Block Island. The Block Island Wind Farm has been in operation since 2016 and is now the primary source of electricity for the island while also providing surplus power to mainland Rhode Island via a subsea power cable. A second demonstration-scale offshore wind farm, this time a two-tower facility off the coast of Virginia, secured its federal permit for wind turbine generators in U.S. waters.

That's the short history of U.S. offshore wind as we begin the third decade of the 21st century. Seven towers—five in state waters, two in federal waters—with a grand total maximum generating capacity of 42 MW. Ørsted alone is now generating about 7,800 MW of electricity from offshore wind globally. This includes 30 MW of the United States' 42 MW, via Block Island, and another 2,900 MW of capacity currently awarded in the United States.

The northeastern United States is perfectly positioned for offshore wind. It has the demand, the wind resources, and sufficient buildable ocean area on the Outer Continental Shelf.[4] Offshore wind speeds tend to be faster than on land, and small increases in wind speed yield large increases in energy production. In 15 mph wind, a turbine can generate twice as much energy as a turbine in a 12 mph wind. Faster wind speeds offshore mean much more energy can be generated, and offshore wind speeds tend to be steadier than on land. A steadier supply of wind means a more reliable source of energy.[5]

As previously stated, the conversation around offshore wind has changed considerably in the last few years. We may now be on the cusp of an historical energy transition in terms of renewable energy in general, and offshore wind farms in particular. Clear, substantial political support at the federal and state levels, growing public support, declining costs, maturing government permitting policies, and a burgeoning supply chain all suggest the offshore wind industry is poised for explosive growth in the United States over the next decade. Complementing that optimistic view is the Coast Guard's *Maritime Commerce Strategic Outlook* which recognizes offshore wind as an "emerging requirement of the maritime domain." The *Strategic Outlook* commits the Coast Guard to engage, support, facilitate, develop, and improve overall maritime planning to facilitate the "new energy product" that is offshore wind.

Lines of Effort:

The *Strategic Outlook* is predicated on three "lines of effort," one of which is to facilitate maritime commerce.

From my perspective in the offshore wind industry, I offer three recommendations that may help further this line of effort:

1. *Acknowledge offshore wind as a key maritime stakeholder and a significant component of the maritime economy.*

In March 2020, the American Wind Energy Association, now American Clean Power (ACP), released its U.S. Offshore Wind Power Economic Impact Assessment. It stated that by developing 30,000 MW of offshore wind along the East Coast, the United States could support up to 83,000 jobs and deliver $25 billion in annual economic output by 2030. An August 2020 study from research group Wood Mackenzie finds that offshore wind in the United States, has the potential to deliver 28,000 new MW of clean energy and $1.7 billion in U.S. Treasury revenue by 2022. This is in addition to about 80,000 direct and indirect jobs annually through 2035. The U.S. Bureau of Labor Statistics estimates that the occupation of wind turbine service technician will be the fastest growing in the United States through 2029.[6]

BOEM currently has 15 OCS leases issued to various offshore wind farm developers, and those leases may hold one or more individual wind generation facilities. Each facility will employ dozens of vessels to conduct geophysical, geotechnical, fish, avian, and other surveys; lay and install cable; erect foundations and towers; assemble hubs and blades and, lastly, service and maintain these facilities over their estimated 30-year lifespans. These vessels will be supported via myriad coastal ports where the offshore wind industry has made or plans to make substantial infrastructure and logistics investments. The U.S. offshore wind industry is no longer an "emerging requirement" of the maritime domain—it has arrived.

2. *Provide certainty to the maximum extent possible in Coast Guard guidance and action, and in a complex federal permitting process filled with uncertainty.*

Uncertainty in the Federal Permitting Process

With respect to the offshore wind industry, the challenges associated with securing the necessary federal permits can be captured in just one word: uncertainty. Uncertainty introduces risk and creates doubt on several levels, including financing, contracts, schedules, hiring, planning, and designing. It also impacts the industry's ability to have constructive conversations with myriad stakeholders, as they expect certainty around topics such as layout, spacing, cabling, and so on.

With respect to permitting, perhaps one critical source of uncertainty is the lack of a single, decisive voice at the federal level, a voice that can make timely decisions on behalf of, and binding to, all agencies. To illustrate the impact of uncertainty let's review an issue, still pending, which originates with BOEM and involves the Coast Guard.

BOEM follows a lengthy and inclusive vetting process to determine areas of the East Coast OCS that may be appropriate for offshore wind development. The agency solicits input from all applicable federal agencies, including the Coast Guard, potentially impacted states, current waterway users, and environmental organizations, among others. An initial wind energy area (WEA) is designed and then essentially whittled down based on additional review and input from stakeholders. Only when this exhaustive vetting process is complete does BOEM, ostensibly speaking for the federal government, formally establish a final WEA and offer it, or portions of it, for lease to offshore wind developers.

BOEM awarded the first offshore wind lease in 2012 and the last in 2019. Once executed, these leases provide an expectation, ideally a certainty, that the area leased is reserved for potential development of offshore wind, subject to BOEM regulations and guidance, National Environmental Policy Act review, and issuance of applicable permits.

In 2020, years after BOEM, with Coast Guard input, created WEA's and awarded over a dozen leases, the Coast Guard introduced a proposed rule to establish coastal fairways that could potentially encroach upon, already leased wind energy areas. This of course could have severe consequences on a developer's ability to meet binding power purchase agreements, among other adverse impacts. That uncertainty persists indefinitely, as a federal rulemaking could be a multi-year process.

Uncertainty in Coast Guard Guidance and Actions

Navigation safety and search and rescue (SAR) are arguably the Coast Guard's most fundamental equities in the federal government's review of offshore wind proposals. To that end, the Coast Guard has issued comprehensive guidance outlining the information developers should provide, through a Navigation Safety Risk Assessment (NSRA) to facilitate an informed analysis of the potential risk a proposed wind farm represents to those equities. The most recent edition of Coast Guard Headquarters guidance is Navigation and Vessel Inspection Circular 01-19, or NVIC 01-19, Guidance on the Coast Guard's Roles and Responsibilities for Offshore Renewable Energy Installations.

NVIC 01-19 is an example of "good government." Per its title, it plainly outlines the Coast Guard's roles and responsibilities and provides a clear path for developers to follow and adhere to in producing a NSRA. In short, it provides certainty, though it does not provide for a Coast Guard/offshore wind industry collaboration to address navigation safety and SAR.

Uncertainty is introduced when new requirements,

or new interpretations of guidance, that deviate from or expand upon the NVIC's guidance are extemporaneously announced. As all guidance eventually becomes outdated and requires revision, it may be helpful to review and/or revise NVIC 01-19 at regular intervals, with active participation and support from the offshore wind industry.

A concerted Coast Guard effort to remove uncertainty as it relates to offshore wind would help further its strategic goal of facilitating maritime commerce—all maritime commerce—and would alleviate potential adverse impacts on financing, contracting, jobs, planning, design, etc., as discussed above. The consequence of continued uncertainty is further delay in producing utility-scale offshore renewable energy, or perhaps outright inability to construct an offshore installation.

3. *Collaborate with offshore wind to address mariner concerns regarding navigation safety and SAR.*

Both navigation safety and SAR are emotional issues for most mariners. The challenge is that navigation safety is to a greater or lesser extent in the eye of the beholder: What one mariner may consider safe another may consider unsafe. And as navigation is both a science and an art, for some mariners no amount of data will convince them that it is safe to navigate within, or in the vicinity of, an offshore wind farm. Ørsted is world-renowned for adopting and adhering to the highest standards of health and safety, frequently exceeding U.S. Coast Guard and International Maritime Organization (IMO) requirements. Its commitment to navigation safety is no less. Consequently, to facilitate navigation safety and enhance SAR, Ørsted devotes an extraordinary amount of resources to stakeholder engagement, including the Coast Guard as a key stakeholder, to ensure their views and concerns are fully understood and sufficiently considered. Ørsted reaches out and engages a wide spectrum of stakeholder groups early and often, especially the northeast U.S. commercial fishing industry and environmental advocacy groups, in an extraordinary effort to ultimately achieve constructive coexistence.

Through information sessions, open houses, port hours, online mariner briefings and other initiatives, stakeholders may provide input on any—or every—facet of wind farm development. This includes all factors impacting safety, as well as survey activity, gear-loss claims procedures, and compensation plans. The offshore wind industry has adopted a comprehensive suite of mitigations to reduce risk and enhance a mariner's ability to safely transit in a wind farm. These measures enhance safety but also help minimize, or even eliminate, the "search" in SAR. These mitigations may include lighting and mariner radio-activated sound signals; fog signals; automatic identification system (AIS) signals on each tower; enhanced VHF and cellular coverage; helicopter platforms on offshore substations; and special charting notations.

But generally, the offshore wind industry has been left to its own devices to convince mariners of three facts:

1. Navigation safety will not be adversely impacted and indeed may be enhanced by the presence of an offshore wind farm.
2. SAR incidents will not increase and, indeed, may decrease in an offshore wind farm.
3. Where the Coast Guard may have to conduct SAR within, or in the vicinity of, a wind farm, it can do so effectively.

My sense is that it would be beneficial for all concerned—mariners, Coast Guard, offshore wind industry—if the Coast Guard adopted a more collaborative approach to these issues. Below is a case in point that illustrates where Coast Guard leadership was paramount in bringing credibility and a measure of finality to the navigation safety and SAR debate in the Northeast.

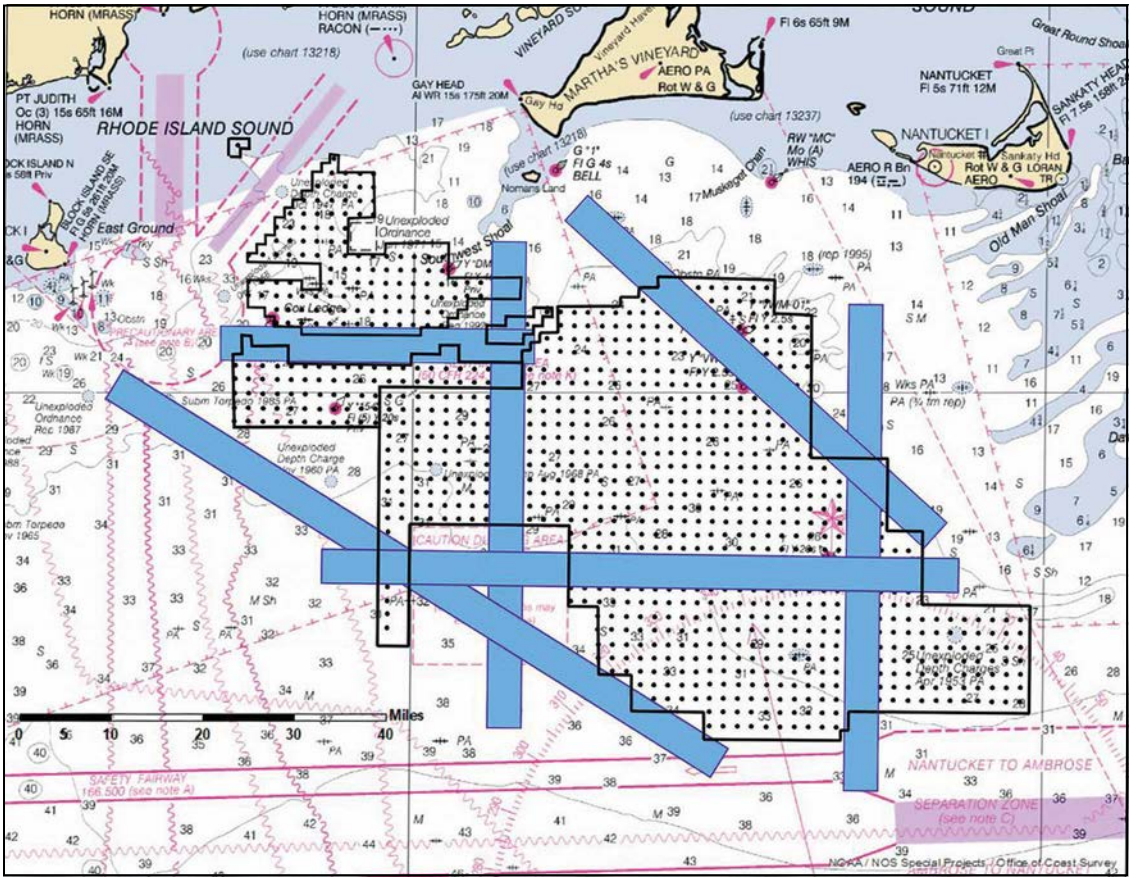
The Massachusetts/Rhode Island Wind Energy Area (MA/RI WEA) is an irregularly shaped polygon of about 1,400 square-miles south of Massachusetts' Martha's Vineyard and Nantucket islands. This uniquely shaped area is further distinguished in that it contains eight BOEM lease areas issued to four separate developers, with each area immediately adjacent to the other. Stakeholders quickly realized that if each lease area had a different array layout pattern and turbine spacing, the MA/RI WEA—if/when completely built out—might resemble an obstacle course for mariners transiting through or within the farms. The notion of navigation transit lanes, potentially two miles wide, was introduced by the Coast Guard in 2018. The intent was that the transit lanes would facilitate navigation while providing developers more flexibility on array layout and turbine spacing.

Concurrently, local states and the commercial fishing industry were advocating for a uniform layout with a minimum of 1 nautical mile spacing between turbines. The Responsible Offshore Development Alliance (RODA), a commercial fishing industry advocacy organization, proposed six, 4-mile-wide transit lanes.

In December 2019, developers holding leases in the MA/RI WEA offered BOEM and the Coast Guard a joint proposal offering to adhere to a standard uniform layout. The proposed layout would have the towers aligned in east/west rows and north/south columns, with a minimum spacing of 1 nautical mile between turbines, as preferred by the commercial fishing industry and coastal states, which negated the need for special transit lanes.

The notion of special "transit lanes" through a wind farm to facilitate vessel passage continues to receive substantial attention. Transit lanes were originally broached by the Coast Guard in the context of the MA/RI WEA,

RODA Massachusetts/Rhode Island Wind Energy Area Proposal



The Responsible Offshore Development Alliance, a commercial fishing industry advocacy organization, proposed six 4-mile wide transit lanes. National Oceanic and Atmospheric Administration graphic

directly in the path of commercial fishing vessels transiting between New England fishing ports and Georges Bank.

The idea was that if transit lanes were established for the safety and expediency of the commercial fishing fleet, then developers could have more flexibility in designing wind-optimized turbine layouts of varying spacing and lines of orientation. But as the fishing community and some state officials continued to advocate for minimum uniform spacing, developers in the MA/RI WEA jointly proposed a 1 nautical mile by 1 nautical mile uniform grid layout that, they contended, would obviate the need for transit lanes. The commercial fishing industry continued to support a RODA transit lane proposal advocating—six lanes through the MA/RI WEA, each lane 4 nautical miles wide. Together these two proposals were analyzed by the Coast Guard in its *The Areas Offshore of Massachusetts and Rhode Island Port Access Route* study. The study concluded that navigation safety would be preserved, as would the Coast Guard's ability to conduct SAR, in a uniform grid layout of 1 nautical mile by 1 nautical mile with three lines of orientation, as proposed jointly by developers in the MA/RI WEA.[7]

Although the debate persists to some extent, the Coast Guard's willingness to assert itself as the federal government's foremost authority on navigation safety and SAR, at least as it applies to the MA/RI WEA, is an outstanding example of collaboration. In terms of facilitating maritime commerce, the offshore wind industry will depend on the Coast Guard to exercise its Captain of the Port authority, particularly as it pertains to safety zones, to control vessel traffic and facilitate safe construction operations.

Looking Ahead

The offshore wind industry welcomed the passage of the 2021 National Defense Authorization Act, which authorized the Coast Guard to establish safety zones beyond the U.S. territorial sea to the OCS for activities related to offshore wind. Ørsted intends to work closely with the Coast Guard to develop a practical, enforceable plan for safety zones that minimizes impacts to mariners while preserving safety for all waterway users, including construction vessels.

A second "line of effort" contained in the *Strategic Outlook* calls for modernizing aids to navigation and marine information systems. Here, too, the offshore wind industry can make significant contributions to complement and support the *Strategic Outlook*.

The aids to navigation (ATON) suite that will be

part of each offshore wind farm will include synchronized flashing lights, sound signals, 24/7 monitoring, electronic (AIS) signals, painting schemes, and unique alpha/numeric labelling of each tower. Sensor packages will enhance VHF and mobile communications; provide meteorological data such as air temperature, barometric pressure, wind speed and direction; include oceanographic data such as current velocity and direction, water column temperatures, and other measures to monitor key environmental indicators. These ATON and sensors will not only enhance navigation safety, but will help reduce or remove the "search" from SAR. They will also facilitate maritime commerce including commercial and recreational fishing, pleasure and excursion vessel activity, and will provide for constructive coexistence with cargo/tanker vessels and tugs and barges. The last line of effort in the *Strategic Outlook* focuses on transforming workforce capacity and partnerships.

To that end, Ørsted has partnered with the North America's Building Trades Unions (NABTU), which represents more than 3 million skilled craft professionals in both national and international unions. The partnership will create a national agreement designed to transition U.S. union construction workers into the offshore wind industry in collaboration with the leadership of the 14 U.S. NABTU affiliates and the AFL-CIO.

The industry's use of non-Jones Act vessels to conduct highly technical survey and wind turbine construction operations in the United States has caused some to question whether the industry is complying with, or intends to comply with, the Jones Act. But the issue before Ørsted and the entire offshore wind industry is not a legal matter—of course we will comply with the Jones Act, and all applicable laws and regulations. Rather, it is a supply chain issue and also an opportunity to create an entire new U.S. maritime sector. Erecting wind towers that extend 60 or more stories into the sky, and then assembling the nacelle and blade components atop each tower, requires tremendously expensive purpose-built vessels and technicians with highly specialized skills honed over decades, primarily in Europe. And given the uncertainty of offshore wind development in the United States, there have been few sources of financing willing to take the risk of investing in a key cog of the supply chain—a heavy lift wind turbine generator (WTG) installation vessel. At least this was true until very recently.

Ørsted has already invested in American-made crew transfer vessels and has contracted for an American-made service operations vessel to support maintenance of its U.S. offshore wind farms when built. Though there are currently only about a dozen WTG installation vessels worldwide—none U.S. flagged—Dominion Energy has led a consortium in commissioning construction of the first Jones Act-compliant WTG installation vessel.

Going forward it is certainly Ørsted's intention to maximize the use of suitable and available Jones Act-compliant vessels, as well as employing U.S. technicians and workforce through each supply chain. No matter the lens through which you view this issue—economics, optics, even patriotism—it makes sense and is good business to employ U.S. vessels and workforce. As the supply chain matures and the availability of these assets improves, so too will our employment of them.

Conclusion

The U.S. demand for renewable energy has never been greater, and all signs suggest the offshore wind industry is poised for explosive growth in the U.S. over the next decade and beyond. The U.S. offshore wind industry is well-positioned to rapidly grow to meet that demand, and is quickly becoming a key stakeholder in the U.S. maritime domain.

But this newest addition to the nation's maritime domain need not be a difficult challenge, nor a burden to Coast Guard resources. Offshore wind's growth and presence in the maritime domain can nicely complement the Coast Guard's vision for enabling maritime commerce, as outlined in its *Maritime Commerce Strategic Outlook*. Offshore wind offers tremendous economic opportunities, will help modernize the U.S. ATON system, reduce SAR, and introduce an entirely new, highly trained workforce capacity to the maritime environment. The industry looks to the Coast Guard to continue its forward-leaning leadership, as expressed in its *Strategic Outlook*, relative to all maritime commerce—including offshore wind.

About the author:

Since 2019, Edward G. LeBlanc has served as the Northeast U.S. Marine Affairs Manager for Ørsted Offshore North America where, among other duties, he serves as the company's primary liaison to the U.S. Coast Guard. Previously he served in the U.S. Coast Guard as an enlisted, officer, and civilian employee from 1975 to 2019. He is a Coast Guard cutterman, a Navy Surface Warfare Officer, and a waterways management subject matter expert.

Endnotes:

1. There are two "demonstration scale" offshore wind projects in the U.S.: The 5-tower Block Island Wind Farm, in Rhode Island state waters; and the 2-tower Coastal Virginia Offshore Wind project, in Federal waters off the coast of Virginia.
2. U.S. Coast Guard *Maritime Commerce Strategic Outlook*, October 2018
3. The nameplate capacity of a wind turbine or offshore wind farm is the amount of energy the turbine or facility would produce if it operated 100% of the time at optimal wind speeds.
4. The OCS is that part of the seafloor where generally there is no noticeable gradient, extending from the shoreline to a point where the shelf markedly slopes. Most of the OCS is in relatively shallow water, with deepest depths typically between 300 to approximately 700 feet
5. American Geoscience Institute
6. www.bls.gov/ooh/fastest-growing.htm
7. From the joint developer letter to the Coast Guard of November 1, 2019

Offshore Wind Farms in the Mid-Atlantic

by LCDR Peter Francisco
Chief, Waterways Management Division
Sector Virginia
U.S. Coast Guard

LT Brittany Akers
Chief, Waterways Management Division
Sector North Carolina
U.S. Coast Guard

Matthew K. Creelman
Marine Information Specialist
Coast Guard District Five
U.S. Coast Guard

Home to New York; Baltimore; Philadelphia; Washington; and Norfolk, Virginia; the East Coast, specifically the mid-Atlantic region, is arguably one of the most densely populated regions of the country. This substantial population density creates considerable energy demand from the power grid. Together, that energy demand, the ideal physical characteristics of the relatively shallow waters of the Outer Continental Shelf, and the government's goals and incentives have created a very favorable environment for offshore wind energy development on the U.S. East Coast.

On January 27, 2021, President Joseph R. Biden signed an executive order setting the goal of doubling offshore wind energy production by 2030, and directing a review of siting and permitting processes to encourage further development. Some states have incentivized development as well. In 2020, Virginia enacted a law requiring the closure of nearly all coal-fired plants the end of 2024. The commonwealth also set a goal for its electric utilities to develop 5,200 megawatts of offshore wind energy generation capacity by 2034.

The states of Massachusetts, Connecticut, New York, New Jersey, and Maryland have also encouraged offshore wind development with a combined goal of 28,000 megawatts, or enough to power the Eiffel Tower for over three years, by 2035.

For comparison, Europe has already made such offshore wind farms commonplace. At the end of 2019, European waters had a total of 5,047 grid-connected wind turbines across 12 countries for a total installed offshore electric generation capacity of 22,072 megawatts.

History

The United States' first commercial offshore wind project, Block Island Wind Farm consisting of five 6-megawatt turbines, began operations in 2016 off the coast of Rhode Island. At approximately 590 feet, these turbines are taller than the Statue of Liberty. As technology is developed and new wind farms are constructed, turbines continue to grow in size and energy output. Newer farms are considering using 14- and 20-megawatt turbines that are able to capture powerful ocean winds and generate vast amounts of energy. The 14-megawatt turbines proposed in projects currently under development are designed to be more than 800 feet tall and will tower over the 6-megawatt turbines currently in operation.

Currently, the mid-Atlantic region has seven wind energy projects in various stages of development. Constructed by Ørsted, Dominion Energy's Coastal

Many areas of the country, such as Atlantic City, New Jersey, supplement their power grid with wind energy production. In early 2021, President Joseph R. Biden signed an executive order setting the goal of doubling offshore wind energy production by 2030. Christian Hinkle | Shutterstock.com

Virginia Offshore Wind (CVOW) pilot project began operating in 2020. This project, with two 6-megawatt turbines, was the first wind farm to complete the federal permitting process run by the Bureau of Ocean Energy Management (BOEM), an agency within the Department of the Interior. Dominion Energy also has an area immediately seaward of its pilot project which may be home to a wind farm of 200, 12- to 14-megawatt, turbines. Just to the south of these projects, off the coast of North Carolina's Outer Banks, is Avangrid Renewable's project, Kitty Hawk Wind. Kitty Hawk Wind is smaller in terms of the number of planned turbines, 62, but will likely use larger, 14- to 20-megawatt machines.

Off the coasts of New Jersey, Delaware, and Maryland, there are five more projects in various stages of planning with projections for another 500 total wind turbines in federal waters. Couple this with the myriad projects in the New England region, and it becomes very clear that this is a rapidly growing industry.

Planning

The Energy Policy Act of 2005 amended the Outer Continental Shelf Lands Act to authorize BOEM to issue leases, easements, and rights-of-way for offshore renewable energy installations beyond 3 nautical miles from shore. For renewable energy installations less than 3 nautical miles from shore, the U.S. Army Corps of Engineers is the lead agency. Regardless of which agency has the lead, the Coast Guard provides an evaluation of potential impacts on the marine transportation system, safety of navigation, and traditional uses of the particular waterway, and other Coast Guard missions. It also develops recommendations to mitigate potential adverse impacts that an offshore renewable energy installation may have on other Coast Guard missions for the lead agency's consideration. The evaluation and recommendations aid the lead agency in preparing its required National Environmental Policy Act documentation.

In its advisory role, the Coast Guard may recommend to BOEM that an offshore wind farm developer conduct a Navigation Safety Risk Assessment (NSRA) as part of the permitting process. Based on the size, location, and configuration of offshore wind farm installations, the farms have the potential to impact navigation safety for all users. An NSRA requires evaluation of marine traffic information based on an analysis of vessel movement data and consultation with pilots' associations, the maritime industry, local fisherman, and recreational boaters. The NSRA must include an analysis of changes that will occur because of the placement of the wind farm, including the possibility of increased recreational and commercial fishing activity in the vicinity. Accounting for seasonal variations, the assessment should also include a recent traffic survey of all vessel types. In addition to identifying the type and density of vessel traffic within the call area, the survey must also take several other matters in to consideration. These include proximity to nearby shipping routes, port approaches, other neighboring offshore renewable energy installations, military firing/bombing ranges, and any danger to vessels imposed by the clearance of wind turbine blades above the water.

How an installation might affect future vessel traffic routes is another consideration of offshore wind energy planning. In 2017, the Coast Guard completed the Atlantic Coast Port Access Route Study (ACPARS), which studied access routes to ports along the Atlantic coastline of the United States. The goal was to determine which routes were critical to maintaining an efficient, robust marine transportation system while supporting future marine planning efforts. The study area included the entire Atlantic Coast from Maine to Florida and focused on waters seaward of the existing port approach systems within the exclusive economic zone (EEZ). Its intent was to identify all current and anticipated new users and determine what impact the location, construction, and operation of proposed alternative energy facilities may have on near-coast users. Additionally, it looked at whether routing measures should be created or modified to ensure safe navigation.

Following the completion of the ACPARS, the Coast Guard initiated a follow-on port access route study (PARS) in 2019 for numerous strategic ports along the East Coast. This study aims to consider the possibility of developing fairways or other access routes from ports along the Atlantic Coast. This potential system of fairways is intended to ensure traditional navigation routes are kept free from obstructions that could impact navigation safety. The ports being considered in this study are economically important, support military operations, or have been identified to be strategically critical to national defense. In Coast Guard District Five, the ports being studied include Wilmington and Morehead City, North Carolina; Hampton Roads, Virginia, Port of Virginia; Port of Baltimore, Maryland; New Castle and Wilmington, Delaware; and the Port of Philadelphia. Similar to the ACPARS methodology, automatic identification system (AIS) data and information from shipping organizations are again being used to identify and verify primary shipping routes where no obstructions exist. There is tremendous benefit to potential developers and other users in understanding the constraints that mariners operate under and how these constraints could affect their installation planning initiatives. It is also an important basis upon which to refine marine planning guidelines and analyze impact to future shipping activities.

In the interest of safe navigation, the Coast Guard has also collaborated with BOEM to create a lighting and marking scheme for wind farms. This marking scheme

Several Coast Guard air and surface assets conduct a simulated rescue operation on wind turbines approximately 28 miles off the coast of Virginia Beach, Virginia, in October 2020. The turbines are more than 600 feet tall and the simulated rescue took place approximately 300 feet above the water. Coast Guard photo

uses lights with different flash characteristics based on where the turbines are located, fog signals at specified locations, unique visual identifiers for each turbine, and has the ability to project an AIS signal over each individual turbine. Each project should be designed in a grid-like pattern with each turbine receiving a specific alphanumeric identifier, such as A01 or U24. Each of these turbines are then charted and labeled so a mariner who sees turbine B03, for example, would know they are in the second row at the third turbine.

Each turbine can then be charted by the National Oceanic and Atmospheric Administration, thus providing the mariner with an exact position that could be used as an around-the-clock aid to navigation. Further, each turbine can be permitted as a private aid to navigation through the Coast Guard and listed in the regional List of Lights giving its position, visual ID, sound signal if equipped, and light characteristic.

One additional consideration for the safety of maritime traffic near an offshore wind farm is the installation's configuration with regards to collision avoidance and search and rescue. Vessels in the United States are generally able to transit through and near the installations as long as they deem it safe to do so. As such, the Coast Guard must be prepared to provide search and rescue services in and around these structures. When planning the layout of the turbine grids, the design and spacing may account for transit by search and rescue helicopters operating at low altitude, as well as other rescue craft. While each wind farm will be assessed on a case-by-case basis, the risk assessments provide information enabling the Coast Guard to adequately understand how the associated risks with the proposed layout have been reduced much as is reasonable. This often includes aligning turbines in straight rows or columns, preferably with multiple lines of orientation. Once the design is finalized, the Coast Guard is often involved in both table-top and full-scale exercises. These exercises aid in the development of joint communications plans and ensure the Coast Guard, and other agencies, are poised to respond in the event of an emergency in the vicinity of a renewable energy installation.

Coast Guard District Five and Sector Virginia units conducted a full-scale exercise in partnership with the project developers at the Virginia CVOW pilot turbines in October 2020. Dominion Energy exercised the evacuation of injured technicians from the turbines, both "evacuated up" to the turbine hub platform for aerial evacuation and "evacuated down" to the main platform for vessel evacuation. A Coast Guard Air Station Atlantic City Jayhawk helicopter and a Dolphin helicopter from Coast Guard Air Station Elizabeth City participated, and captured stunning video of a rescue swimmer being lowered to the turbine hub platform, over 300 feet above the surface of the water. During the exercise, the turbine blades were locked in two different positions.

On the water, a 154-foot fast-response cutter (FRC), an 87-foot patrol boat, and a 45-foot response boat-medium

(RBM), and the purpose-built crew transfer vessel, *WindServe Odyssey*, participated in the exercise. The patrol boat and RBM were able to approach the main platform directly, while the FRC sent its small boat to the main platform. This exercise represents a starting point for further coordination and exercises.

When other safety precautions may not be sufficient, the Coast Guard may now consider safety zones for offshore energy development activities further than 12 nautical miles from shore. Section 8343 of the National Defense Authorization Act, passed into law on January 1, 2021, directs the Coast Guard to conduct a two-year pilot program to assess the use of safety zones in the 200-mile EEZ for offshore energy, as well as for space launch and re-entry activities. With input from the developer, the Coast Guard will have to determine what these safety zones may look like, how far they will extend around wind turbines, and whether the safety zones will be permanent or only in effect during turbine construction, major maintenance, and decommissioning.

Industry Impacts

The development of offshore wind projects will also a have other significant impacts on the maritime industry for which the Coast Guard must prepare. To date, there have been virtually no U.S.-based construction assets available for the installation of offshore wind farms, but changes are occurring. For Virginia's two-turbine pilot project, contracted foreign construction companies with temporary local presences and foreign installation vessels were used to conduct the main construction work, and materials were staged in Canada in order to comply with the Jones Act. Retrofitted U.S. vessels were used for survey work and served as safety vessels during the construction phase. *WindServe Odyssey* catamaran was the first purpose-built U.S. vessel to assist with wind farm work in the mid-Atlantic. Built by Senesco Marine in Rhode Island, the 64-foot crew transfer vessel was inspected and certificated as an offshore supply vessel.

Since then, in a sign of maturation of the U.S. offshore wind industry, the construction of two new U.S.-flagged ships have been announced for service in offshore wind installations. The first, by Great Lakes Dredge and Dock Corporation, would be a vessel capable of precisely placing large rocks on the ocean seabed around the wind turbine foundation for scour protection. The second vessel, a 472-foot turbine installation vessel, has been announced by a Dominion Energy-led consortium. This vessel will be built by Keppel AmFELS at its Brownsville, Texas, shipyard. Both vessels are expected to be in service in 2024. Beyond the installation vessels, each wind energy area will use additional inspected and uninspected vessels, such as crew transfer and offshore supply vessels, to conduct continuous maintenance. This speaks to another significant paradigm shift. Going forward, some large electric utility companies will become significant marine operators.

Conclusion

With both overall energy demand and interest in renewable energy increasing, offshore wind farms are likely to continue their upward trajectory. As more of these installations are planned and constructed, vessel routing and marine traffic planning will continue to be a priority in order to support maritime commerce and maintain a strong marine transportation system. The planning and analysis occurring now will pay future dividends for the country's energy market and maritime supply chain.

About the authors:

LCDR Peter Francisco is the chief of the Waterways Management Division at Sector Virginia. He is a Maritime Academy graduate and has served as a marine inspector, marine investigator, and waterways manager during his 16 years in the Coast Guard.

LT Brittany Akers is the chief of the Waterways Management Division at Sector North Carolina. She has more than 10 years of Coast Guard experience, including waterways management industry training with the U. S. Army Corps of Engineers, as well as marine safety tours in vessel inspections and marine investigations.

Matthew K. Creelman is a marine information specialist at Coast Guard District Five in Portsmouth, Virginia. Currently, he is responsible for marine planning in the mid-Atlantic region as well as program management of the Private Aids to Navigation program for the district. He is a 1987 graduate of the Coast Guard Academy, a cutterman, and has served the Coast Guard for more than 30 years.

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Green, Greener, Greenest

What is the future of marine transportation?

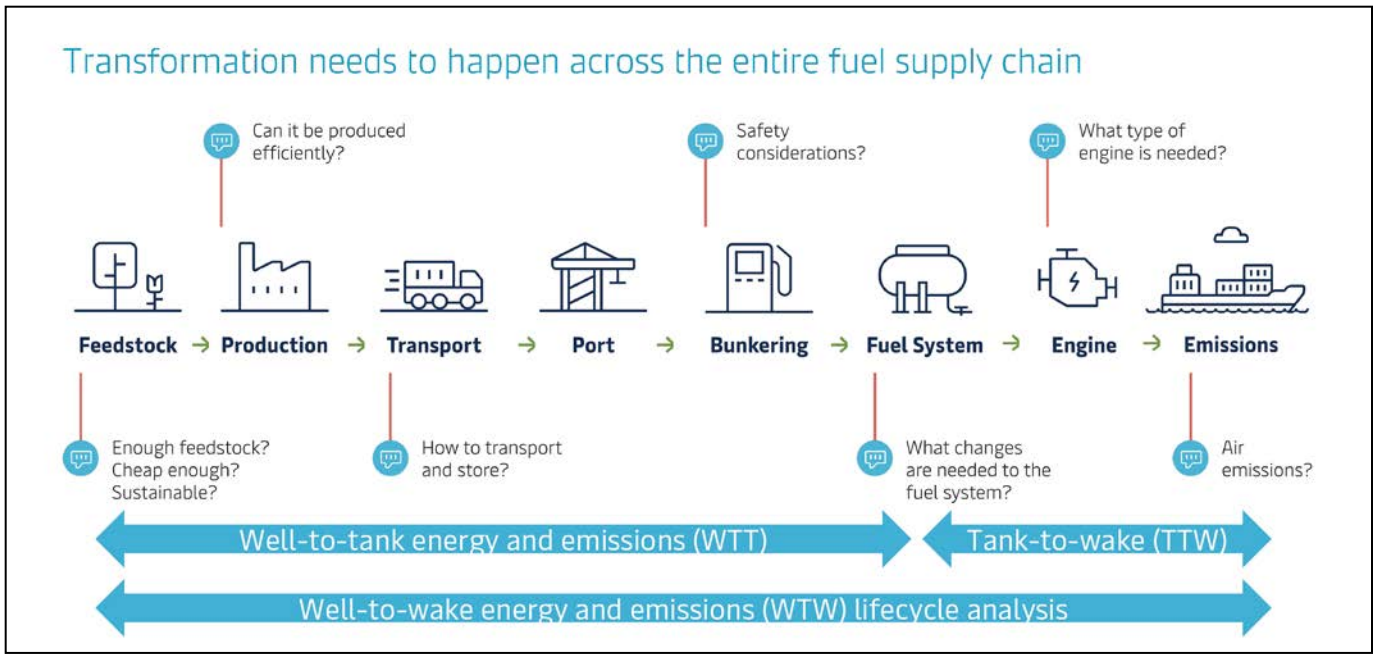
by Lee Kindberg, Ph.D., GCB.D
Environment & Sustainability for North America
Maersk

Ocean shipping is by far the most energy efficient, climate-friendly mode for moving cargo long distances. The good news is that focused energy efficiency work over the last 15 years has and continues to improve that efficiency each year. However, incremental improvements are no longer sufficient to meet the world's climate and environmental goals, or those of many cargo owners. A total transformation in fuels, technologies, and propulsion is facing all of us who go to sea or support or regulate those who do. This transformation will take us away from our familiar well-established, petroleum-based fuel systems and infrastructures, and into brave new worlds of biofuels, E-fuels, fuels cells, and more.

The maritime sector and aviation were not included in the Paris Agreement. In 2018 the International Maritime Organization (IMO) adopted an initial strategy on reduction of greenhouse gas (GHG) emissions from ships, with a commitment to reduce GHG emissions from international shipping and to phase them out completely as soon as possible. IMO set targets of a 50 percent reduction in total greenhouse gas emissions by 2050 compared to 2008, and a 40 percent reduction in emissions intensity by 2030. Discussions continue at IMO to define specific metrics and short-term measures, and IMO will revisit the targets in 2023.

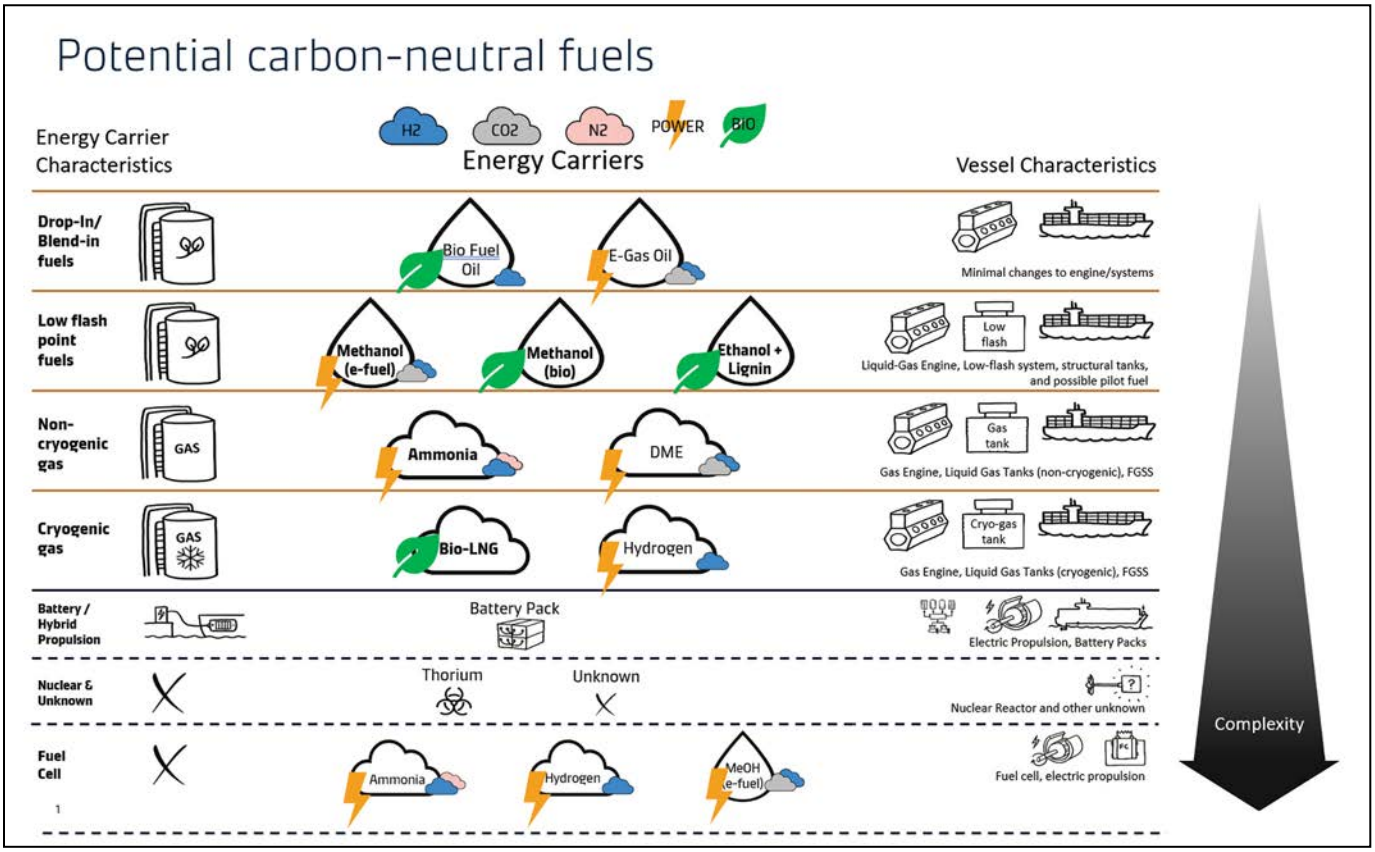
> Emissions intensity is the emissions generated by moving a weight of cargo a set distance.

However, regulations are not currently the primary drivers for maritime GHG reductions. Expectations of major shippers, investors, and societies have raised the bar far more quickly than could have been imagined only a few years ago. Almost half of Maersk's 200 largest ocean shipping customers have set, or are in the process of setting, ambitious science-based targets, or other zero carbon targets, for their supply chains, and those commitments continue to expand. The current industry



Graphic courtesy of Maersk

Figure 1



Graphic courtesy of Maersk

developments seem to be driven more by these expectations rather than by developing regulations.

As a result, vessel owners and operators are accelerating the pace of change, implementing the first new fuels and vessels and setting goals that are more ambitious than even the "moon shot" visionary goals of two to three years ago. For example, in 2018 Maersk set a goal of launching the first net carbon neutral vessel by 2030 and achieving a net zero carbon fleet by 2050. In February 2021, this was modified to include a commitment to launch a biomethanol-fueled feeder vessel by 2023. Maersk is pursuing biofuels as a more immediate option, and alcohol-lignin and ammonia as future options. In the future, marine operations may involve several carbon-neutral fuels and propulsion systems.

Where Are We Today?

Driven by both economics and customer and stakeholder demand for more environmentally friendly supply chains, most major shipping companies have made huge improvements in energy efficiency since 2008. The IMO's Fourth Greenhouse Gas Study ("GHG4") reports that between 2008 and 2018 the carbon intensity of international shipping decreased approximately 30 percent. Some major carriers report efficiency improvements approaching 50 percent.

These dramatic changes in efficiency are due to larger, more energy-efficient new vessels, retrofits on existing vessels, and order of magnitude increases in analytic capabilities with almost real-time vessel to satellite data acquisition. Optimized networks and more precise operations incorporate slower "steady steaming," and cooperation with ports and terminals enable just-in-time arrival. These investments and practices all contribute to reduced GHG generation.

However, from a total emissions perspective, industry growth has offset efficiency improvements, and GHG4 found that total greenhouse gas emissions increased 9.6 percent from 2012 to 2018. Other environmental improvements to vessels—ballast water treatment systems, exhaust gas cleaning systems, higher Tier NOx-removal designs—often also require additional energy.

Efficiency gains and operational controls will continue to be very important but cannot deliver a net zero carbon shipping future. This can only be achieved through new propulsion solutions based on carbon neutral fuels and energy systems.

So Many Choices

After decades of reliance on diesel, what's next in

propulsion? Industry is exploring a number of options, each with benefits, risks, and supply questions. We expect more than one winner, and different approaches will be more appropriate for different sectors of the marine transportation system.

For long-haul international and Jones Act vessels, early attention focused on liquified natural gas (LNG), which has provided early operational experience and expanded fueling infrastructure. LNG has a lower carbon content than heavy fuel oil, but today is a fossil fuel (natural gas, which is primarily methane). Questions remain about methane emissions, nitrogen oxide (NOx) emissions from some engine types and the full well-to-wake (WTW) lifecycle analysis. Depending on production route and engine technology, methane emissions can be substantial and can offset some of the CO_2 emission reduction benefits. In the future, bio-LNG could address some of these questions, and could potentially be manufactured from wastes to provide win-win circular economy solutions.

Other biofuels have now been demonstrated in marine applications. Liquid biofuels may require only limited vessel modifications and fuel supply changes, enabling rapid scale-up and implementation. These are called "drop-in fuels" since they can be used in existing engine and fuel systems. Operational experience with such fuels is limited and significant challenges remain in defining acceptable feedstocks, fuel specifications, traceability and certification, and audit standards for carbon credit or taxation standards. Scalability will also depend on feedstock availability, fueling infrastructure development, and the risk of competition with other transportation modes for limited bio-based fuels. Advanced biofuels and synthetic biofuels are also interesting options, but currently in the development stage, and scalability to meet the needs of the global fleet must be determined.

As shown in Figure 1, other innovative fuels and energy technologies will require more substantial and complex changes to vessels, ports, and fueling infrastructure. Some also raise questions of safe handling; toxic or flammable fuels, or battery production operations; and disposal/recycling.

Figure 2 includes thoughts on the status and challenges for a range of new fuels and energy systems. The current outlook is the end of the existing two-fuel global marine system, with the future systems becoming more complex and diverse as new fuels and energy sources are developed to meet the wide range of maritime applications.

The future is approaching our sector rapidly. Short sea shipping and ferries are already employing electrical power and some hydrogen-powered fuel cells. Some global companies have committed to the LNG pathway, which can lead to equipment and practices for other gaseous fuels. Maersk has stated publicly that its focus is on biofuel-based services available today, followed by alcohols, alcohol-lignin blends, and ammonia. Combination approaches, such as a hybrid of electrical and diesel, will extend ranges and broaden applicability.

Policies and Decision-making

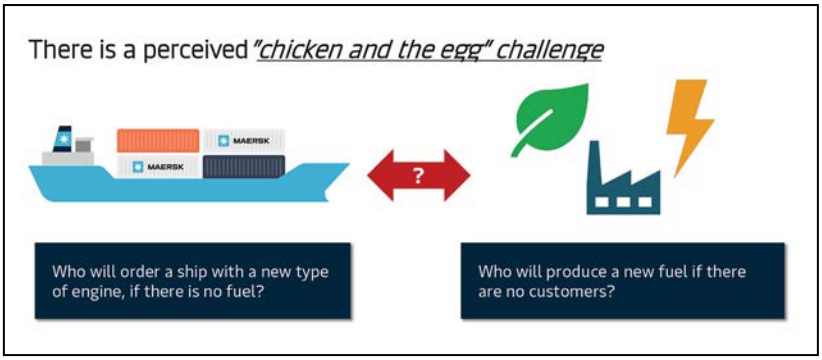
Global alignment of technical, regulatory and operational

Figure 2

Technology	Current Knowledge and Challenges Needs
Battery	Batteries are viable for short-sea shipping, but presently not for deep-sea shipping. Could be used for peak shaving or as a hybrid option.
Nuclear	Thorium technology is under development, but there are public concerns.
Onboard carbon capture	This is in the concept stage only, and space is a serious concern.
Fuel cells	Fuel cells have great potential to be a disruptive technology to combustion engines in the future but, at present, they are too expensive for shipping.
Biofuels/biodiesel	Biodiesels are now in limited blended marine use. Feedstocks, scaling, and competition with other modes are concerns. Synthetic biofuels—biomass-to-liquid—and advanced biofuels are at the development stage and will expand the options, though scalability remains a concern.
Bio-methane	Scalability of production, combined with methane emissions during production and combustion are concerns which bring into question whether this is a route to net zero GHG emissions.
Hydrogen	Hydrogen is not currently feasible for deep-sea shipping due to range—storage space and availability—but is very important as a feedstock. Safety is a concern.
Alcohols	Methanol is technically feasible today, but green methanol production is not yet available at scale. Only second-generation ethanol is acceptable and is more expensive than methanol
Lignin-alcohols (LEO)	LEO is in the early stages of development.
Ammonia	Green ammonia offers zero emissions both tank-to-wake and well-to-wake. Production is not yet available at scale, and engine and safety developments are ongoing. There are both technical and regulatory barriers to the use of toxic fuels.

standards, and financial incentive structures is essential to support progress in this field and to allocate reductions fairly to nations and companies to achieve decarbonization with minimal false starts or pathways. Key aspects include:

- Regulatory frameworks, goals, and meaningful data collection and tracking systems
- Fuel and engine/fuel system safety engineering and certification standards (Safety is already an active focus.)
- Economic structures to direct and accelerate change, support R&D, finance new vessel designs, and build new fueling infrastructures
- Structures rewarding and encouraging first movers in the industry
- Methodologies and metrics to define and compare lifecycle impacts of new energy/fuel alternatives and set and track global goals and progress



Graphic courtesy of Maersk

What is "Carbon Neutral?"

What is net carbon zero from a GHG perspective? What feedstocks and fuels are sustainable and acceptable? Do carbon offsets count in the analysis, and if so which ones? Metrics and standards in this area are vital for decision-making.

Lifecycle assessment of marine fuel and energy systems needs to be based on the full suite of greenhouse gases, or "CO_2e," with particular attention to carbon dioxide, methane, and nitrogen oxides. International standards for such analyses are essential to understanding and prioritizing the options, and developing consistent global strategies and regulations. Although considerably more challenging, full WTW analysis can provide the information needed for good investment decisions and GHG reduction strategies. A well-to-wake analysis includes the emissions generated in producing and transporting the fuel, as well as the tank-to-wake (TTW) emissions, associated with fuel use.

The potential for financial programs, such as the cost of carbon and other credits, as well as levies or incentives, requires transparency, auditability, and verification standards for full carbon accounting.

Adding one more dimension of complexity, for bio-derived fuels, changes in land use must also be considered in consistent ways. Standards will also need to consider extended impacts such as manufacturing and waste disposal for more imaginative approaches such as nuclear systems and new energy storage approaches.

The Chicken and the Egg

Who will order a new ship with a new type of engine if there is no assured fuel supply? Who will produce a new fuel if there are no vessels to use it? And will shippers be willing to foot the bill for the additional costs? Demand signals from the carrier to fuel providers, and from cargo owners to those carriers are vital in enabling progress. First movers in the industry play a key role, and are vital to breaking through the "chicken and the egg" barrier.

This "chicken and egg" challenge seemed to be a major conundrum. Then, in February 2021, Maersk announced a new biomethanol feeder vessel for 2023, a commitment to dual-fuel technologies to enable all future new vessels to operate on new fuels, and a partnership to produce green ammonia using wind power. The same month, another carrier announced an expanded commitment of LNG-powered vessels to U.S. services.

The Role of the USCG Will Expand

The U.S. Coast Guard will play a unique and pivotal role in this transformation. With increasing complexity in fuel characteristics and associated risks, the job of those front-line enforcement personnel and their leadership, policymakers, and trainers will become increasingly complex. From the industry perspective, we rely on the Coast Guard to understand and enforce environmental and safety regulations, play a major role in defining safe operating practices, and create the level playing field so essential to making this transition successful. Partnering with industry and supporting stakeholders, like classification societies, will be an important component in this transformation.

About the author:

Lee Kindberg, Ph.D., currently serves on the Marine Board of the U.S. National Academies of Science, Engineering and Medicine and the Transportation Research Board's Standing Committee on Marine Environment. She served on the U.S. Environmental Protection Agency's Clean Air Act Advisory Committee and Mobile Source Technical Review Subcommittee and co-chaired the EPA Ports Workgroup from 2014-2016. She is also active in Business for Social Responsibility's Clean Cargo Group, a global group dedicated to assessing and improving the environmental impact of shipping.

The Benefits of Being Proactively, Voluntarily Green

by Manon Lanthier
Communications Manager
Green Marine

Eleanor Kirtley
Senior Program Manager
Green Marine

Increasing globalized trade has significantly heightened the demands on shipping just as public scrutiny has intensified on the environmental footprint of transporting goods. Social expectations are anticipated to increase with people catching a glimpse of how nature has made positive gains during COVID-19 slowdowns and amidst the dual crises of climate and social justice.

Fortunately, a significant portion of the Canadian and U.S. shipping community has already been effectively addressing these environmental challenges for well over a decade through Green Marine, the leading environmental certification program for maritime transportation in North America. Launched in 2007 as a voluntary, binational partnership in the Great Lakes and St. Lawrence region, Green Marine has rapidly gained a global reputation as a transparent, credible, effective program that challenges participants to measurably improve their environmental performance beyond regulatory compliance. Strong interest from the outset led to the program's expansion across North America within a few years.

At last count, Green Marine had 149 participants. These 40 ship owners, 49 ports, 58 terminals and shipyards, as well as both the Canadian and U.S. seaway corporations voluntarily engage in the program. Green Marine has also welcomed 35 maritime associations that serve in ambassadorial roles to encourage their respective members to participate in the program.

Green Marine participants are maritime industry leaders who voluntarily commit to going beyond environmental regulations. While some environmental self-improvements result in cost efficiencies, the program's focus has always been on doing the right thing as corporate members of the community. Taking certain steps can involve significant investment, especially at the higher echelons of the program's five levels of performance. The program's loyal membership and steady expansion over 14 years reflect the certification's intrinsic value in terms of maintaining social license and motivating effective industry change.

In addition to continual self-improvement, to determine each year's performance levels the program's certification requires annual reporting to rigorous performance standards through a detailed self-assessment. This is combined with transparency that comes with the

Green Marine Priorities

The following six environmental issues and objectives have been identified as priorities under the initial Green Marine Program:

1. **Invasive Aquatic Species**
   Reduce the risk of introducing and propagating aquatic organisms and harmful pathogens by means of ship's ballast water
2. **Air Emissions**
   Reduce emissions of sulphur oxide gases (sox) and nitrogen oxides (nox)
3. **Greenhouse Gases**
   Reduce greenhouse gas (GHG) emissions
4. **Cargo Residues**
   Reduce cargo residue discharges
5. **Oily Water**
   Minimize any risk of oily water discharge
6. **Environmental Impacts at Ports and Terminals**
   Reduce the amount of noise, dust, odor, and light to which people residing close to port facilities are exposed

annual publication of every participant's results backed by independent verification every second year.

Consensus-based Process

Green Marine started with its membership agreeing to address six priority issues. It has since continued this collaborative approach involving the industry, government, environmental organizations, the scientific research community, and other relevant stakeholders to determine additional priorities involving waterborne and landside maritime operations.

The environmental certification program is updated annually to incorporate changing environmental realities and sustainability priorities, like social acceptability. Green Marine already had an indicator for landside operations involving community impacts, but it primarily focuses on nuisances, like dust, light, and noise. Port participants requested a distinct performance indicator with its criteria focused exclusively on community relations intended to foster dialogue and social acceptability. In January 2021, Green Marine unveiled a new performance indicator for community relations. This new indicator leads the way in terms of defining societal aspects of sustainability that are becoming a greater preoccupation for all of Green Marine's participants. It is the result of two years of bilingual collaboration to thoroughly assess its requirements based on community, governmental, academic, and industrial realities.

The program's ship owners also recently sought to embrace additional challenges. In 2020, after significant consultation, Green Marine broadened the program's scope to include a performance indicator for responsible ship recycling that now applies to all ship owners participating in the program.

Still carried out without regulatory oversight in a number of countries, ship recycling continues to be among the most dangerous and environmentally impactful work related to maritime transport. The goal of Green Marine's new ship recycling indicator is to better protect health, safety, and the environment by establishing better practices and performance benchmarks for this activity.

The new performance indicator is the result of 18 months of development involving the collaborative expertise of various industry stakeholders and partners. It is largely based on the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, which is yet to be ratified by the required number of International Maritime Organization (IMO) member states.

Divided into two sections, the first set of criteria in the new indicator encourages ship owners to establish an inventory of hazardous materials onboard. The second applies to ship owners who dismantle or recycle one or more vessels in any given year.

By addressing this issue when there are no regulations obligating ship owners to do so, Green Marine's participants are showing visionary leadership in their proactive stance. Their actions move the needle on improving worker health and safety as they also significantly reduce the environmental impacts of this essential undertaking.

The opportunity to influence the development of certification requirements by participating in work groups and advisory or technical committees is a key membership benefit. Green Marine's collaborative process ensures productive dialogue among representatives of the industry, government, environmental organizations, and the scientific research community. By gathering a subject's experts and decision-makers, as well those responsible for the day-to-day actions, Green Marine's network achieves a clear understanding, and ultimately

Levels of Performance

Graphic courtesy of Green Marine

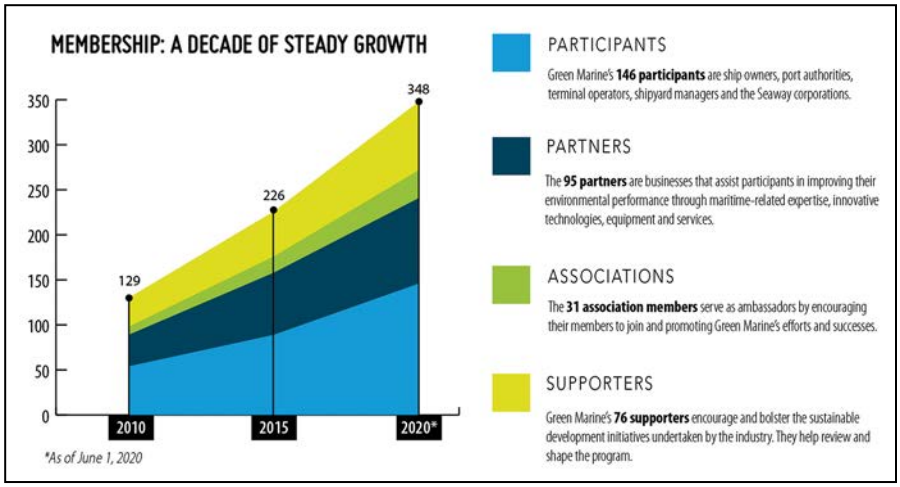
workable consensus, of key issues, challenges, and possibilities. This inclusive developmental approach requires time. It can take a couple of years to develop a new performance indicator, but the process results in stakeholders reaching a consensus on criteria that progress from the framework's Level 1, the monitoring of regulations, to Level 5, excellence and leadership.

An Evolving Scope

The five levels of criteria aren't set in stone, though. The commitment to continual improvement calls for the program's yearly review to ensure its criteria remain fully relevant and sufficiently challenging at each performance level beyond regulatory monitoring. In addition

to raising the bar quite often on the existing requirements, the program has significantly expanded in terms of the issues that it addresses since its founding. The participating terminal operators, port authorities, ship owners, and shipyard managers have not only welcomed challenges beyond regulations, but to address newly emerging issues, like the aforementioned community relations and ship recycling. Underwater noise is another example.

Meanwhile, the program's initial performance indicators to reduce air emissions and greenhouse gases remain as relevant as ever by being made more demanding with Level 5. For example, that level of compliance now requires that the participant meet a yearly reduction target.



Graphic courtesy of Green Marine

The annual program review ensures that each of the four levels beyond the initial baseline of monitoring regulations is sufficiently demanding while still feasible. In keeping with the Green Marine core tenet of continual improvement, the bar is set higher to keep criteria ahead of existing or expected regulations and well aligned with scientific understanding, emerging technologies, and evolving best management practices.

Green Marine has established a loyal membership in good part because the industry has a sense of ownership of the program. At the same time, maritime enterprises are challenged to improve environmentally year over year, which further earns the industry a positive and proactive reputation when it comes to sustainability efforts.

Flexibility and Innovation

Building on these core values, the membership and the scope of issues addressed have grown steadily with the quadrupling of certified participants since the program's launch. Green Marine's structure is solidly based on a voluntary, member-led approach that offers the flexibility to include maritime enterprises that vary in terms of activities, location, size, resources, priorities, and regional environmental concerns. Based on the extensive research, discussion and, ultimately, consensus, the criteria for each performance indicator are written or revised to provide clear direction and specific benchmarks within a framework offering a progressively more challenging range of five performance levels. The levels allow the criteria to be consistently applied broadly to a diverse range of maritime enterprises at different starting points. The program's annual cycle permits a trial of new sustainability concepts with the opportunity to revise or refine the criteria a year later as required based on member feedback, or if new technologies and/or best practices are identified.

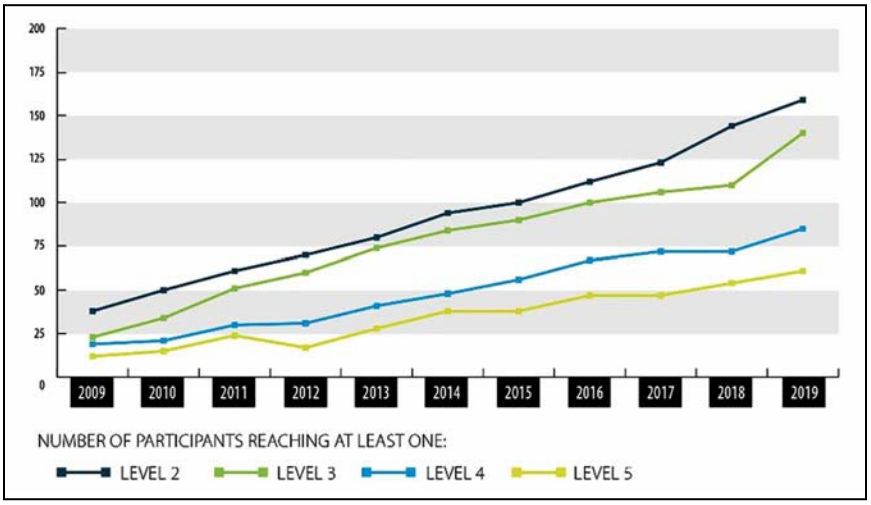
As mentioned earlier, the willingness to set aside usual competitive tendencies for a new maritime culture is one of the most treasured aspects resulting from Green Marine. That culture readily shares information and expertise when it comes to the environment so the industry, as a whole, benefits and improves.

Graphic courtesy of Green Marine

The Benefit of Social License

Right from the start, the Green Marine environmental certification program has focused on regaining and retaining social license by advancing environmental excellence. Green Marine helps its participants achieve their specific goals by providing them with the structured,

progressive framework; support and accountability; and latest information about emerging technologies and practices. Marine-related enterprises with innovative products and services to improve sustainability are invited to become Green Marine partners. Each partner's specialty is detailed in an online directory. A number of partners also present their offerings in person at Green Marine's annual GreenTech conference when travel is not an issue. Some participants also speak on their actual experience with emerging technologies and/or new best practices at the conference.



Overall levels of achievement increase over time as anything beyond Level 1 surpasses regulatory compliance. In staying true to continual improvement, Green Marine requires any new participant to achieve at least one Level 2 criteria as part of its first-year report. Graphic courtesy of Green Marine

This proactive engagement in a comprehensive, rigorous, and continually more challenging certification process is a significant investment in social license. It allows participants to build the reputational capital they need when it comes time to propose a new project or expansion of activities. The program's transparency with the annual publication of results that are independently verified on a regular basis fosters true relationships with relevant stakeholders that lead to constructive dialogue focused on feasible solutions.

Green Marine offers participants an essential tool for communicating their various sustainability efforts through the Green Marine certified logo and with the straightforward, easy-to-understand, five-level performance scale. Every participant must re-earn the Green Marine certification annually by completing a new detailed report on the year's sustainability efforts. The rating system is a way for the participants to assess their progress in key areas and effectively communicate their voluntary efforts to go above and beyond existing regulations.

Stakeholders can be reassured of the rigor of the certification process by reading the specific criteria that each level demands for each performance indicator. Additionally, it is known that all of the results are reviewed on a regular basis by an independent verifier. As a result of the framework, they readily know what a shipping company or a port is doing to deal with issues like air emissions, spill prevention, or aquatic invasive species; how it compares to its peers; and how the North American maritime industry, as a whole, is progressing.

Broader Horizons!

The success and value of the program is evidenced by Green Marine's 2020 expansion into Europe. The program's North America team is working in partnership with Surfrider Foundation Europe. This NGO is leading the initiative to adapt the program's framework to the environmental specifications of European ship owners, while maintaining the same rigor, transparency, and measurable accountability as the North American model. The European license obligates the program to pursue the same type of environmental priorities as the North American framework.

In North America, the program is also striving to expand and establish strategic partnerships to offer the membership increased benefits without compromising the certification's rigor. Financial returns include incentive programs offered to Green Marine-certified ship owners by Green Marine-certified ports, like the Vancouver Fraser and Prince Rupert port authorities.

Green Marine's founding principles remain the cornerstone of the program's success—evidence that voluntary, proactive steps taken in consultation with key stakeholders are an effective strategy to greater sustainability.

About the authors:

As Green Marine's communications manager since 2011, Manon Lanthier is responsible for the organization's external and internal communications. She manages Green Marine's social media platforms, website, newsletter, magazine, and the logistics of the organization's annual GreenTech conference. Prior to joining Green Marine, she enjoyed a long career as a CBC radio journalist. She began her career in print media as an Ottawa reporter upon graduating in journalism from La Cité collégiale (1992).

Eleanor Kirtley, Ph.D., is the senior program manager for Green Marine. She joined the program and opened its West Coast office in 2014. Before that, she worked at Glosten as a project manager and principal investigator for vessel traffic and risk assessment studies. She completed her Bachelor of Science in mechanical engineering from Tufts University (2004) and Ph.D. in naval architecture and marine engineering from the University of Michigan (2008).

The New Central Ocean

The United States can no longer give the Arctic Ocean and Northern Sea routes the cold shoulder

by Cadet 1st Class Alexander Mastel
Golf Company Executive Officer
United States Coast Guard Academy

The goal of good business is maximizing profit. Capitalism develops countries' economies through healthy competition and by rewarding the most efficient party. Today, the melting of the Arctic Ocean stands to revolutionize shipping, while helping maximize profits and increase efficiencies, like never before. Arctic shipping lanes may eventually prove the fastest method to move goods around the world.

Northern sea routes will be vital to the global shipment of raw materials like iron ore, coal, bauxite, phosphate ore, steel, scrap metal, forest products, fertilizer, oil, and liquified natural gas (LNG).[1] Moreover the Arctic is projected to contain 23 percent of the world's undiscovered energy deposits.[2] Eight nations—the United States, Canada, Russia, Iceland, Denmark, Sweden, Finland, and Norway—have territory inside the Arctic Circle and coastlines from which they can access emerging Arctic shipping lanes, with two exceptions. Finland and Sweden access Arctic waters though the Baltic Sea.

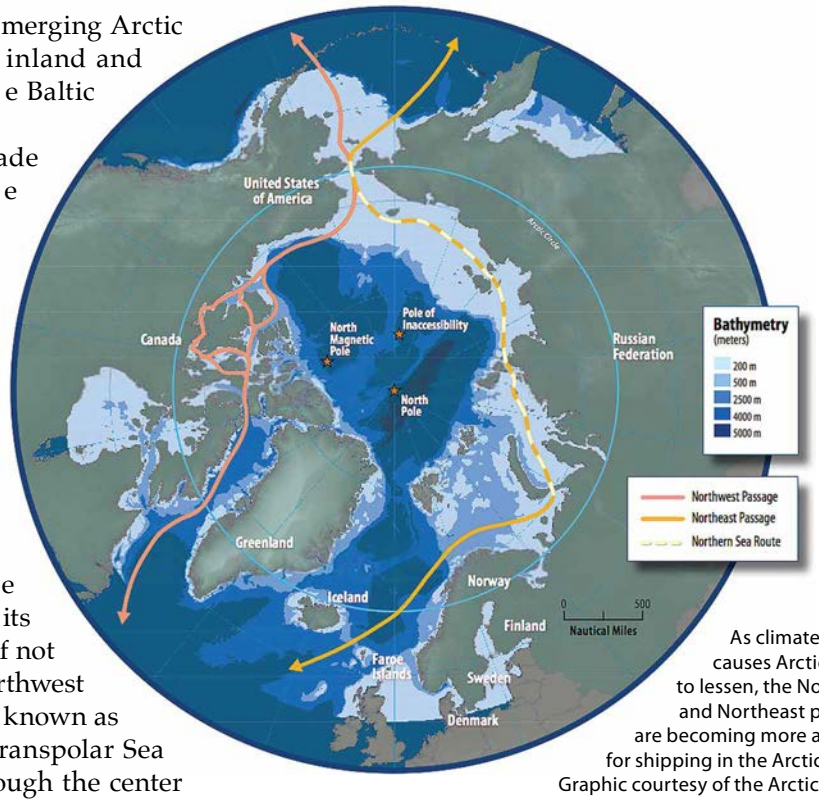
Both Russia and Canada have made moves to project their influence into the Arctic by developing and controlling their respective Arctic shipping lanes. The following article will explore and make the case for whether the United States should build and maintain an Arctic port to serve these emergent maritime trade routes.

A New Arctic

The Arctic has changed significantly in the past century. Climate change has caused Arctic sea ice to lessen and recede for longer periods. Today, maritime transits through the Arctic Ocean are possible, if not yet routine, via two current paths, the Northwest Passage and the Northeast Passage, also known as the Northern Sea Route. A third, the Transpolar Sea Route, or Trans-Arctic Route, right through the center of the Arctic Ocean, will open later as the effects of climate change intensify. These new Arctic shipping lanes could have major ramifications on the global market, and the globalized world at large, setting the Arctic Ocean up to become the world's central ocean, much like the Mediterranean Sea in antiquity.[3]

The Northwest Passage, passing through the Canadian Archipelago, has been sought after since the Age of Exploration. It was supposed to circumvent the Ottoman Empire and reach the lucrative trade nodes in Asia, but the journey was treacherous and all but untenable until sea ice levels changed.

North of Siberia, the Northeast Passage was once impassable, part of a region gripped by a great Arctic ice barrier. Recent changes have reduced this to a seasonal



As climate change causes Arctic sea ice to lessen, the Northwest and Northeast passages are becoming more available for shipping in the Arctic region. Graphic courtesy of the Arctic Council

barrier during the colder months, allowing 71 transits through the Northeast Passage in 2013 alone.[4] Now, the melting ice has exposed energy deposits and opened a maritime shipping lane connecting Europe to Asian markets that is 70 percent shorter than its trans-canal counterparts[5] and will create drastic savings of time and fuel costs for the shipping industry. These savings are likely to be passed on to consumers in the form of lower costs for goods.

As the world warms, the strategic landscape of Russia changes and the nation can no longer use Arctic ice as a barrier to prevent being outmaneuvered by opponents. Transit through the Arctic is now feasible, and Russia has been quick to adapt, reinvesting in its mothballed, Cold War-era military installations in the northern territory.[6] While Russia has been a leader among Arctic nations in

The Coast Guard is currently developing next-generation Polar Security Cutters to close the gap between the United States and other Arctic nations' icebreaker fleets. Artist rendering of the Halter Polar Security Cutter design. Illustration Credits: Halter Marine/Designer: Technology Associates, Inc.

Petropavlovsk-Kamchatsky is currently Russia's closest port to the mouth of the Northern Sea Route in the Pacific Ocean. The United States is working to establish a bigger footprint along this increasingly vital shipping route, but is trailing other Arctic nations. Alexander Piragis | Shutterstock.com

developing its Arctic infrastructure, the United States perceives Moscow's efforts as a potential threat to its security. The Russian government, however, maintains these measures are essential to protecting its economic resources and security.

Russia has also decisively moved to access the natural gas deposits on its Arctic coast.[7] The port of Yamal, in the middle of the Northern Sea Route, has been heavily developed to allow tankers easy access to the LNG facilities there. Access to energy deposits at Yamal and other Arctic sites are central to Russia's plan for the region, which includes expanding its role as a global energy supplier.[8] Additionally, Russia has seized on the opportunity of the emerging Northeast Passage and is developing two Arctic gateway ports on either end of the shipping lane. The port of Murmansk near Finland and Petropavlovsk-Kamchatsky on Russia's Pacific coast have seen substantial state financial investment in recent years.[9] Moscow has been seeking more investment from China, Japan, and the Republic of Korea.[10]

With 40 icebreakers, several of which are nuclear powered,[11] Russia maintains the largest icebreaker fleet in the world.[12] The United States Coast Guard is under contract for the first of the nation's next-generation polar-capable assets—the Polar Security Cutter—which is contracted to be delivered in 2024. It currently has just two diesel-powered, sea-going polar-capable icebreakers—*Healy* and *Polar Star*.[13] Because icebreakers are key to enabling container ships access to the region, Russia stands to continue its domination over shipping through the Northern Sea Route, which Moscow claims as its territorial waters.

The Canadians, also exploring their options, view the Northwest Passage as exclusively Canadian.[14] While less aggressive about investment and use of the Northwest Passage than Russia has been with its counterpart, Canada has long attempted to assert sovereign control over the waters of the Northwest Passage as territorial waters, a view not shared by the United States. As with the Northern Sea Route and Russia, the United States views the Northwest Passage as an international strait.

The United States has maintained that Canada cannot own an international strait, but Canada has pushed back by arguing it is no different from other internal waters since passage is both flanked by Canada's archipelago and remains ice covered much of the year. Thus, according to Canada, it falls under article 234 of the 1982 United Nations Convention of the Law of the Sea.[15] The issue is not resolved and the United States will need significantly more resources in the Arctic if it wants to maintain freedom of navigation in those waters.

The United States is behind in the race to secure this

freedom of navigation, strategic Arctic shipping lanes, and resources. Before the PSC program was approved to modernize the U.S. icebreaker fleet, it lacked the capacity to enforce freedom of navigation in both the Northern Sea Route and the Northwest Passage at once. Russia and Canada have used their positions to claim a stake in the future of Arctic shipping while the United States may be under using its Arctic gateway—Alaska. As the United States' sole state and territory in the Arctic, Alaska sits not only at the terminus of the Northwest and Northeast passages, but also at the access point for the shorter Trans-Arctic Route that will emerge as more sea ice melts. However, the United States does not have a deep-draft Arctic port above the Arctic Circle, nor enough icebreakers to support marine commerce through the Arctic corridors.

Seattle, the nearest major international port is too far to effectively serve as an Arctic hub, as are the several deep-draft ports in Alaska, from Anchorage to Dutch Harbor.[16] The United States has to invest more in the foothold Alaska offers to secure its Arctic ambitions.

The Alaska Deep-Draft Arctic Ports Planning Study was commissioned to do just this by identifying ideal locations for the United States' Arctic deep-draft port.[17] Several possibilities were identified as far south as Bethel and as far north as Barrow. All are closer to the mouth of the Northern Sea routes than Russia's Pacific counterpart of Petropavlovsk-Kamchatsky.

With an Arctic deep-draft port, the United States could better serve Arctic marine vessels and provide services to the increasing flow of vessels in and through the region. Additionally, the presence of a deep-draft Arctic port would provide additional synergies with the global shipping industry, and be included in emergent Arctic shipping routes. There are those who would rather use the United States as a base of operations instead of Russia, but there first needs to be availability in the United States. An Arctic port would only be the first step to projecting U.S. sovereignty in Arctic shipping. Right now, the United States is the only Arctic maritime nation without a deep-draft port north of the Arctic Circle. A more robust Arctic port system, with a deep-draft port in the Arctic, would enhance U.S. Arctic marine capabilities.

The drawback to increasing U.S. presence in the Arctic may be the financial cost. The Russians are looking to finance their gateway ports with partners because spreading the enormous cost across multiple investors outweighs the power an Arctic monopoly might bring. The Arctic is an infamously inhospitable place with no areas of dense populations like those found at lower latitudes, and little infrastructure to support massive projects. It will be incredibly expensive to bring in the resources and personnel required to build and operate the port. Additionally, the benefit of Arctic shipping lanes is unproven, so there is risk associated with the massive investment. However, it seems likely the world will see the rise of the importance of the Arctic in the coming generation.

Conclusion

The Arctic is not immune to the cataclysmic effects of climate change. Melting ice has brought a Spring to the Arctic that is hundreds, if not thousands, of years in the making. The long sought-after routes to connect Europe to Asia now exist. Russia and Canada both recognize the strategic importance of Arctic shipping, and are positioned accordingly. The United States may become a secondary power in the region and will be almost completely reliant on foreign infrastructure for its Arctic interests if it does not act accordingly. That requires significant Arctic investment to protect its global interests.

About the author:

Alexander Mastel is a senior at the United States Coast Guard Academy. He was born and raised in Washington, D.C., and attended Marion Military Institute in Alabama for a year before being accepted to the Coast Guard Academy. He is a member of the government major at the Academy and will graduate with honors.

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Creating the Ocean We Want

United Nation's Ocean Decade provides marine transportation sector opportunities

by Craig McLean
Assistant Administrator
Office of Oceanic and Atmospheric Research
NOAA

Rear Admiral Richard T. Brennan
Director, Office of Coast Survey
NOAA

Taylor Goelz
John A. Knauss Marine Policy Fellow for the Ocean Decade
NOAA

Alexis Maxwell
Communications and Policy Specialist
Office of Coast Survey
Lynker Contractor

Although *Star Trek* declared outer space "the final frontier," the ocean represents a frontier that is still widely unknown and unfamiliar, particularly to the American public. The United States is a maritime nation, with more than 25,000 miles of navigable waterways and harbors, more than 82,000 vessel calls at American ports, and a contribution of over $4 billion in annual wages.[1] Despite this proud maritime history, and the importance of the marine transportation sector (MTS) to the U.S. economy, the complexities, intricacies, and importance of marine transportation is not widely appreciated.

In particular, there is a lack of appreciation and understanding of the role that the MTS can play in the global pursuit of lowering carbon emissions and addressing the concerns of climate change. Global shipping is one of the biggest emitters of carbon dioxide and has lagged behind other transportation sectors in pursuing a low-carbon path and reducing emissions.[2] In 2018, however, the U.N.'s International Maritime Organization (IMO) adopted mandatory measures to reduce greenhouse gas emissions from international shipping. The MTS is getting greener and the U.N. Decade of Ocean Science for Sustainable Development (Ocean Decade) provides an opportunity to highlight the existing sustainable development advances in the sector and continue to push the community as a whole.

In 2017, UNESCO's Intergovernmental Oceanographic Commission (IOC) proposed a global decade of focus on ocean science and technology to inform sustainable development. With its implementation plan approved by the U.N. General Assembly in December 2020, the Ocean Decade launched in January 2021 with the aim of transforming the ocean we have into the ocean we want. Through a series of regional planning meetings, which occurred in every ocean basin around the world, the IOC devised seven outcomes characterizing the goals of this desired ocean.

- A clean ocean where sources of pollution are identified and reduced or removed
- A healthy and resilient ocean where marine ecosystems are understood, protected, restored, and managed
- A productive ocean supporting a sustainable food supply and a sustainable ocean economy
- A predicted ocean where society understands and can respond to changing ocean conditions
- A safe ocean where life and livelihoods are protected from ocean-related hazards
- An accessible ocean with open and equitable access to data, information and technology, and innovation
- An inspiring and engaging ocean where society understands and values the ocean in relation to human well-being and sustainable development

Crucially for the MTS, these outcomes focus both on ocean science concerns *and* the sustainable development

What is UNESCO?

UNESCO is the United Nations Educational, Scientific and Cultural Organization, which seeks to build peace through international cooperation in education, the sciences and culture.

solutions that will help build the ocean we want. Thus, the sustainable development efforts of the global MTS can both contribute to the goals of the Ocean Decade and benefit from the new partnerships, diverse stakeholders, and global attention that the Ocean Decade will bring to key issues within the sector. The most exciting opportunities lie within the "big" ideas and novel challenges the MTS faces moving forward. This article seeks to provide an overview of the most pertinent engagement opportunities for the MTS within the Ocean Decade. This isn't a prescriptive list, but a way for the sector to think about what it can contribute and what it would like to achieve during this once-in-a-lifetime global focus on the ocean and coasts.

Seabed 2030 and Global Ocean Mapping

One of the most immediate opportunities that benefits the MTS is the IOC's focus on incorporating the Nippon Foundation-GEBCO Seabed 2030 Project (Seabed 2030) into the Ocean Decade.[3] Seabed 2030 aims to bring together all available bathymetric data to fill in previously unmapped areas, to make that data publicly available, and to produce a definitive map of the world ocean floor by 2030. A complete map of the ocean is a crucial underpinning of the the ocean we want, and touches on many of the Ocean Decade priorities, but in particular directly addresses Ocean Decade challenge 8.[4]

Accomplishing global seafloor mapping requires a gain in mapping efficiencies, particularly through sensor development, testing, and deployment, as well as data processing development, and automation. The scale of this challenge is global in nature, requiring new partnerships, novel methods, and the organized dedication that a decade of focus provides. In order to map the nearly 2 million unmapped square nautical miles of the U.S. Exclusive Economic Zone (EEZ),[5] it is clear that the same methods, partners, and approaches of the past 200 years cannot be used alone to accomplish this goal. Acquiring the resolution of data necessary to accomplish a global ocean map will require more days at sea and an exponential increase in the number of sensors acquiring ocean mapping data. The exponential increase in the number of sensors deployed will also result in an exponential increase in the volume of data, requiring a commensurate investment in automated processes and artificial intelligence to process this data and deliver the rich catalog of products it promises. The advancements and developments made during this global focus on mapping the ocean will benefit sustainable development both in the MTS and beyond.

Though global shipping is one of the biggest emitters of carbon dioxide, the marine transportation sector is getting greener and has a role to play in reducing carbon emissions. Mohamad Ridzuan Bin Ramli | Shutterstock.com

Decarbonizing the Marine Transportation Sector

Past advances in surface current data and models have led to advances in fuel savings and route optimization across the MTS, prioritizing both environmental and economic benefits. The global maritime community, through the 2018 IMO regulations, has recognized and acknowledged, however, that the next advances in the sector have to be near zero emissions. Decarbonization is being advanced through partnerships like the Global Maritime Forum, the Friends of Ocean Action, and the World Economic Forum's "Getting to Zero" coalition. Groups like these are coming together in ways they never have before to try to solve one of the biggest issues affecting the MTS to date.[6]

The Ocean Decade's focus on sustainable development and a thriving blue economy, reflected in challenges 4 and 10,[7] provides decarbonization-focused groups a platform to reach a wider audience. Additionally, it allows these groups to grow the visibility of the green-blue future of the sector, and bring funding and attention to the development of sustainable fuels and zero-carbon options that will make this zero-carbon pursuit a reality across the MTS.

Data and Accessibility

Within the IOC's framework, a focus on marine transportation decarbonization would represent a "Programme" of the Ocean Decade—a large, multisector, multi-ocean basin initiative that is truly moving to transform part of the ocean. To achieve these Programmes, however, requires many moving parts, focused undertakings, and coordinated initiatives termed projects and activities.[8] This hierarchical nature is meant to allow stakeholders to participate at different levels while all working to achieve large-scale, collective goals. The International Hydrographic Organization's (IHO) S-100 Universal Hydrographic Model for the development of standardized products and services for the maritime, hydrographic, and oceanographic community is an example of a project and associated activities. These would help achieve a potential Programme focused on lowering emissions and decarbonization.

The National Oceanic and Atmospheric

Ocean Decade Challenges

Knowledge and Solutions

- Challenge 1: Understand and map land and sea-based sources of pollutants and contaminants and their potential impacts on human health and ocean ecosystems, and develop solutions to remove or mitigate them.
- Challenge 2: Understand the effects of multiple stressors on ocean ecosystems, and develop solutions to monitor, protect, manage and restore ecosystems and their biodiversity under changing environmental, social and climate conditions.
- Challenge 3: Generate knowledge, support innovation, and develop solutions to optimise the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions.
- Challenge 4: Generate knowledge, support innovation, and develop solutions for equitable and sustainable development of the ocean economy under changing environmental, social and climate conditions
- Challenge 5: Enhance understanding of the ocean-climate nexus and generate knowledge and solutions to mitigate, adapt and build resilience to the effects of climate change across all geographies and at all scales, and to improve services including predictions for the ocean, climate and weather.

Essential Infrastructure

- Challenge 6: Enhance multi-hazard early warning services for all geophysical, ecological, biological, weather, climate and anthropogenic related ocean and coastal hazards, and mainstream community preparedness and resilience.
- Challenge 7: Ensure a sustainable ocean observing system across all ocean basins that delivers accessible, timely, and actionable data and information to all users.
- Challenge 8: Through multi-stakeholder collaboration, develop a comprehensive digital representation of the ocean, including a dynamic ocean map, which provides free and open access for exploring, discovering, and visualizing past, current, and future ocean conditions in a manner relevant to diverse stakeholders.

Foundational

- Challenge 9: Ensure comprehensive capacity development and equitable access to data, information, knowledge, and technology across all aspects of ocean science and for all stakeholders.
- Challenge 10: Ensure that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood, and identify and overcome barriers to behaviour change required for a step change in humanity's relationship with the ocean.

Source: United Nations Decade of Ocean Science for Sustainable Development Implementation Plan

Administration's (NOAA) Office of Coast Survey, in particular, is leaning forward in developing products, such as high-resolution bathymetry, surface current, and water level forecasts for the maritime hydrographic and oceanographic communities. These products are designed not only to work in navigation systems that will allow mariners to make informed decisions to safely navigate in environments with tight safety margins, but also help with route optimization that will burn less fuel during transit. Realizing the transition to the S-100 hydrographic data model will create the foundation for all data to be used interoperably with regards to earth science and governance needs, addressing Ocean Decade challenges 7 and 8. The diversity of the MTS and the variety of initiatives and interests within the sector align well with the collaborative multisector and disciplinary focus of the Ocean Decade. The MTS will be able to use the Ocean Decade to address any challenges it sees fit over the next 10 years, and beyond.

The U.S. maritime workforce has been dwindling in spite of the global carbon-neutral push that will bring more jobs. Globally, the early career ocean professionals have been organizing since May 2019 to focus on blue economy professional development. Denys Yelmanov | Shutterstock.com

Workforce Development and U.S. Global Leadership

The U.S. Department of Transportation's Maritime Administration has highlighted the dwindling size of the U.S. maritime workforce, despite a global carbon-neutral push that will bring more jobs and opportunities to the sector.[9] Toward a carbon-neutral future, the Ocean Decade, particularly challenges 4 and 9, provide the United States with an opportunity to focus on sustainable economic development and capacity building through workforce development within the emerging blue economy. This emphasis on workforce development is particularly needed over the course of the Ocean Decade, and was emphasized leading up to 2021. Representing the next generation of ocean experts and leaders, early career ocean professionals (ECOPs) have been organizing around the world since May 2019, and are focused on bringing professional development opportunities and intergenerational diversity more broadly to the forefront of the Ocean Decade.[10] ECOPs cross-disciplinary training and dedication to sustainable development will ensure the U.S. and global maritime communities continue to push the envelope and get ahead on big issues facing the sector like sea level rise, emergency response, and decarbonization.

Embracing the contributions of ECOPs and ensuring a robust focus on maritime workforce development in general is essential to the success of the global maritime community and the Ocean Decade itself, particularly for the United States. A 2020 report from NOAA and the Bureau of Economic Analysis found that America's blue economy contributed around $373 billion to the nation's gross domestic product and supported 2.3 million jobs in 2018. This is a clear demonstration of the crucial role the blue economy plays in the U.S. economy overall, and how the ocean needs to be at the forefront of any conversation concerning sustainable development.[11] Focus on workforce development within the U.S. blue economy, including a climate-aware MTS, will help the United States demonstrate global leadership by emphasizing the importance of a sustainable blue economy and advocating for climate-focused solutions within international MTS bodies like the IMO.

Importance of Partnerships

To further the Ocean Decade's goal to transform the ocean, ocean science and sustainable development work must engage with new partners and examine existing problems in new ways to work toward transformation together. The emerging offshore renewable energy sector in the United States—wind, waves, and solar—represents novel types of partners the MTS will need to engage with to work toward regional, national,

and international goals set during the Ocean Decade. Within the United States, MTS partnerships and collaboration are best fostered through the U.S. Committee on the Marine Transportation System (CMTS), the federal interagency maritime policy coordinating committee. More than 25 federal agencies gather under the auspices of the CMTS to envision, plan for, and execute concepts that can be accomplished for the MTS during the Ocean Decade.

For example, the Maritime Administration (MARAD), under the Department of Transportation, is prioritizing partnerships and funding across the federal government, but also with the maritime industry, universities, and maritime training centers during the Ocean Decade. MARAD's Small Shipyard Grant Program, which provides funding to help shipyards modernize and improve efficiencies, is a great example of the connection between global sustainable development goals, the Ocean Decade, U.S. national priorities, and local sustainable development and blue economy work.[12] Through this multiple stakeholder approach, MARAD's work exemplifies how the U.S. and global maritime communities can connect their work on topics like workforce development, innovative marine technology research and development, port safety, efficiency, and emission reduction.

NOAA has been focused on reengaging existing partnerships and bringing in new groups for cross-federal agency, cross-discipline, cross-generational, and cross-U.S. ocean community engagement in the Ocean Decade. Since 2018, NOAA has led a coalition of federal agencies, academics, nongovernmental organizations (NGOs), industry members, artists, teachers, aquariums, and youth activists passionate about the idea of creating the ocean we want. NOAA convened panels at more than two dozen conferences and industry events, connected with more than 30 environmental NGOs, and brought together almost 20 federal agency partners. Additionally, the agency launched the U.S. National Committee on the Ocean Decade with the National Academies of Sciences, and led federal agency coordination of 17 Programme proposals which were submitted to the IOC in January 2021. NOAA is also working in consultation with the Coast Guard, the National Science Foundation, and private fleets to plan port call events across the United States, post-COVID 19, to share U.S. ocean science and tech with the general public.

Conclusion

The significance of the MTS to the sustainable development portion of the U.N.'s Decade of Ocean Science for Sustainable Development is undeniable. The marine transportation solutions, projects, technology, and partnerships that are fostered during this global focus on the ocean will impact the lives and livelihoods of individuals within the United States and around the world.

About the authors:

Craig McLean is responsible for NOAA's research enterprise as the assistant administrator for Oceanic and Atmospheric Research. He also serves as the U.S. representative to the Intergovernmental Oceanographic Commission (IOC), and as the co-chair of the U.S. European Union Marine Working Group, and in the US-Canada-EU North Atlantic Ocean Research Alliance under the Galway Statement.

RDML Richard T. Brennan, Director, Office of Coast Survey, has served with the NOAA Officer Corps for over 20 years. He has previously served as the chief of both the Coast Survey Development Laboratory and the Hydrographic Surveys Division. He has a Master of Science degree in ocean engineering from the University of New Hampshire's Center for Coastal and Ocean Mapping, and a Bachelor of Science degree in civil engineering from the Citadel.

Taylor Goelz, MS/MPP, is the program manager for the Energy & Environment Program's Shipping Decarbonization Initiative for the Aspen Institute. Within this role, he helps the Cargo Owners Zero Emission Vessel Initiative (coZEV) engage multinational businesses and U.S. policy makers to accelerate decarbonization of maritime shipping. Prior to Aspen, he served as a Knauss Marine Policy Fellow with NOAA focused on U.S. engagement in the UN Decade of Ocean Science for Sustainable Development.

Alexis Maxwell is a Lynker contractor supporting the Office of Coast Survey's international program. Previously a policy analyst working on global ocean governance issues at the Global Ocean Forum, she has a master's degree in marine policy from the University of Delaware and a bachelor's degree in environmental studies from American University.

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Buoy Diplomacy in the Indo-Pacific

by LCDR Nic Jarboe
Office Chief
District 14 Waterways Management

LT Kristi Sloane
Deputy Office Chief
District 14 Waterways Management

LCDR Ryan Adams
Commanding Officer
USCGC Sequoia

Despite the ongoing global COVID-19 pandemic, Coast Guard Cutter *Sequoia*, a 225-foot seagoing buoy tender homeported in Apra Harbor, Guam, recently completed a unique multi-year aids to navigation (AtoN) mission in the Republic of Palau. This mission played a vital role in reconstituting Palau's aging AtoN constellation, enhancing the global maritime transportation system (MTS), and upholding the United States' commitment to a "Free and Open Indo-Pacific."[1]

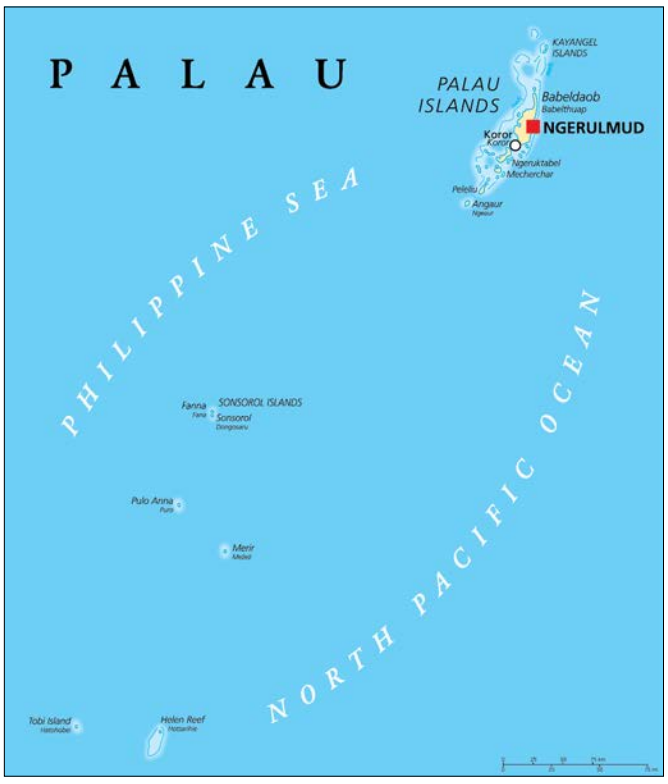
The Republic of Palau is a grouping of eight major, and hundreds of smaller, islands situated on the west end of the Federated States of Micronesia. It lies nearly 2,000 miles south of Japan, and 1,400 miles north of Australia. The Palau reef, partly barrier and partly fringing, encloses all of the islands except for two small atolls to the north, and the island of Ngeaur to the southwest. As an independent state, Palau is in free association with the United States. The close strategic and economic ties between the countries date back to the end of World War II, and have proven increasingly vital in recent years amidst emerging power struggles in Oceania.[2]

In March 2018, the Coast Guard received a request from Palau's Office of the Ministry of Public Infrastructure, Industries, and Commerce for assistance with establishment of new AtoN and reestablishing existing AtoN that had fallen into disrepair. The request arose from specific concerns, the first being that the Palau Department of Transportation was unable to adequately monitor the progress of vessels transiting the waterway because mariners unfamiliar with it could not adequately report their location. A second, more pressing concern was the increased risk of environmental incidents due to the inadequacy of the AtoN constellation.

Upon receiving the request, Coast Guard District 14 personnel from Honolulu and Apra Harbor coordinated with U.S. Embassy Koror, Coast Guard Headquarters, the State Department, and the Department of Interior to ensure the request and anticipated work met statutory requirements. The Coast Guard approached the mission as a three-phased process.

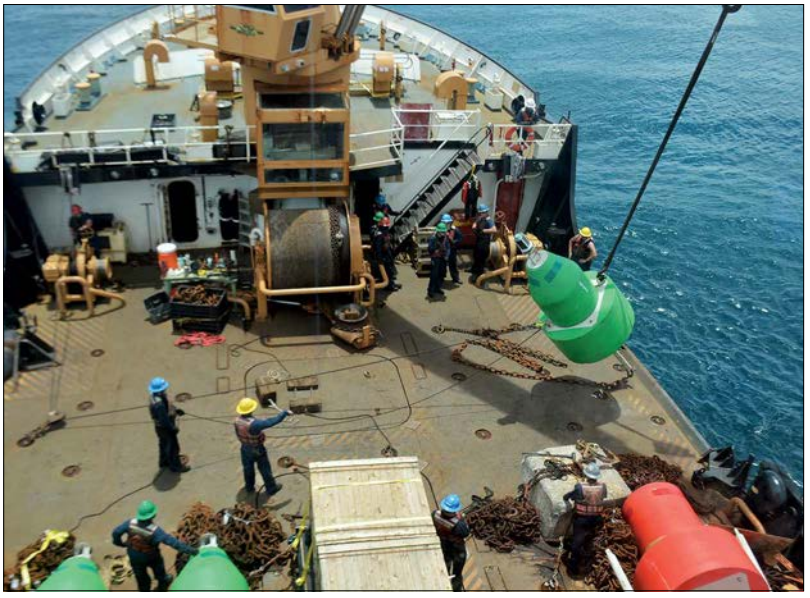
- Conduct an AtoN assessment to identify what work needed to be done.
- Conduct physical work and replace, restore, and add new AtoN.
- Provide direction and support for long-term sustainment through purchase of equipment, training, and education.

The project began in August 2018, when *Sequoia* was tasked with conducting a Waterways Analysis



The Republic of Palau, situated at the West end of the Federated States of Micronesia, consists of eight principal islands and hundreds of smaller islands. Peter Hermes Furian | Shutterstock.com

and Management System (WAMS) study to assess the condition of the AtoN constellation in the main shipping channels leading into Palau's primary port in Koror. During the assessment, *Sequoia* visited each of the AtoNs in waterways referred to as West Pass; East, or Malakal, Pass; and Malakal Harbor. The underlying goal of this assessment was to provide an accurate baseline of the current state of the aids, and make recommendations about improvements to bolster safety, usability, and reliability of the waterways' navigation aids.



The crew of Coast Guard Cutter *Sequoia* works to set the Malakal Pass Entrance Lighted Buoy 1 near the port of Koror, Palau, in May 2020. Coast Guard photo

The WAMS found that the AtoN around Koror were in significant disrepair and did not meet the specifications set forth in the International Association for Marine Aids to Navigation and Lighthouse Authorities' (IALA) Maritime Buoyage System for the region. There were many concrete pillar-type structures, some of which were in good condition. Others were in poor condition, and some were completely destroyed. The latter were often partially submerged, or submerged as wreckage and found in immediate vicinity to a newer aid. There were no working AtoN lights in the waterway. The vast majority of aids did not have any type of dayboards, substantial color, or shape markings. This made them very difficult to sight and use while transiting the waterway, and impossible to visually identify by number without further reference to a chart, or substantial local knowledge. At a distance, the near complete lack of color and shapes associated with IALA aid configuration made it difficult to determine the aids' lateral significance—which side of the channel they mark—especially in relation to the numerous turns throughout the waterway. During a public meeting, many waterway users confirmed they relied on the use of GPS units for navigation due to the unreliability of the AtoN constellation.

The WAMS identified an extensive list of recommendations including, but not limited to, discontinuing or replacing aids no longer serviceable, establishing new aids to better assist in safe navigation, rehabilitating aids still in serviceable condition, and various chart updates. The estimated cost was $500,000.

As the Coast Guard is not funded for AtoN missions outside U.S. territories, funding for the project was ultimately provided by the Department of Interior. However, additional time was needed to conduct a final site visit, compile a detailed work list, and design, order, and receive the needed supplies. Efforts included designing and fabricating beacon structures suitable for local conditions, collaborating with Civic Action Team Palau to fabricate concrete buoy anchors, and coordinating with Coast Guard divers to identify and develop a course of action for AtoN needing dive support. It also required coordination with the country team and the government of Palau to safely facilitate the planned operations.

Finally, in late May 2020, after sequestering themselves on board the cutter for 14 days before entering Palauan waters in compliance with COVID-19 quarantine requirements, *Sequoia's* crew began the crucial AtoN work. The crew established 10 new floating aids to navigation and established or substantially rehabilitated 43 fixed aids to navigation in Palau's main shipping channel leading to the Port of Koror, the nation's primary deep-water port, which is essential to maritime commerce. The work included installing modern foam buoys, which can stay on scene significantly longer than legacy steel hulled buoys, and modern LED lights on all lighted buoys and structures allowing mariners to safely transit the waterway at night. In a show of true collaboration, a team from Palau's Department of Marine Transportation was on scene to observe and assist with the work nearly every day. While the team was not able to closely interact with *Sequoia's* crew members because of COVID mitigation measures, they learned how the Coast Guard teams completed the work. This partnership is critical to ensuring ongoing maintenance of Palau's aids to navigation.

In preparation to complete the project, *Sequoia*'s crew once again sequestered themselves on board the cutter in September 2020. This time, however, 14 days stretched into 24 because of unexpected engineering failures, which delayed the ship's departure.

In addition to carrying the needed AtoN supplies for the mission, *Sequoia* transported a U.S. Army mobile decompression chamber to facilitate necessary

dive operations in Palau. Upon arriving in Palau, *Sequoia*'s crew teamed with Coast Guard divers from the Regional Dive Locker Pacific—a U.S. Army Dive Team from 569th Dive Detachment—and representatives of the government of Palau to successfully complete the remainder of the planned work. The completed project resulted in the reconstitution of Palau's physical AtoN constellation.

Although the crew's primary focus was rehabilitating Palau's AtoN constellation, it also worked closely with the government to protect its national marine sanctuary and exclusive economic zone from illegal, unreported, and unregulated (IUU) fishing. The crew also participated in the Pacific Islands Forum Fisheries Operation Kurukuru, a joint operation between Pacific Islands Forum nations intended to combat IUU. This collaboration enhanced Palau's maritime domain awareness and vessel monitoring to help protect the country's fisheries from IUU.

Crew members from Coast Guard Cutter *Sequoia* visit Sonsorol, Palau, to carry out a humanitarian mission by delivering among other items, food, fuel, and medicine from the Palau Ministry of Health in October 2020. Coast Guard photo

Additionally, *Sequoia* completed a humanitarian mission to the island of Sonsorol during the patrol, delivering fuel, food, and medicine to the island on behalf of the Palau Ministry of Health. The U.S. ambassador to Palau, the governor of Palau, members of Palauan delegation, and partners from Australia and Japan accompanied the *Sequoia* to Sonsorol after completing prescribed COVID protocols.

While the mission to rehabilitate the physical AtoN constellation is complete, the Coast Guard will work closely with Palau's government to continue modernizing and maintaining the system as part of the project's third phase. This includes plans to install an electronic aids to navigation (eAtoN) system in 2021 to supplement the physical aids to navigation. *Sequoia* has also procured AtoN structure climbing equipment for Palau and will be providing informal training to ensure teams from Palau are able to service the aids to navigation on a regular basis and correct future discrepancies in a timely manner.

Civic Action Team Palau

Civic Action Team Palau provides construction support to the host nation, assists, and trains apprentices with general engineering skills, facilitates a medical outreach program, and coordinates community relationship programs. The team is made up of Defense Department personnel on 6-month deployments and rotates between Navy, Army, and Air Force teams.

About the author:

LCDR Nic Jarboe spent the majority of his Coast Guard career in waterways management. He has tours at the International Ice Patrol, Sector New York Waterways Management, Sector Honolulu Waterways Management and, most recently, at District 14 Waterways Management. He holds a bachelor's degree from the U.S. Coast Guard Academy and a master's degree from the University of New Haven.

LCDR Ryan Adams is the commanding officer of the Guam-based CGC Sequoia. *He has previously served on CGC* Campbell, *CGC* Washington, *and CGC* Sequoia *as the executive officer. He has also completed staff tours at District 17 in Juneau, Alaska, and DCMS-83 at Coast Guard Headquarters. He holds a bachelor's degree from the U.S. Coast Guard Academy and a master's degree from Oklahoma State University.*

LT Kristi Sloane is a marine safety officer with tours at Sector St. Petersburg Inspections, Sector Juneau Waterways Management, and most recently at District 14 Waterways Management. She holds a bachelor's degree from the American Military University.

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Houston Ship Channel

National Strike Force response mitigates economic and environmental impacts

by LCDR Rafael Shamilov
Branch Chief
International Resident Training Division
U.S. Coast Guard Training Center Yorktown

On the afternoon of March 26, 2019, I received a call from the Gulf Strike Team, our sister unit in the National Strike Force (NSF), requesting additional members from the Pacific Strike Team to assist with a petrochemical spill in Deer Park, Texas. All I knew at that point was that there had been an explosion at a tank farm and that the Houston Ship Channel had been closed for two days because of chemical products spilling into the waterway. Little did I know that this would be one of the most significant responses of my career.

Nine days earlier, a massive fire had erupted in a 50.4-million-gallon petrochemical tank farm at the Intercontinental Terminals Corporation Facility located at the heart of the largest petrochemical port complex, and fourth-largest metropolitan area, in the nation. The fire burned for nearly 65 hours, overwhelming 13 of the farm's 15 tanks, each with an 80,000-barrel-capacity. This caused the collapse of the primary containment and, ultimately, a partial breach of the secondary containment leading to a subsequent release of more than 3 million gallons of petrochemical products into the federally regulated Houston Ship Channel. Coast Guard Sector Houston-Galveston, the first federal entity on the scene, responded immediately, but multiple federal, state, local responsible parties, and contracted oil spill response organizations would combat the fire and subsequent release for 53 days.

We were requested to assist with oversight of on-water recovery efforts, air monitoring, and commercial vessel decontamination. As the incoming deputy operations section chief, my job was to oversee these operations. Based on preliminary information, I assembled a five-person team and got on a plane to Texas.

Upon arriving at the incident command post on March 27, 2019, the Gulf Strike Team members that had responded to the incident a week prior to my arrival provided vital on-scene information to help make important tactical decisions. I realized the result of the explosion and the subsequent fire was more severe than I had initially anticipated and more people would be needed. My immediate priority became figuring out how many strike team personnel I had on hand between

Coast Guard responders conduct an overflight to check the status of the Houston Ship Channel after an explosion at the Intercontinental Terminals Corporation's tank farm in Deer Park, Texas, on March 17, 2019. Debris and nearly 3.5 million gallons of spilled petrochemicals caused by the explosion left the channel severely restricted for several weeks. Coast Guard photo by LCDR Rafael Shamilov

the Pacific and Gulf teams, and requesting more personnel to fill additional roles. The goal was to have at least another eight members on scene within 48 hours. At the peak of the response, 25 strike team members from all three teams—Atlantic, Gulf, and Pacific—were on scene.

Also, prior to my arrival, Coast Guard Sector Houston-Galveston had established five geographic divisions and five vessel decontamination stations, but high benzene readings made using their own personnel to support and respond in certain areas unsafe. This made mobilizing additional strike team resources and personnel as soon as possible even more critical.

In the Coast Guard, only NSF units have the personal protective equipment and training to respond to incidents involving elevated readings of chemical or hazardous materials. Historically, strike team members either augment resources and personnel or act as a force multiplier. In this case it was both. Strike team personnel were mobilized throughout the affected areas and oversaw contracted operations, which gradually helped reopen larger parts of the Houston Ship Channel to commercial traffic freeing some of the sector personnel to continue performing other Coast Guard missions.

Maintaining the safety of contractors and Coast Guard personnel was our top priority. Working in a situation with above average benzene levels posed inherent health and safety concerns. The Gulf Strike Team's industrial hygienist played a vital role in drafting an approved safety plan that addressed all hazards and provided critical recommendations to the Operations section which proved essential for mission planning.

The second priority was to remove as much of the spilled material from the water as possible so commercial vessels could arrive and depart. This included various moorages throughout the area. Due to the port's economic importance, skimming operations were a critical long-term operation that eventually restored the marine transportation system. Strike team leaders in the field and at the incident command post collaborated with contractors to simultaneously operate throughout the five geographic divisions, prioritizing the most heavily impacted areas for skimming. Coast Guard responders assisted in overseeing operations to recover spilled material from the water and conduct air monitoring during busy daytime port operations across all five geographic divisions. All on-water recovery and decontamination operations were conducted in tandem to maximize vessel transits, arrivals, and departures, which were crucial to restoring and facilitating commerce in the port.

Reopening the channel was crucial as the annual national economic impact of the port includes 3.2 million jobs, nearly $802 billion in economic value, and more than $38 billion in tax revenue, as reported by the Port of Houston. Any waterway closures or restrictions can have a catastrophic economic impact on the region and the country. This fact, combined with the issues of personnel safety and environmental impact significantly elevated this response's severity. To assuage any economic ramifications, it was vital to tackle the challenges of this response in a safe, but efficient, manner.

Our short-term plan was to maintain operations to decontaminate impacted vessels and port facilities so commercial traffic could safely transit outbound and continue transporting vital goods and services. This included hundreds of fleet barges that could not depart due to contamination and waterway closures. Team leaders prioritized operations and worked with contractors and fleet barge representatives creating an effective system to decontaminate barges and large commercial vessels. As a result, two additional decontamination stations were established to expedite operations, including an additional roving decontamination team.

The Houston Ship Channel was ultimately closed for two days, but was severely restricted for several weeks, impacting vital maritime commercial traffic, including an average of 42 deep draft vessel transits and 230 vessel and barge transits daily. In its entirety, the response

LCDR Rafael Shamilov led the Pacific Strike Team's oversight of on-water recovery efforts, air monitoring, and commercial vessel decontamination after an explosion at the Intercontinental Corporation Terminal in Deer Park, Texas, resulted in a petrochemical spill into the Houston Ship Channel. The March 17, 2019, explosion curtailed commercial operations for several weeks. Coast Guard photo by Chief Petty Officer Justin Sawyer

Coast Guard Gulf Strike Team members conduct on-water air monitoring, wearing air-purifying respirators to protect against heightened levels of benzene. Coast Guard photo by Chief Petty Officer Travis Rogers

encompassed nearly 5,000 personnel across 322 organizations. Ultimately, responding federal, state, and local personnel and contracted responders used 214 response vessels, 142 skimmers, 50 vacuum trucks, and 168,000 feet of boom to remove 3.36 million gallons of petrochemical products. This action mitigated the substantial threat to the environment and nationally significant economic waterway.

Collaboration between hundreds of organizations and agencies was critical during this response, as was resource management in prioritizing the most heavily impacted areas. With thousands of personnel and resources on scene, having the right tactical picture and communicating resource needs between different geographic areas was paramount and kept circumstances from becoming increasingly overwhelming.

As the United States continues to become more energy independent, the capabilities and expertise of NSF units to respond to spills of various natures have never been more relevant. Comprised of the National Strike Force Coordination Center (NSFCC); the Atlantic, Pacific, and Gulf strike teams; and the Coast Guard Incident Management Assist Team, the NSF provides an array of mission-specific capabilities that leverage the Coast Guard's unique authorities to support operational commanders. These highly trained professionals with specialized equipment and incident management expertise train and operate in a unique arena where operations can be dynamic and potentially hazardous. Ready for rapid deployment, they assist federal on-scene coordinators and lead agency incident commanders in preparing for, and responding to, oil discharges, hazardous materials releases, weapons of mass destruction incidents, and other complex incidents, as well as large-scale natural disasters/contingency events. Assistance can be requested by contacting your servicing NSF strike team or the NSFCC.

About the author:

LCDR Rafael Shamilov joined the U.S. Coast Guard in 2005, and has served at Sector New York's Enforcement Division, Maritime Safety Security Team Seattle, and the Coast Guard District 13 Command Center. During this incident, he was the operations officer at the Pacific Strike Team. He currently serves as the branch chief at Coast Guard Training Center Yorktown's International Resident Training Division.

Leveraging Findings of Concern

by LCDR Megan Clifford
Detachment Chief
U.S. Coast Guard Investigations
National Center of Expertise

Bryan Johnson
Marine Casualty Investigator
U.S. Coast Guard Sector Charleston Investigations

The public dissemination of safety information originating from a marine casualty investigation is a critical mission of the Coast Guard Marine Investigations Program. Marine casualty investigators sift through multitudes of evidence to determine the causes of an accident. Investigators are trained to recognize that there may be multiple causal factors found during an investigation, and knowing all of the causal factors is motivation to act. This is the birth of safety information, and getting that information through the process, molded into an organizational lesson learned, and disseminated to the widest possible audience is the challenge we all must accept.

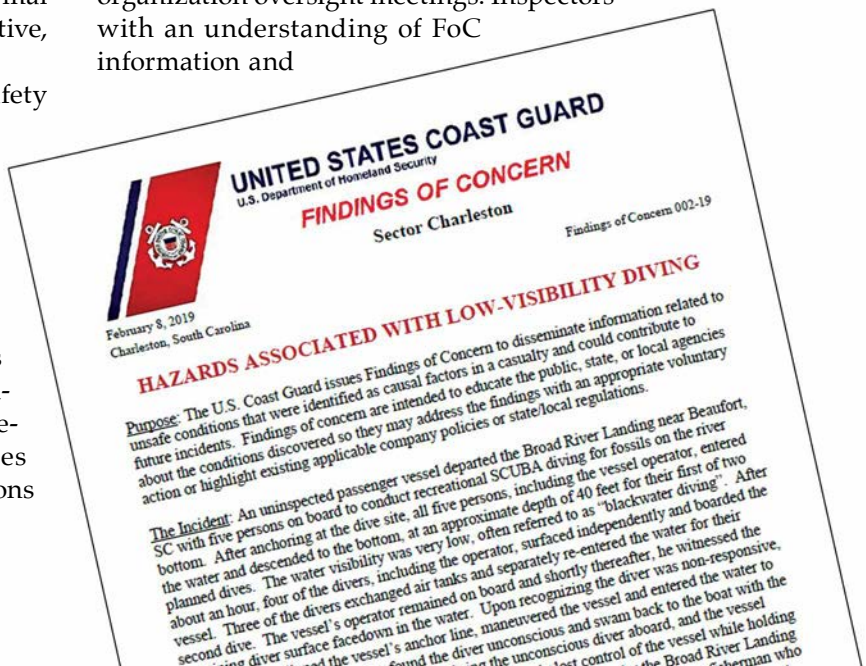
In 2018, the manner in which the program and its investigating officers categorized safety information changed. The Coast Guard Office of Investigations and Casualty Analysis (CG-INV) Policy Letter 2-18 introduced procedures[1] for publicly highlighting unsafe conditions that could contribute to future incidents. By themselves, the new category of safety information, termed Findings of Concern (FoC), are not the most urgent threats to the safety of life at sea. Nor are they recommendations to rectify deficient statute, regulation, or policy. Instead, they bring attention to safety issues where more formal action by the Coast Guard is not desirable, cost effective, nor within agency purview or authority.

FoCs are similar in nature to the Coast Guard Safety Alert, in that there is no intent to change policy, regulation, or law. These two types of information categories are directly linked to marine casualties because the event-based urgency can best support and inspire a culture of safety on a vessel or within an organization.

A pivot from the universal turn of phrase, "Lessons Learned" to "Findings of Concern" was made to more accurately portray the safety information as it exists in the post-investigation, pre-implementation phase. The term *lessons learned* implies education has happened and possibly corrective actions have already been taken, while a FoC is information where education may be needed and following action desired. The release of a FoC signals that the Coast Guard is offering the public and the maritime industry important lessons at the beginning of the education process.

FoCs are formal communications drafted as a part of full investigation and review process, a different pace from the more urgent safety alerts released as soon as critical issues have been identified. They are also the expected methods officers in charge of marine inspections should use to communicate investigation findings. With the finalization of the marine casualty investigation,[2] both communication types are posted for public release on the Coast Guard Deputy Commandant for Operations, CG-INV website.[3] All communication types are also highlighted via the Coast Guard *Maritime Commons* blog.[4] Depending on the incident, these safety information types may also be discussed within narrative investigation reports and accompanying final action memos.

FoCs are tools that can deliver important investigation findings with regard to internal company inspections, foreign flag vessel examinations, and third party organization oversight meetings. Inspectors with an understanding of FoC information and


UNITED STATES COAST GUARD
U.S. Department of Homeland Security
FINDINGS OF CONCERN
Sector Charleston
Findings of Concern 002-19
February 8, 2019
Charleston, South Carolina
HAZARDS ASSOCIATED WITH LOW-VISIBILITY DIVING
Purpose: The U.S. Coast Guard issues Findings of Concern to disseminate information related to unsafe conditions that were identified as causal factors in a casualty and could contribute to future incidents. Findings of concern are intended to educate the public, state, or local agencies about the conditions discovered so they may address the findings with an appropriate voluntary action or highlight existing applicable company policies or state/local regulations.
The Incident: An uninspected passenger vessel departed the Broad River Landing near Beaufort, SC with five persons on board to conduct recreational SCUBA diving for fossils on the river bottom. After anchoring at the dive site, all five persons, including the vessel operator, entered the water and descended to the bottom, at an approximate depth of 40 feet for their first of two planned dives. The water visibility was very low, often referred to as "blackwater diving". After about an hour, four of the divers exchanged air tanks and separately re-entered the water for their second dive. Three of the divers remained on board and shortly thereafter, he witnessed the vessel's operator remained on board and separately re-entered the water for their vessel. The vessel's operator facedown in the water. Upon recognizing the diver was non-responsive, diving diver surface facedown in the water. Upon recognizing the diver was non-responsive, maneuvered the vessel and entered the water to found the vessel's anchor line, maneuvered the vessel and entered the water to the boat with the the unconscious diver unconscious and swam back to the boat with the unconscious diver aboard, and the vessel lost control of the vessel while holding the Broad River Landing fisherman who

a respect for prioritization can use the information to build partnerships, and differentiating between important and critical safety information promotes trust in the messaging system.

The underlying foundation of Coast Guard causal analysis regards maritime transportation as a "production" system churning out equivalent products—stacks of containers on the pier, a delivered hold full of fish, or passengers' photos and memories from safe voyages.[5] Building on the foundation of Coast Guard causal analysis, FoCs can highlight important causal factors within the segment of that production system controlled by the operator, the owner, and the public, not the government. This safety information, is a compelling story that may prevent a future accident outside the Coast Guard's immediate ability to act, placing the onus of action on the audience. FOCs are intended to communicate changes the public may be able to implement, but they are not attempts to embarrass or shame those involved in a casualty.

Examples of Findings of Concern

Diving (002-19)[6]

Findings of Concern in Distribution Format

Incident: An uninspected passenger vessel was a platform for low visibility or "blackwater diving" in pursuit of the abundant fossilized shark teeth found off the coast of Beaufort, South Carolina. That day's diver count was five individual divers including the vessel operator. At the conclusion of the first planned dive and the transition to the second, the vessel operator was on board and witnessed a diver surface in a facedown position. Recognizing the floating diver's lack of response, the operator unclipped the vessel's anchor line in an effort to maneuver for recovery of the diver. The operator entered the water to lift the unconscious diver. The vessel was lost to the current as he worked to keep the diver's head above water. Good Samaritans fishing onshore assisted with the drifting vessel's recovery while nearby boaters assisted in pulling the diver onboard for CPR. The three remaining divers were recovered by emergency responders. The unconscious diver with more than 200 dive completions, including more than 60 in low visibility, was declared deceased after arriving at the hospital.

Contributing Factors and Analysis: It is believed the diver had exhausted his air supply tank. This is indicated by the inability to inflate the buoyancy compensation device upon surfacing unconscious without a weight belt, signaling potential emergency ascent. The Coast Guard investigation revealed multiple contributing factors that led to this incident, which if addressed may have prevented it. In particular, the lack of use of a "buddy system" while diving in low-visibility with strong currents made it challenging to accurately account for all divers. Additionally, no designated crew supporting the diving vessel operator remained on board the vessel while divers were underwater, nor did the vessel's configuration have adequate means to recover an unconscious person from the water. A lack of training and preparation on how to effectively recover an unconscious person also delayed the initiation of potentially critical first aid to the victim. Lastly, adequate preplanned emergency procedures were not established or executed when the victim was spotted face down in the water. When unaddressed, these factors create elevated risk.

Findings of Concern:

- **Use of a Buddy System:** Implement a "buddy system" when conducting dive operations to ensure enhanced accountability of all divers. Maintaining partner contact throughout the entire dive, including during entry and ascent, is advisable. One method involves employing "buddy lines" with prearranged signals.
- **Planning and Mitigation:** Plan, assess, and continually monitor the unique risks associated with low-visibility and/or high-current underwater environments. Refer to the most current tide charts and current tables and account for heavy rainfall when planning a dive.
- **Crew and Equipment:** Designating a trained crew member to remain on board the vessel to monitor dive participants and assist with recovery is a best practice. This is particularly important for uninspected passenger vessels that are not subject to annual Coast Guard inspections or man overboard drills. If necessary, implement and maintain equipment on board that can be used to recover persons from the water such as backboards, lifts, or slings. Ensure any lifting equipment is adequately rated for the weight of the heaviest diver. Additional equipment such as a redundant air supply and deployable surface marker is highly recommended.
- **Emergency Procedures:** Always conduct a safety brief including emergency procedures with participants before embarking on any dive operation. Procedures should include a sound signal or other method to alert the other divers in the water of an emergency and signal them to return to the vessel as soon as possible.
- **Operational Awareness:** Never assume an experienced diver will be safe or is medically suitable for diving without supervision or safeguards in place. Development of specific training and/or certification for low-visibility diving could help educate and prepare divers for the unique risks and challenges associated with blackwater diving.

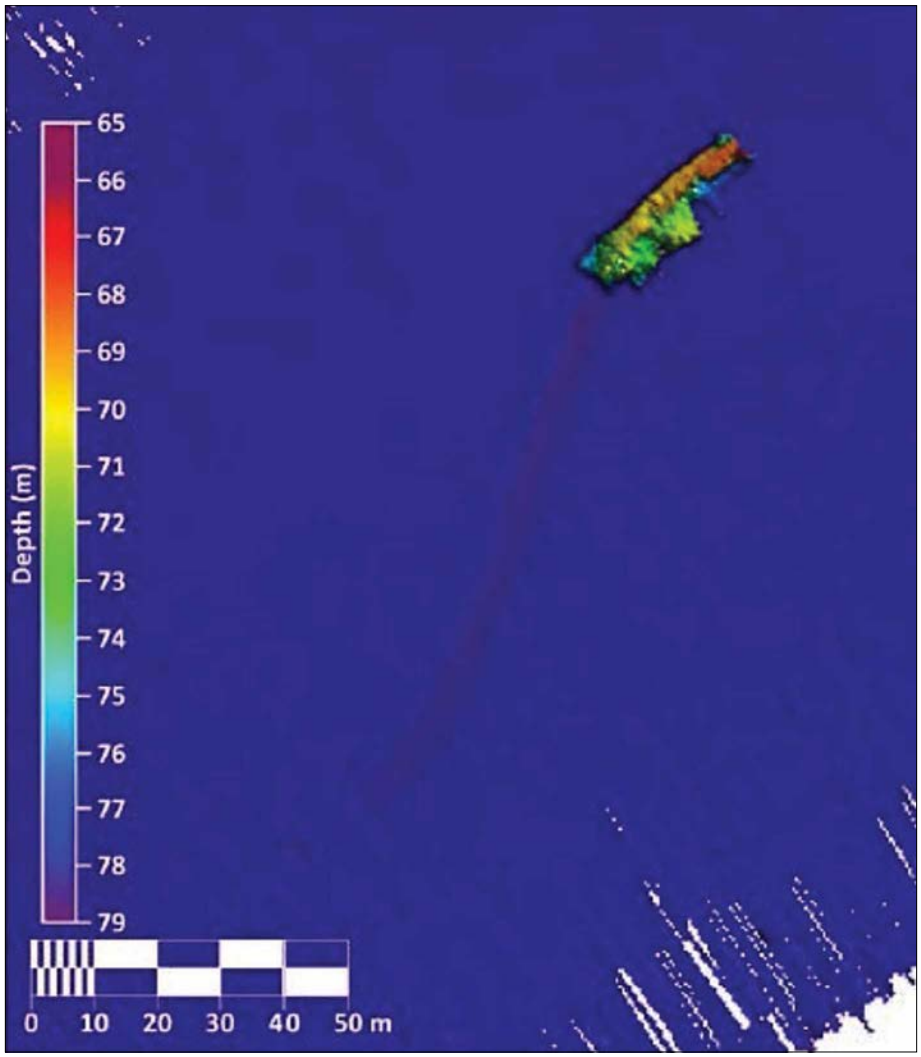
Modifications, Alterations and Weight Creep (006-19)[7]

Incident: In February 2017, immediately after 27 days of cod fishing, a 98-foot commercial fishing vessel departed Dutch Harbor, Alaska, and proceeded toward St. Paul Island to drop off bait with the intent of transiting to the Opilio crab fishing grounds. The vessel, carrying a crew of six and 200 crab pots, got underway despite multiple National Weather Service marine forecasts indicating areas of freezing spray along the vessel's planned route. After being underway for 30 hours and less than 5 miles off St. George Island, Automatic Identification System (AIS) data showed the vessel's speed abruptly slowed and its heading swung hard to starboard into the prevailing seas and northeastern winds. Shortly thereafter, the vessel appeared to suddenly lose maneuverability. Its heading pivoted to the west, the vessel drifted to the north and sank, taking the lives of all six crew members.

Contributing Factors and Analysis: The investigation showed that the owner failed to properly use the services of a qualified individual to formally evaluate and update the vessel stability instructions following changes to the vessel structure and loading conditions. These included:

- installation of a bulbous bow,
- addition of bulwark on the bow, and
- use of larger, heavier crab pots

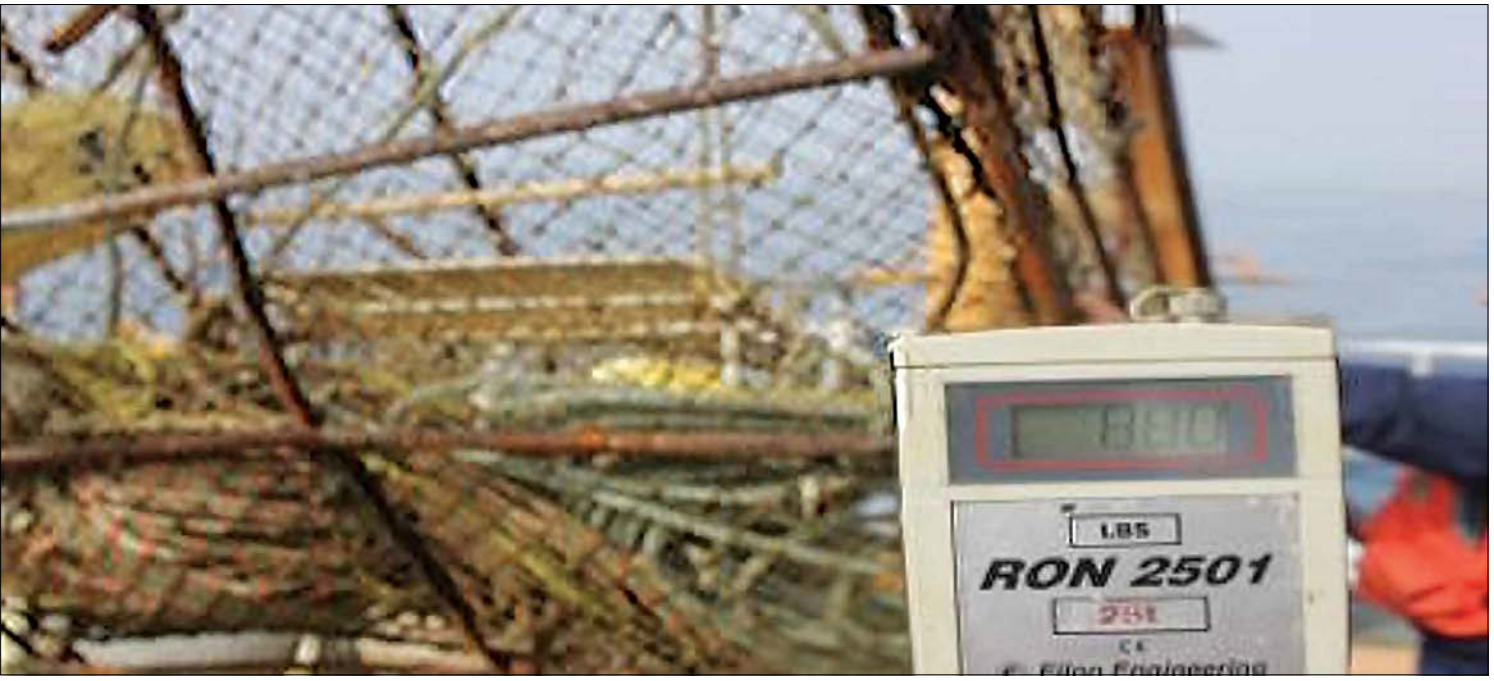
The weight of the larger, heavier crab pots exceeded that of the pots used to formulate the existing and most current stability instructions. Although investigators do not know if the vessel master referred to existing stability instructions for operating the vessel, the instructions were incorrect, and any decisions based on them would have been faulty. Additionally, a decision to place an additional 3,080 pounds of crab bait on top of 5 tiers of stacked crab pots, raised the vessel's center of gravity and further reduced the vessel's stability. The Coast Guard believes these issues, combined with the master's decision to depart port with a fatigued crew, active freezing spray warnings in the area of transit, and in a heavily loaded condition, negatively impacted the vessel's stability, contributing to its capsize and sinking.



Fishing Vessel *Destination* as viewed with side scan sonar courtesy of Regional Dive Locker West and Coast Guard Cutter *Healy*. Coast Guard photo

Findings of Concern:

- Owners, operators, and masters should maintain an active awareness of vessel stability issues at all times. This includes the need for qualified individuals and naval architects to update stability instructions and booklets when structural changes are made to a vessel, other equipment or operational gear is changed, or their placement is altered. Furthermore, qualified individuals and naval architects should take the opportunity when stability instructions and booklets are updated to examine the vessel's stability history to ensure previous calculations were sound and are suitable to continue to serve as a solid basis for any changes and updates.
- Owners, operators, and masters are encouraged to attend formalized stability training which should include stability principles regarding overloading, the effects of alterations and weight creep, icing, watertight integrity, deck drainage, and other issues



Fishing Vessel *Destination*'s crab pot as recovered by Coast Guard Cutter *Healy* crew with weight in the foreground. Coast Guard photo

particular to their type of vessel and fishery.

- Owners and operators are encouraged to take advantage of the flexibility of the stability instruction requirements for uninspected commercial fishing vessels in 46 CFR 28.530. These regulations, applicable to vessels 79 feet or greater, intentionally provide maximum flexibility for owners and qualified individuals to determine how best to convey stability information to the masters or individuals in charge of their vessels. In doing so, they should take into consideration that operating personnel in the commercial fishing industry do not typically have specialized stability training.
- Owners, operators, masters, qualified individuals, technical superintendents, and other personnel need to remain fully cognizant of "weight creep," the result of modifications and alterations to the vessel that occur over its lifespan. Modifications and alterations may occur due to changing fisheries, fishing methods, variations in equipment and area of operation. These weight changes impact stability, and ultimately create the need for a qualified individual to revisit the stability instructions and associated calculations.
- One way to prevent weight creep is to develop a modification and alteration log which can be maintained in various formats. The log can be as simple as a notebook or spreadsheet, or in the form of computer software. The vessel's existing stability instructions and data should first be validated by a qualified individual or naval architect prior to creating a log to ensure future stability calculations start from an accurate baseline.

For the Common Good

Forward leaning organizations strive to build a culture of safety and, to achieve this, lessons need to be constantly consumed. Internalizing investigative findings of concern and discussing those findings is critical.

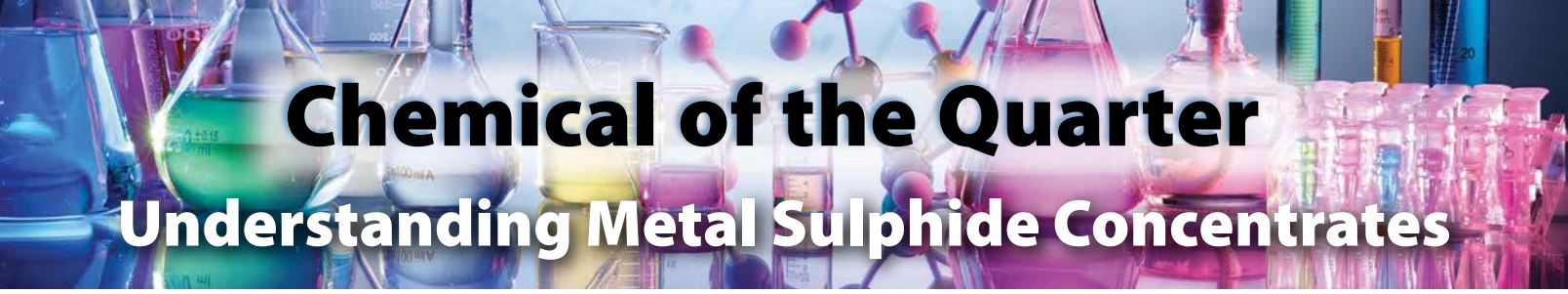
About the authors:

LCDR Megan Clifford is currently the detachment chief at the Investigations National Center of Expertise. Prior assignments include assistant senior investigating officer at Sector New Orleans, as well as duty inspections Sector Puget Sound and Sector San Francisco.

Bryan Johnson has served at the USCG Sector Charleston Investigations Department for nine years and conducts several diving investigations each year.

Endnotes:

1. U.S. Coast Guard Marine Investigations: MISLE Documentation and Reporting Procedures (MCI-05) Version 1.02
2. See cgmix.uscg.mil/IIR/IIRSearch.aspx
3. See www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Inspections-Compliance-CG-5PC-/Office-of-Investigations-Casualty-Analysis/
4. See mariners.coastguard.dodlive.mil/category/investigations-casualty-analysis/
5. Marine Safety Manual Volume V: Investigation and Enforcement Commandant Instruction M1600010.A
6. See www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/CG-5PC/INV/foc/FoC_2019-002_HazardsLowVisibilityDiving.pdf?ver=2019-02-21-161512-547
7. See www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/CG-5PC/INV/foc/FoC_2019-006_ImpactsOfModificationAlterationsAndWeightCreepOnStability.pdf?ver=2019-03-03-121021-913



Chemical of the Quarter

Understanding Metal Sulphide Concentrates

by Amy Parker, Ph.D.
Hazardous Materials Division
U.S. Coast Guard Office of Design and Engineering Standards

What is it?

Metal sulphide concentrates, also known as mineral concentrates, are refined ores which have undergone enriching processes to eliminate undesirable materials while concentrating highly valued components. The most prevalent metal sulphide concentrates are zinc, lead, and copper.[1] They are primarily used in the production of metal and alloy materials.

Why should I care?

➤ *Shipping Concerns:*

All metal sulphide concentrate cargoes have the potential to liquefy.[2] Liquefaction occurs in cargoes comprised of fine particles that also contain some moisture. Liquefaction will not occur in cargoes comprised of large particles or lumps, or when the cargo has a low moisture content. During liquefaction, water within the cargo separates from the solid particles, resulting in the cargo behaving more like a liquid than solid. Liquefaction causes significant cargo shift and decreases ship stability.

Some metal sulphide concentrates may also have the potential to oxidize, resulting in the cargo self-heating.[3] Heating of the cargo causes oxygen depletion and the evolution of toxic fumes. Additionally, the presence of moisture in the cargo may form sulfurous acid which is corrosive to steel.[4]

➤ *Health Concerns*

Metal sulphide concentrates are known to have both acute and long-term health effects.[5] Zinc, lead, and copper concentrates all cause damage to the respiratory system and may cause cancer via inhalation of dust from these cargoes.[6,7,8] Exposure to both zinc and lead concentrates may also negatively impact fertility and unborn children.[9,10]

What is the Coast Guard doing about it?

Metal sulphide concentrates are primarily shipped as bulk solid cargoes. Domestically, metal sulphide concentrates are shipped under 46 Code of Federal Regulations Part 148. The International Maritime Solid Bulk Cargoes (IMSBC) Code specifies how metal sulphide concentrates are loaded, unloaded, and transported by cargo vessel for international shipments. Under the IMSBC Code, metal sulphide concentrates may be shipped under the following four schedules or entries:

1. METAL SULPHIDE CONCENTRATES *(see also Mineral concentrates schedule)*
2. METAL SULPHIDE CONCENTRATES, CORROSIVE UN 1759 *(see also Mineral concentrates schedule)*
3. METAL SULPHIDE CONCENTRATES, SELF-HEATING UN 3190 *(see also Mineral concentrates schedule)*
4. Mineral Concentrates *(see Bulk Cargo Shipping Names below)*

Prior to the shipment of metal sulphide concentrates, the shipper must provide the vessel's master or his representative a signed certificate of the transportable moisture limit and a signed certificate or declaration of the moisture content. Additionally, procedures for sampling, testing, and controlling moisture content of metal sulphide concentrate cargoes must be approved by the competent authority of the port of loading, for example, the Hazardous Materials Division at USCG Headquarters (CG-ENG-5) for the United States.

About the author:

Dr. Amy Parker is the lead chemical engineer for Bulk Solid Cargoes and Packaged Hazardous Materials in the Hazardous Materials Division at U.S. Coast Guard Headquarters. She has worked for the Coast Guard since 2011. She received her B.S. and Ph.D., both in chemical engineering, from Mississippi State University.

Endnotes:

1. International Maritime Organization, International Maritime Solid Bulk Cargoes Code and supplement, incorporating Amendment 05-19, 2020 Edition, pp 292–302 (2020).
2. Ibid
3. Ibid
4. Ibid
5. Ibid
6. Zinc Concentrate Safety Data Sheet. www.teck.com/media/Zinc-Concentrate%20-SDS-Red-Dog.pdf. Visited 02 February 2021.
7. Lead Concentrate Safety Data Sheet. www.teck.com/media/2015-Products-Lead_Concentrate_Red_Dog_SDS-T2.5.pdf. Visited 02 February 2021.
8. Highland Valley Copper Concentrate Safety Data Sheet. www.teck.com/media/HVCCopper-Concentrate-SDS.pdf. Visited 02 February 2021.
9. Zinc Concentrate Safety Data Sheet. www.teck.com/media/Zinc-Concentrate%20-SDS-Red-Dog.pdf. Visited 02 February 2021.
10. Lead Concentrate Safety Data Sheet. www.teck.com/media/2015-Products-Lead_Concentrate_Red_Dog_SDS-T2.5.pdf. Visited 02 February 2021.

Nautical Engineering Queries

Prepared by NMC Engineering Examination Team

1. The airborne concentrations of substances, like hydrogen sulfide, under which nearly all workers may be repeatedly exposed without adverse effects are called _____ .

A. Exposure limits
B. Concentration limits
C. Threshold limit values
D. Substance limit values

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2. Worn cylinder head valve seats in a diesel engine will cause _____ .

A. Less cold valve lash
B. More cold valve lash
C. Excessive pressure in hydraulic valve lash adjusters
D. Broken valve springs

---

3. With regards to pilot controlled pneumatic regulating valves, the spring force of the regulating valve should be adjusted to _____ .

A. Maintain the required system set point
B. Maintain the value of the manipulated variable
C. Maintain the output steam pressure of the system
D. The operating range of the pilot output loading pressure

---

4. When a resistor is used as a shunt and is connected in parallel with a meter movement coil, what capability does this provide?

A. A measurement of circuit resistance
B. An increased accuracy of approximately 1.5 percent
C. An extended meter range
D. This is never done

Engineering Answers

1. A. Exposure limits — Incorrect

B. Concentration limits — Incorrect

C. Threshold limit values — **Correct answer.** "Threshold limit values (VLV)—levels of airborne concentrations of physical agents, expressed in parts per million (ppm), that represent conditions under which average personnel may be repeatedly exposed, during normal working hours, without adverse effects."

D. Substance limit values — Incorrect

Reference: Naval Ships Technical Manual, *Chap. 074, Vol. 3, Gas Free Engineering, Appendix M, Page Gloss-9*

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2. A. Less cold valve lash — **Correct answer.** If the valve seat is worn, this will cause a shorter distance in valve linkage, hence less cold valve lash.

B. More cold valve lash — Incorrect

C. Excessive pressure in hydraulic valve lash adjusters — Incorrect

D. Broken valve springs — Incorrect

Reference: Diesel Engine Operation & Maintenance, *Maleev, Pages 94–96*

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3. A. Maintain the required system set point — Incorrect

B. Maintain the value of the manipulated variable — Incorrect

C. Maintain the output steam pressure of the system — Incorrect

D. The operating range of the pilot output loading pressure — **Correct answer.** "Screwing the nut upward increases the compression of the adjusting spring and therefore, the pressure that must act on the pilot's upper diaphragm to increase the output pressure (i.e., the controlled-pressure set point is raised). Screwing the adjusting nut downward reduces the set point of the controlled pressure."

Reference: Modern Marine Engineer's Manual, *Vol. 1, 3rd Ed.; Pages 11–87*

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4. A. A measurement of circuit resistance — Incorrect

B. An increased accuracy of approximately 1.5 percent — Incorrect

C. An extended meter range — **Correct answer.** "The resistance of a shunt becomes smaller as you extend the range of a meter movement."

D. This is never done — Incorrect

Reference: Electricity One-Seven, *2nd Ed; Mileaf, Pages 5–63*

Nautical Deck Queries

Questions

Prepared by NMC Engineering Examination Team

1. Both international and inland: A 20-meter vessel is towing another vessel astern. The length of the tow from the stern of the tow is 75 meters. How many white towing masthead lights shall the towing vessel show at night?

A. 1
B. 2
C. 3
D. 4

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2. A vessel is taking on water but is not in immediate danger of sinking. What would be the best action to take to increase the vessel's stability?

A. Increase the center of gravity
B. Reduce the free surface where possible
C. Pump out the double bottoms to reduce draft
D. Counter list by shifting deck cargo to the high side

---

3. Individuals who have consumed alcohol within 24 hours prior to exposure to H2S can tolerate which of the following?

A. Unusually large concentrations of H2S
B. Moderate concentrations of H2S without the usual reactions
C. Longer exposure to H2S concentrations
D. Smaller than normal concentrations of H2S

---

4. While preparing to enter a Brazilian port (IALA-B), you see ahead a red and green horizontally striped buoy. The upper band is red. What action should you take?

A. Pass the buoy well clear on either side
B. Pass the buoy close aboard on either side
C. Alter course to leave the buoy to starboard
D. Alter course to leave the buoy to port

1. A. 1 — Incorrect

B. 2 — **Correct answer.** "A power-driven vessel when towing astern shall exhibit (i) instead of the light prescribed in Rule 23(a)(i) or 23(a)(ii), two masthead lights in a vertical line. When the length of the tow, measuring from the stern of the towing vessel to the after end of the tow, exceeds 200 meters, three such lights in a vertical line."

C. 3 — Incorrect

D. 4 — Incorrect

Reference: Inland/International Rule 24(a)

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2. A. Increase the center of gravity — Incorrect

B. Reduce the free surface where possible — **Correct answer.** "If transverse stability in the flooded condition is poor or negative, every effort should be made to reduce the free surface and to lower the center of gravity."

C. Pump out the double bottoms to reduce draft — Incorrect

D. Counter list by shifting deck cargo to the high side — Incorrect

Reference: Stability and Trim for the Ship's Officer, *George, 4th Ed., Page 282*

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3. A. Unusually large concentrations of H2S — Incorrect

B. Moderate concentrations of H2S without the usual reactions — Incorrect

C. Longer exposure to H2S concentrations — Incorrect

D. Smaller than normal concentrations of H2S — **Correct answer.** "Among the conditions which may compromise a person's tolerance to H2S are any pulmonary, respiratory, bronchial, or heart problems. Other medical considerations include an eye infection, diabetes, epilepsy, hypertension, and alcoholism (or persons who have consumed alcohol within 24 hours of exposure)."

Reference: Safety on the Rig, *PETEX, 4th Ed., Unit 1/Lesson 10, Pages 108–109*

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4. A. Pass the buoy well clear on either side — Incorrect

B. Pass the buoy close aboard on either side — Incorrect

C. Alter course to leave the buoy to starboard — **Correct answer.** "Buoys with horizontal red and green bands mark junctions (where two channels come together) or bifurcations (where two channels split off one). If the top-most band is green, keeping the buoy on the port hand will follow the preferred channel, as if the whole buoy were green. If the top-most band is red, keeping the buoy to starboard ("red right returning" applies) will keep you in the preferred channel."

D. Alter course to leave the buoy to port — Incorrect

Reference: Dutton's Navigation and Piloting, *Cutler, 15th Ed., Pages 57–58*

In the News: Gulf of Mexico Rescue

Crew members from Coast Guard Cutter *Glenn Harris*, a pre commissioned 154 foot fast response cutter, pull a person from the water April 13, 2021, after the 175 foot commercial lift boat, *Seacor Power*, capsized 8 miles south of Port Fourchon, Louisiana. The Coast Guard and multiple good Samaritan vessels responded to the capsized vessel and searched for multiple missing people in the water. Coast Guard photo

COMMANDANT (CG-5PS-D)
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A 47-foot motor lifeboat from Coast Guard Station Cape Disappointment transits the Pacific Ocean several miles offshore from Washington state on November 14, 2020. In the background, a commercial freighter can be seen departing the mouth of the Columbia River. Coast Guard photo by Petty Officer Steve Strohmaier