The Coast Guard Journal of Safety & Security at Sea
PROCEEDINGS
Winter 2022 of the Marine Safety & Security Council

The Great Lakes

The Ninth District's Unique Operating Environment

Guardians of the Great Lakes

NINTH COAST GUARD DISTRICT

GUARDIANS OF THE GREAT LAKES

We will maintain and safeguard the Great Lakes system and the commercial and recreational users that depend on it through the collaborative pursuit of safety, security and stewardship.

Strategic Priorities of the Ninth District's Great Lakes Maritime Strategy

1. Ensure Preparedness for Emerging Threats and Challenges
2. Enhance Cooperation and Stakeholder Relationships
3. Maintain the Safe, Secure, and Efficient Usage of the Great Lakes Marine Transportation System
4. Protect the Cyberspace of the Great Lakes Marine Transportation System
5. Optimize Mission Readiness and Execution
6. Ensure Support for Shore Infrastructure, Operational Resources and Personnel

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The Great Lakes Marine Transportation System

On Deck

On the Cover: *U.S. Coast Guard Cutter* Mackinaw *(WLBB-30) breaks ice in Whitefish Bay, on eastern Lake Superior, in March 2009, in support of the spring breakout of vessels laid up for the winter. Icebreaking is a vital mission performed across the Great Lakes in coordination with the Canadian Coast Guard. In addition to facilitating the movement of domestic and international commerce, icebreaking operations mitigate the risk of flooding and prevent the destruction of property in the United States and Canada.*

Coast Guard photo by
Petty Officer 3rd Class George Degener

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District Commander's Perspective

by Rear Admiral Michael J. Johnston
Commander, Ninth Coast Guard District
U.S. Coast Guard

I am honored and excited to present this inaugural edition of the storied *Proceedings* magazine focused on a specific Coast Guard District's operations, environment, and challenges. During my tenure here, I have learned something new and fascinating nearly every day! This outstanding collection of articles highlights many of the unique attributes of our service's work in these shared, sensitive, and salt-free bodies of water. The most striking of which is the dramatic shift in operations caused by changing seasons. We refer to these two operating environments as "soft water" in the summer months and "hard water" in the winter. The resulting cyclical training and equipment preparations, and different risk profiles, truly test our crews.

Champion's Point of View

by Lorne W. Thomas
Chief of External Affairs, Ninth Coast Guard District
U.S. Coast Guard

The timing was perfect when I was asked to champion the issue of *Proceedings* highlighting the Great Lakes and the Ninth District's missions. I recently combined my 20 years of Great Lakes experience with the Ninth District staff's expertise to produce an introductory primer titled *Fresh Water University* for personnel new to the District. This document provides an overview of the District's world of work on these binational bodies of fresh water and the differences from similar coastal operations. This *Proceedings* issue serves the same purpose and also includes insightful perspectives on issues of mutual concern from our partners and stakeholders.

This issue opens with an introduction

The more than 4 million registered recreational boats, in addition to large numbers of personal watercraft, ensure Search and Rescue (SAR) remains our "bread and butter" mission. The District—comprised of four sectors, 45 small boat stations, and two air stations—handles more SAR cases between Memorial Day and Labor Day than most of other Districts handle in a year. Come winter, our crews, ice rescue equipment, and airboats support our expanding ice rescue mission as thousands participate in ice fishing and other winter sports. Similarly, our cutter fleet transitions from buoy tending and law enforcement to breaking ice for the U.S. and Canadian Lakers. These carriers, vital to the economic well-being of our two countries, move bulk raw materials supplying the region's manufacturing industries.

Simple geography contributes to some of the distinctive challenges of the Ninth District. The Lakes span over 95,000 square miles touching eight states, two provinces and numerous tribal nations. The 1,500 miles of shared maritime border with Canada is a potential conduit for illegal crossings and contraband. The depth and breadth of our responsibilities require partnerships with state, federal, and Canadian agencies. None of these is more important than our relationships with Transport Canada, the Royal Mounted Canadian Police, and the Canadian Coast Guard, which is celebrating its 60th anniversary this year.

I sincerely hope you enjoy this issue and learn something new about the men and women who serve as the Ninth District's "Guardians of the Great Lakes." Their work is critical to ensuring the safety, security, and environmental stewardship of these national treasures.

to the largest fresh surface water system in the world and some of the challenges facing it due to climate change, invasive species, and persistent pollution. Fortunately, there is a robust and diverse network of binational, federal, state, and local agencies; tribes; associations; and non-governmental organizations that collaboratively work together to both protect and restore this fragile ecosystem ensuring the sustainability of its resources.

The section that follows focuses on the diverse and mature mission set executed by the regular, Reserve, civilian, and Auxiliary forces across the District. These activities include law enforcement on binational waters, responding to boaters in distress, and preparing for oil and hazardous substance discharges that may occur. The latter could be devastating to the highly sensitive environment that provides drinking water for 35 million citizens and supports an extraordinarily high level of commercial and recreational activity.

The final section examines the support for the Great Lakes marine transportation system used by Canadian Lakers, foreign-flag break-bulk ships, and the U.S. Laker fleet. The Ninth District is the only district that manages its entire area of responsibility as a complete system. For the most part, other coastal districts are made up of a collection of ports that are not critically dependent on a shared waterway.

In closing, I would like to offer my heartfelt thanks to all of the contributing authors to this groundbreaking edition of *Proceedings*. It will certainly endure as an exceptional overview of Coast Guard operations on the Great Lakes and St. Lawrence River; for use both inside and outside the Coast Guard.

Our Great Lakes

Sustaining life across a globally unique region

by Joel Brammeier
President & CEO
Alliance for the Great Lakes

The Great Lakes are the Midwest's most prominent natural feature and are so large they are easily spotted from space. Home to more than 6 quadrillion gallons[1] of fresh water, or nearly 20 percent of the world's surface supply,[2] the lakes span more than 1,000 miles from Minnesota to Quebec. More than 40 million people in the United States and Canada rely on the Great Lakes and its watershed for daily drinking water.[3] Thousands of species of fish, wildlife, and plants thrive in their abundant waters, and the lakes are the backbone of our region's economy. The lands and waters of the Great Lakes region are home to more than 100 sovereign nations and communities of native peoples and have been for thousands of years.[4]

Post-industrialization, the Great Lakes region played an outsize role in the manufacturing economy of the late 19th and 20th centuries. Cheap, easy access to seemingly limitless water, raw materials like iron ore, and maritime and rail transportation routes made the Great Lakes a national manufacturing hub. The Lakes helped build powerhouse metropolises and tight-knit communities, created jobs from New York to Detroit to Chicago, while making transit between cities and rural areas easy, and the flow of goods possible. The Great Lakes help feed people and livestock while cooling refineries and power plants. If the Great Lakes region were a single country, its GDP across eight U.S. states and two Canadian provinces would be the third largest in the world, outdone only by the United States and China.

The Lakes have paid a price for this that is still being tabulated. Rivers, harbors, and groundwater are fouled by toxic chemicals. Overloads of nutrients have, at worst, taken a whole city's water supply offline and continue to feed toxic algal blooms every year. Invasive species from across the globe have devastated the ecosystem and threaten a sport fishing and recreational boating industry, worth $7 billion and $16 billion, respectively.[5,6] As investment in the region receded in the late 20th century, the water infrastructure that cities and people depend on every day crumbled, threatening human health and the lakes themselves. Additionally, our rapidly changing global climate is bringing extreme storms and warming water, making problems the region has grappled with for decades demonstrably worse.

Progress Made

For a region this diverse in geography, economy, and people, the Great Lakes has accomplished something special. On more than one occasion, the public's faith in the value of fresh, clean water has been rewarded with policy and investment commensurate with the need to

The Great Lakes' beaches, like this one in Michigan City, Indiana, are favorite destinations for the recreational opportunities they offer. For many visitors, these areas offer getaways that are close to home. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

Pictured Rocks National Lakeshore in Munisings, Michigan, is one of many scenic areas found along the Great Lakes which support both recreation and commerce. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

protect that water for today and tomorrow.

In 1972, the United States and Canada signed the first Great Lakes Water Quality Agreement, a voluntary commitment to protect and restore the ecological values of the lakes.

One eventual outgrowth of the Agreement was the Areas of Concern (AoC) program, under which the countries designated 43 coastal and riparian sites.[7] The AoCs are home to some of the worst contamination in the Great Lakes region, including chemicals like polychlorinated biphenyls and dioxin. After many years of community-level planning, the U.S. federal government authorized spending to clean up the AoCs for the first time in the early 2000s.[8] Eventually, this work under the Great Lakes Legacy Act was incorporated into the Great Lakes Restoration Initiative (GLRI), which today stands as the largest regional watershed restoration program in the country.

Since 2010, the GLRI has invested about $3.8 billion in the cleanup of the AoCs and much more, including nonpoint source pollution reduction, invasive species prevention and control, and habitat restoration.[9] In 2022, Congress provided the program an additional $1 billion and the Environmental Protection Agency committed to using the bulk of the funds to clean up most of the remaining United States' AoCs by 2030.[10] In 2018, researchers estimated that every dollar spent on the GLRI program from 2010 to 2016 would return $3.35 in additional economic output through 2036.[11]

Great Lakes advocates zealously guard the lakes' water quality and quantity. Despite seeming limitless, artificial changes to water flows have permanently altered the level of the lakes. The most famous, or notorious, occurred at the turn of the 20th century and was the result of reversing Chicago's rivers so they flow to the Mississippi. This action caused an estimated drop of more than 2 inches in the levels of Lake Michigan and Lake Huron.[12]

In 1998, a proposal to export water in bulk via tanker prompted the region to develop a binding and legally defensible policy that would prevent unsustainable use of lake water. After a decade of work, the states and Congress unified to pass the Great Lakes Water Resources Compact. The Ontario and Quebec legislatures also passed a corresponding agreement.[13] The Compact bans most diversions of water; requires that any approved diversions return water to the lakes after use; and requires each jurisdiction to set water use rules

following the same legal framework. The Compact has been tested several times since its passage, but continues to hold strong.

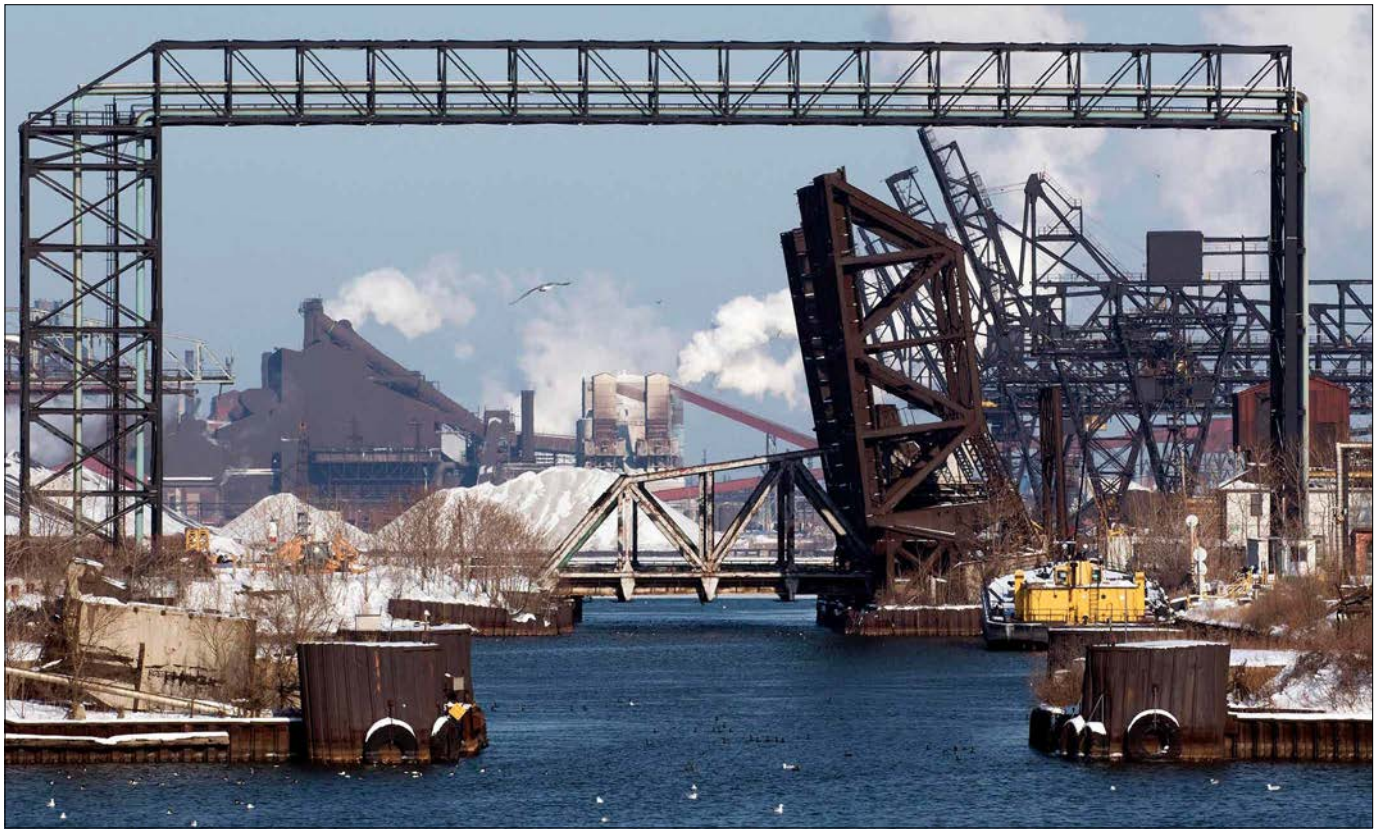
Intentionally imported into the Mississippi River basin, bighead carp devastated the ecosystem. Now this, and other invasive species, are threatening to enter the Great Lakes where they could have similar effects. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

Damage Done

The lakes are globally ground zero for the invasion of freshwater species. Starting in the early 20th century, and growing dramatically with the opening of the St. Lawrence Seaway to global trade in 1959,[14] the Great Lakes today are home to more than 180 non-native aquatic species.[15] Several of the most damaging organisms, including the zebra and quagga mussels, round goby, and spiny water flea migrated to the lakes in the ballast tanks of ocean cargo vessels. These organisms have dramatically altered the Great Lakes' food webs and are estimated to cost the region more than $200 million annually.[16]

The threat of invasive species making their way to the Great Lakes from the southern United States is another consequence of connecting Chicago's rivers to the Mississippi River. Today, bighead and silver carp—intentionally imported species that have decimated parts of the Mississippi River basin—are threatening to enter the lakes through Illinois.

Suffering the brunt of the damage from aquatic



The Grand Calumet River at Lake Michigan was designated an Area of Concern under the 1987 amendment to the Great Lakes Water Quality Agreement. The legacy pollutants from steel mills, foundries, as well as other industrial wastes affected the water quality of the river that runs primarily through northwest Indiana. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

Agriculture poses a challenge to the Great Lakes. Farms, like this one on the Maumee River in Ohio, use chemical and manure fertilizers. These create runoff that contains high levels of phosphorus, which can produce algal blooms that can be toxic to humans and pets. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

invasive species, the Great Lakes region has helped lead binational efforts to protect our waters from new invasions. The state of Michigan passed a ballast water pollution policy in 2005.[17] The first oceangoing vessel with ballast water treatment technology on board entered the lakes in 2016.[18] Two years later, after years of litigation and political wrangling, Congress affirmed that the federal Clean Water Act's pollution standards apply to invasive species in ballast water. This ensured that the U.S. Coast Guard had clear authority to inspect vessels and enforce compliance.[19]

In 2021, Canada finalized rules requiring that freshwater vessels install technology to limit the spread of invasive species within the Great Lakes. The United States continues to consider similar measures.[20] Earlier this year, Congress approved $226 million to pay for the completion of design work and initial construction of new protections against the movement of invasive carp toward the Great Lakes at Brandon Road Lock and Dam in Illinois.[21] More than a decade of collaboration and negotiation among the states, provinces, federal governments, and advocates across the region made this progress possible.

Challenges Ahead

The Great Lakes are so massive and diverse that there is no single answer to the question, "How are the lakes doing?" On a warm, dry, summer day, it is easy to look out over the calm blue water and feel the peace and euphoria that comes from sensing your place in the grand scale of nature. However, the region grapples with massive problems that will challenge efforts to deliver on the promise of safe, clean Great Lakes for all.

Agriculture

The future of the region's $15 billion agricultural economy is certainly a challenge.[22] In the 20th century, most damaging water pollution came from the ends of pipes at industrial facilities and via chronic overflows of sewage. Some of this gave rise to the contaminated AoCs. Today, runoff from chemical and manure fertilizers with high concentrations of phosphorus regularly sparks harmful algal blooms, some of which create toxins that can make people and animals sick if ingested. This is a chronic problem in large watersheds like western Lake Erie, Green Bay, and Saginaw Bay.[23] Agriculture was to blame for the pollution that shut down drinking water for nearly

500,000 people in Toledo, Ohio, and the surrounding area in 2014.[24] Pollution from farms also contaminates groundwater, and climate change is making these problems worse. Warmer water is more conducive to algal blooms, and extreme and less predictable storms—particularly in spring—can flush large concentrations of nutrients into the lakes that lead to large blooms months later.[25] Figuring out how the region can grow food without poisoning the water is the next step towards keeping the lakes clean.

More than 22 million pounds of microplastics find their way into the Great Lakes each year. There, they have a negative impact on the wildlife and find their way into the tap water, as well as products produced using the water from the lakes. Photo courtesy of the Alliance for the Great Lakes

Infrastructure

Great Lakes water infrastructure is also troubled, and this systemic problem burdens large cities and rural areas alike. Since the passage of the Clean Water Act in 1972, great progress has been made to reduce the amount of sewage entering the lakes. But many of the communities and people that remain hard hit by sewage overflows, community flooding, and basement backups are lower income and have the fewest resources to protect themselves and remediate the damage. As with agricultural runoff, extreme and unpredictable storms and a changing climate are already overtaxing our stormwater infrastructure.

The Great Lakes region also has seven of the 10 states with the highest number of lead service lines delivering drinking water to homes in the United States.[26] While targeted for removal under the recent Infrastructure Investment and Jobs Act, progress to date has been slow, and the cost of solving these problems continues to rise, as evidenced by a growing affordability gap in water rates across the region.[27]

Microplastics

While it is difficult to highlight just one emerging industrial contaminant that threatens the lakes today, the scourge of microplastics pollution is hard to ignore. More than 22 million pounds of plastic flow into the lakes each year[28] from sources like single-use food packaging, beverage bottles, and fibers from airborne deposition and laundry. Larger plastics readily break down into small particles once in the environment. While you are unlikely to see rafts of plastic washing up on the shores of the lakes, microplastics are everywhere including in tap water and processed products, like beer.[29]

Drawing visitors from near and far, the Great Lakes support both recreational and economic activity. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

In 2015, the Great Lakes region helped lead the country in the ban of plastic microbeads that had been used in cosmetics for years.[30] Despite eliminating this major source, wildlife continues to consume microplastics, and recent alarming research shows that they are in the human bloodstream[31] and lungs.[32] The Great Lakes region can play a role in solving this global problem by focusing on policies and practices to reduce the consumption of single use plastics and keep plastic out of the waste stream.

Ever Hopeful

The more than 40 million people that depend on the Great Lakes for drinking

water are not statistics. They are individuals, families, and communities that comprise a nonpartisan consensus that building and restoring our region around clean water is job one. Poll after poll demonstrates unified public support in the region for investing in restoring our lakes; providing safe, clean drinking water for all; and protecting our way of life today and tomorrow.[33] That the Great Lakes region has already met and overcome such tremendous challenges has convinced us that, when we put clean water and people at the center, just about anything becomes possible.

The largest source of fresh surface water on the planet, the Great Lakes provides drinking water for more than 40 million people in the region. Maintaining the lakes' water quality and quantity is essential. Photo courtesy of the Alliance for the Great Lakes/Lloyd DeGrane

About the author:

Joel Brammeier, president and CEO of the Alliance for the Great Lakes (www.greatlakes.org), leads a team of professionals and tens of thousands of supporters across the region dedicated to protecting clean water and building a sustainable future for the Great Lakes.

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Ingredients to Success

The seven "Ps" of a winning navigation system and ecosystem vibrancy

by Cameron Davis
Vice President
GEI Consultants

More than ever, navigation system efficiency, ecosystem health, public safety, and other needs cannot be seen as competing priorities. The Great Lakes region is leading the way in showing the rest of the country, if not the world, how these imperatives and their stakeholders can—and must—be mutually reinforcing.

With the longest coastline in the contiguous United States, it is astonishing that the Great Lakes system, the largest source of fresh surface water on the planet, is often overlooked as a driver for waterborne transportation, infrastructure, and clean water policy for the country. But, if we dare to take a closer look, that is where our story begins.

In my nearly four decades of Great Lakes advocacy, I have seen how stakeholders in the region have gone from competing against one another for resources to working together to support each other's priorities. As a federal government appointee once told me, "I'm on several regional committees and task forces around the country. Working on Great Lakes issues is so refreshing because everyone tries to help each other."

Cameron Davis

With shrinking budgets, intensifying divisiveness, competition for media attention, and other challenges, finding a way to marry policy priorities is *the* recipe for success. By following it, we can overcome obstacles to make our waterways safer and healthier, and navigation more cost-effective to manage over time. We are also happy to share it with other regions struggling with similar challenges.

Policy

Policy is our first ingredient in the recipe for success. Often, the world of policy is too abstract to seem relevant and policies can be artificially divided. We often think economic policy differs from environmental policy, which differs from public health policy, and so on. But if we take a step back, we see they can be beneficially linked.

As the late U.S. Rep. Elijah Cummings once said, "Our transportation decisions determine much more than where roads or bridges or tunnels or rail lines will be built. They determine the connections and barriers that people will encounter …."[1] Cummings served as chair of the House Transportation and Infrastructure's Subcommittee on Coast Guard and Maritime Transportation. Similarly, Sierra Club Founder John Muir famously stated, "When we try to pick out anything by itself, we find it hitched to everything else in the Universe."[2]

When we understand that policies can be integrated, we can advance multiple public imperatives at the same time instead of advantaging one to the disadvantage of others. We also have the opportunity to save money and bring people together at a time when we need both more than ever.

Productivity

Economic productivity is a public policy imperative to the region's—if not North America's and world's—welfare.

Today's waterborne navigation interests rightfully pride themselves on their contributions to the economic health of the Great Lakes region. According to data produced for the Great Lakes St. Lawrence Seaway Development Corporation and others, the Great Lakes-St. Lawrence River navigation system's cargo and vessel movement contributes $35 billion in economic

The Great Lakes system, the largest source of fresh surface water in the world, offers countless recreational opportunities while also providing the region with nearly 240,000 jobs and $35 billion in economic activity annually. This makes its protection and preservation a necessity. Photo courtesy of National Oceanic and Atmospheric Administration.

activity and nearly 238,000 jobs in the region.[3] Moving cargo via ship is 59 percent more fuel-efficient than rail and 773 percent more fuel-efficient than trucks.[4] The environmental community should—and increasingly does—support many aspects of commercial navigation because these economic contributions lead to environmental contributions in the form of reduced greenhouse gas emissions that exacerbate climate change, among other benefits. And, climate change contributes to less predictable lake levels, which are not in the interest of commercial navigation, but that is a topic for a different article.

The opposite is true, too. When the Great Lakes navigation system is inefficient, it can erode economic productivity. The risk of inefficiency is often highest at the system's chokepoints, such as the locks at Sault Ste. Marie (the Soo). According to the Lake Carriers' Association:

> *Had the Poe Lock [in the Soo] been unable to reopen for an extended period after its winter maintenance program, the impacts of COVID-19 on the North American supply chain would have been accelerated and even more devastating. The Midwestern steel manufacturing plants would not have been able to resupply their iron ore stockpiles. Blast furnaces would have been banked. Automobile and heavy manufacturing's raw material supply would be in jeopardy.*[5]

We need a safe, efficient Great Lakes navigation system because we all have a stake in the region's economic health.

Purlieu

Purlieu comes from the French language meaning "surrounding area." A healthy environment is in the best interest of the entire region and, in many ways, the ultimate policy goal. It touches all other policy imperatives as a key ingredient for advancing the region's overall interests. A healthy environment is tied to a healthy economy.

Over the past 150 years, the Great Lakes—and the health of all of us who depend on them—have been besieged. The culprits are industrial chemicals, habitat loss, invasive species that unravel the delicate food web, climate change that whipsaws lake levels and wreaks coastal damage, and pollution from agricultural, as well as other land uses.

For example, invasive species have entered the Great Lakes through the pet trade and aquaculture, as exotic species are intentionally imported into the country. They have entered through the ballast tanks of oceangoing freighters and through artificially connecting channels. Along the way, the ecological and economic consequences have rippled throughout various economic sectors, including the devastation of local sport fisheries and increased costs to utilities to keep their cooling and

drinking water intakes free of barnacle-like quagga and zebra mussels.

Additionally, sediment from upstream land disturbances can suffocate tributary spawning beds for fisheries. Sedimentation indicates the loss of top soil invaluable to farming and also means the loss of water quality upon which all of life—not just ours as humans—depends.

Public Health and Safety

Public health and safety will always be a public policy imperative; it is the central reason for the government's existence. Pollution is one way public health and safety is compromised, and it is not just the kind of pollution that comes from a smokestack or discharge pipe. Sedimentation not only puts environmental health at risk, it puts public safety at risk as it washes downstream to clog recreational and commercial navigation routes, especially during periods of low lake levels. It is also expensive to deal with, which undermines economic productivity.

Similarly, fertilizers run off land into the Great Lakes, sometimes with devastating public health results. For instance, fertilizers moving downstream from farmland into the Ohio's Maumee River through Toledo and into Lake Erie incubates *microcystis*. A form of cyanobacteria, excessive levels of *microcystis*—such as those generated by fertilizers—contribute to *microcystin*, which can cause liver and neurological damage in people. It is also a potential carcinogen.

Pecuniary

We could go on with other public policy needs, but let us leave it at economic, environmental, and public health.

Linking public policy imperatives and advancing them together will have a positive pecuniary, or financial, impact. For example, the U.S. Army Corps of Engineers (USACE) spends roughly $20 million annually for dredging and dredged material management around the Great Lakes.[6] And those are just annual costs. There are also backlog costs. The Great Lakes are experiencing decades of deferred maintenance when it comes to ridding the region's rivers, harbors, and ports of excess

Commercial vessels like *Marsgracht* are common sites on the Great Lakes as they carry goods to ports around the Great Lakes system. Moving goods via ship is 773 percent more fuel-efficient than doing so via truck, and nearly 60 percent more fuel-efficient than moving them by rail. Photo courtesy of Duluth Seaway Port Authority

On June 17, 2018, northern Michigan and parts of Wisconsin received torrential rains. The flooding caused historical property damage and brought river discharge levels well above their averages, sending sediment runoff into Lake Superior. Two days later, the resulting runoff near Duluth, Minnesota, was visible from the International Space Station. Photo courtesy of NASA

sediment. According to the American Great Lakes Ports Association, the U.S. Great Lakes have nearly $1 billion in backlogged dredging needs.[7] This does not even account for the time, money, and effort by navigation stakeholders to advocate for these public policy needs.

What if we did not have to spend that much each year for clearing harbors, rivers, and ports? What if we could minimize sedimentation, toxic bacteria, and other runoff-based threats to our health, environment, and economy?

Funding (also pecuniary) programs exist that can help. The Great Lakes Restoration Initiative (Initiative) is one example of a federal funding program that is investing in reducing ecosystem health risks while addressing safer navigation, public health, and other public policy needs. Established by President Barack Obama in 2009, the program has invested more than $3 billion for ecosystem restoration since its inception. Prioritizing five "focus areas," the Initiative supports efforts to tackle toxic hotspot cleanups, invasive species, runoff reduction and coastal health, habitat recovery, and "foundations for future restoration action." The latter focus area supports science-based adaptive management—adjusting work as needed to implement goals—communications, outreach, and partnerships, among others.[8]

The Initiative has invested in projects that promote environmental health, economic vibrancy, public health and safety, and other critical regional needs. It does so by identifying and preventing damage before it occurs, in addition to fixing historic threats. Prevention is worth more, and is less costly, than remediation.

Prevention

We save even more money advancing several public policy needs at a time when we minimize the prospect of harm in the first place.

Recognizing that sedimentation is as preventable as its impacts are expensive to fix, the USACE has used the Great Lakes Tributary Model to estimate sediment loads to the lakes from tributaries. The program, unfortunately, has had difficulty getting funding since 2017, but that does not detract from the need. The modeling capabilities exist and are invaluable for understanding where sedimentation prevention can be most cost-effective.[9]

The USACE's Great Lakes Tributary Model was not the only mechanism that can support work to mitigate multiple problems at once. It was also not the only program that has invested less up front to prevent damage than what it invested later to fix damage.

Another instance of Initiative dollars working to

The barge *Double Skin* and tugboat *New York* transit the Black Rock Lock in Buffalo, New York, on April 25, 2022. The barge was the first major vessel of the commercial shipping season to transit the lock, which provides the only means for deep draft commercial vessels on the Great Lakes to reach delivery ports on the upper Niagara River. Photo by Avery Schneider

prevent Great Lakes problems occurred when the U.S. Fish & Wildlife Service (USFWS) recently took an unusual, if not unprecedented, action. Coupling funds from the Initiative with its invasive species management powers granted under a law called the Lacey Act, the USFWS identified 11 species that could get into the Great Lakes but had not yet done so to the best of the agency's knowledge. The prevention-oriented listing also used climate change forecasts[10] to estimate that the Great Lakes could become more hospitable to these potential invaders, information that reinforced the need to prevent their entry into the ecosystems. In listing the 11 species, the USFWS summarily made their entry into the country illegal.[11] This was a significant departure from previous Lacey Act listings that limited the spread of invasive species after they had already entered and started damaging U.S. ecosystems.

The work being done to keep some forms of invasive carp from entering the Great Lakes is another example of preventative measures to reduce public safety and ecological health risks. Intentionally introduced in the 1960s to reduce algae in Mississippi River basin aquaculture ponds, the federal government had little way of knowing these fish would escape and jeopardize the Great Lakes. However, that is exactly what happened with silver and bighead carp. Today, they have been heading toward Lake Michigan through the Illinois and Chicago River systems. Silver carp in particular, irritated by the underwater whining of outboard and other engines, try to escape these sounds by jumping out of the water. The result is fish that, while airborne, have been known to break noses and otherwise injure people using personal watercraft.

A hospital visit after a silver carp collision is serious and expensive for individuals. Invasive carp entering the Great Lakes and reproducing risks the viability of the U.S.'s $7 billion Great Lakes sport fishery. Fortunately, thanks to millions of dollars in state and federal investments, partner agencies as part of the Invasive Carp Regional Coordinating Committee[12] have kept a critical mass of the fish from escaping into the lakes and reduced the probability of more public injuries. The Initiative has invested tens of millions of dollars toward thinning carp populations in the Illinois River and engineering blockades of other artificially connecting channels, including Indiana's Wabash River, as it connects the Mississippi River watershed to Lake Erie during wet floods.[13]

Going forward, Initiative dollars also should be invested to enhance coastal resilience infrastructure, the projects that protect the public from shoreline damage while enhancing healthy coastal ecosystems. Additionally, the funds should be invested in expediting cleanups, supporting disproportionately impacted communities, restoring habitat, and reducing runoff.

Participation

With strong participation in public policy decision making by stakeholders across the societal spectrum, we can harmonize and implement these mutually reinforcing needs.

It used to be that the navigation sector's advocacy flowed in one direction, toward its own self-interests.

Environmental and economic development interests also worked on their own priorities in isolation. A multitude of other stakeholders went their own ways, sometimes acting in a vacuum and sometimes working on overlapping priorities with other stakeholders as it suited them. The result was that decision makers, typically legislators, had to determine the winners and losers, and legislators do not like to do that.

Today, the varied stakeholders of the Great Lakes are much more likely to find ways to reinforce one another, flowing in a similar, if not identical, direction toward the best interests of the region and its needs. That is not to say stakeholders do not work to advance their own priorities. However, collaboration is much more likely today because stakeholders take a wider view of what "self-interest" means. If the region's economy thrives, for instance, the tax base is much more able to make environmental protection a priority. And, when environmental protection is strong, or at least stable, it makes the region attractive for jobs, quality of life, and other factors that underpin a strong regional economy. It means we are more likely to achieve environmental justice and make sure no community is shouldering disproportionate health risks.

A turning point in regional stakeholders' ability to work together came in 2005, when the federal government, cities, states, and tribes of the Great Lakes convened more than 1,500 stakeholders to develop the Great Lakes Regional Collaboration.[14] It proved that fishery managers could help water quality advocates; science managers could work alongside foresters; and leaders from other disciplines could work together.

That effort gave rise to the Great Lakes Restoration Initiative, which has drawn support from such previously disparate and credible stakeholders as the American Great Lakes Ports Association,[15] Healing Our Waters Great Lakes Coalition,[16] Great Lakes Metro Chambers of Commerce,[17] and the Great Lakes states through the Great Lakes Commission.[18] Municipalities, through the Great Lakes and St. Lawrence Cities Initiative and others, advocated for bipartisan Congressional support of the Initiative even at a time when President Trump was calling for its virtual elimination.[19] Tribes from across the region have benefited from the Initiative's funding for their habitat, public health, and other projects, too.[20]

Conclusion

The seven Ps are the magic recipe: pecuniary investment efforts can prevent harm to productivity, purlieu (environmental), and public health policy through participation.

We live in an era when it seems harder than ever to get things done, which is all the more reason to squeeze more out of our efforts, like achieving the aforementioned public policy imperatives, and others. To do that, collaboration with stakeholders, who might have been imagined as opponents in the past, must be considered.

About the author:

Cameron Davis served as the federal government's "Great Lakes Czar," coordinating the work of 11 federal departments, including the U.S. Department of Homeland Security, to invest more than $2 billion for Great Lakes restoration. He is a former University of Michigan law professor and CEO of the Alliance for the Great Lakes. Today he also serves as an elected commissioner at the Metropolitan Water Reclamation District of Greater Chicago and is a small-scale farmer.

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Aquatic Nuisance Species Invasion in the Great Lakes

by Erika Jensen
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The Great Lakes have been subject to the invasion of nonnative aquatic species since early settlement of the region. Nonnative aquatic species arrive via direct or indirect pathways, including ballast water discharge, canals and waterways, transport via recreational boating equipment, escape from aquaculture facilities and water gardens, releases of aquarium plants and pets, and the live bait trade. There are 189 nonindigenous aquatic species documented in the Great Lakes, many of which are invasive and cause damage to the ecosystem and economy.

Be it zebra mussels fouling commercial and industrial infrastructure, the ongoing toll the parasitic sea lamprey is taking on important fish species, or the alteration of food webs by the quagga mussel, the damage from these nonnative species can be substantial. The estimated cost to the region is hundreds of millions of dollars annually.[1] The threat of new invasions, such as invasive carp, also continues. New nonnative species could cause further harm to the $7 billion a year sport fishing industry, and human health is also at risk through increased harmful algal blooms and the threat of new invasive pathogens and diseases. In response, the Great Lakes region has invested considerable time, expertise, and financial resources to address the ongoing costs and the threat of future damage caused by aquatic invasive species (AIS).

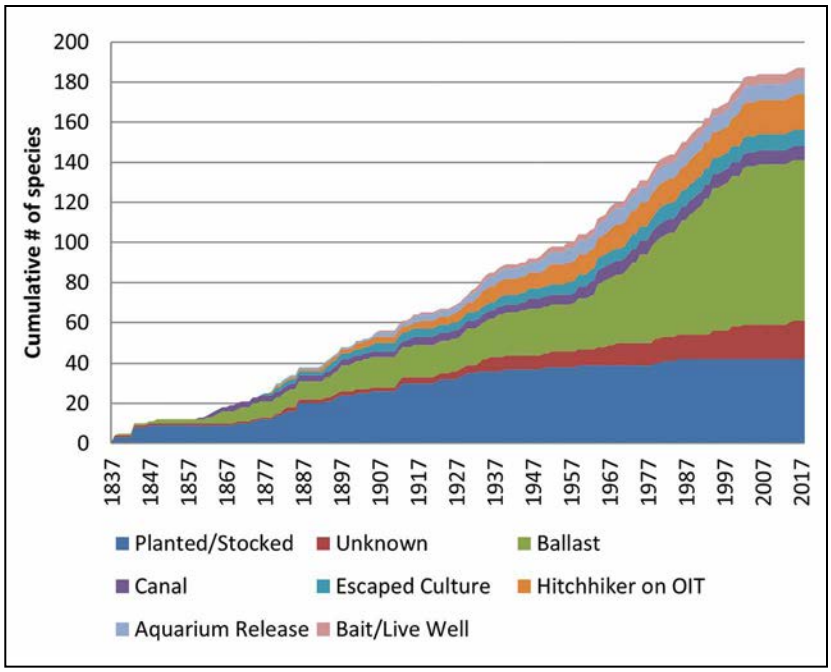
Pathways of invasion

Historically, one of the most significant pathways of introduction for these species has been ballast water discharged from vessels using the Great Lakes and St. Lawrence River. Scientific literature indicates that 85 nonnative species have been introduced to the Great Lakes through the shipping pathway,[2] including the zebra and quagga mussels, and fish like the Eurasian ruffe and round goby. The ruffe[3] and round goby[4] are documented threats to native fish species, while the zebra and quagga mussels are having significant impact on the Great Lakes' complex food web.[5]

The extensive canal and waterway system in the region, while used beneficially as a transportation corridor for commercial and recreational activities, establishes connections between watersheds and provides pathways for aquatic species movement. One of the first known AIS to have had a significant negative impact on the Great Lakes—the sea lamprey—was introduced via these waterways. The Chicago Sanitary and Ship Canal, an engineered waterway that connects the Mississippi River and Great Lakes watersheds, provides a cross-basin pathway for AIS like the round goby. There is currently significant concern about the northward migration of certain invasive carp species through the Chicago waterway system.

Nonnative aquatic species marketed for commercial purposes are referred to as organisms in trade or OIT.

Invasion Rate of Nonnative Species



Courtesy of the National Oceanic and Atmospheric Administration

Examples include baitfish, live food fish, stocked fish, and aquatic plants and animals sold in the aquarium, pet, and water gardening trade. OIT may be introduced for beneficial uses, but over time, some imported plant and animal species establish wild populations, causing harmful impacts. A 2005 study of the invasion risk that the aquarium and live food trade pose to the Great Lakes found a variety of nonindigenous species were available in the marketplace.[6] These species included the invasive bighead and grass carp, which are the target of large-scale prevention and control efforts. The live organism trade has also been linked to the escape of some of the most problematic aquatic weeds in the United States, including Brazilian elodea and hydrilla. Nonnative aquatic weeds in the United States are estimated to cause $10 million in losses and damages and $100 million in control costs each year.[7]

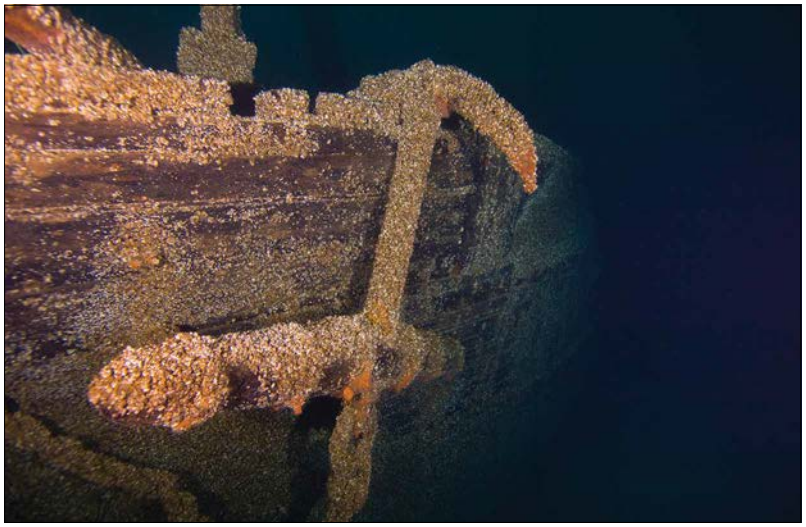
Boats and related vehicles used for recreational purposes on or near water bodies may also pose a risk of introducing or spreading unwanted AIS. These vehicles may transport unwanted organisms entwined with propellers or trailers, as hitchhikers in standing water within the watercraft, or encased in mud on tires or surfaces. Once a nonnative species is introduced, it can easily move around to new bodies of water through watercrafts or other equipment and expand its invasion range. The movement of recreational boats and equipment is the primary culprit in the westward expansion of zebra and quagga mussels from the Great Lakes to waterbodies in the western United States. It is also implicated in the movement of the New Zealand mudsnail, a tiny snail that forms dense colonies and competes with other native species.

Strategies to Combat Aquatic Invasions

The process for a nonnative species to invade a new ecosystem offers several points of intervention for those attempting to mitigate potentially harmful impacts of an invasion or prevent new invasions from occurring. The first is to take steps to prevent the arrival of a new species entirely. Preventing the introduction of new nonnative species is the most cost-effective approach to minimizing potential costs and damages of AIS. Prevention strategies include the adoption and enforcement of policies and regulations targeting specific pathways and species; outreach and education to change the behaviors of individuals or industries that facilitate species introductions; and adoption of voluntary best practices to further minimize risk. These strategies are intended to reduce the risk of uptake, movement, and introduction of nonnative species, and may be applied to any of the pathways that introduce AIS into the Great Lakes basin.

For example, ballast water regulatory regimes designed to prevent the introduction and spread of AIS are being implemented at the international, national, and state levels. Internationally, the regulatory regime is the International Maritime Organization (IMO) Ballast Water Management Convention. In the United States, both the Coast Guard and the Environmental Protection Agency

First discovered in Lake St. Clair in 1990, the invasive round goby is thought to have been introduced to the Great Lakes in the ballast water of ocean-going vessels and have since spread to all of the Lakes. Photo courtesy of U.S. Fish and Wildlife Service



The schooner *Kyle Spangler* sank in 1860 in what is now Thunder Bay National Marine Sanctuary off the coast of Michigan in Lake Huron. Taken in 2008, this photo shows the wreck almost completely encrusted with invasive quagga mussels. Zebra mussels may be the more famous Great Lakes invader, but quaggas present an equally serious threat. Photo courtesy of National Oceanic and Atmospheric Administration

The Invasion of Zebra and Quagga Mussels

Zebra and quagga mussels, are perhaps the greatest examples of Great Lakes aquatic invaders after the sea lamprey. These tiny mussels shut down drinking water systems and foul beaches used for recreation, fundamentally changing the Great Lakes ecosystem. Great Lakes regional involvement in AIS issues gained focus and targeted investment following the introduction and spread of zebra mussels in the Great Lakes region.

Zebra and quagga mussels are native to the Baltic region and were transported here in the ballast water of ocean-going ships. First discovered in Lake St. Clair in 1986, zebra mussels were present in all five Great Lakes by 1989. As they spread, the mussels colonized lake bottoms, infrastructure, recreational, and industrial equipment; clogged intake pipes at water treatment and power plants and within boat engines' cooling systems; and began to dramatically alter the Great Lakes food web. It was their rapid spread and devastating impacts that led the U.S. Congress to pass legislation addressing AIS on a national level by way of the Nonindigenous Aquatic Nuisance Prevention and Control Act. This legislation laid the groundwork for many of the programs supporting AIS prevention and control on a state, regional, and federal level that are in place today.

Native to the Baltic region, Zebra mussels traveled to the Great Lakes via the ballast water of ocean-going ships. This invasive species, along with the quagga mussel, have fundamentally changed the Great Lakes ecosystem, not only colonizing the lake bottoms, but fouling infrastructure and recreational beaches, and wreaking havoc with industrial equipment. Photo courtesy of Michigan Sea Grant

Quagga mussels, a relative of zebra mussels, followed a similar, though slightly slower, trajectory. The quagga mussel was first identified in the Great Lakes in September 1989, when one was found near Port Colborne, Lake Erie. Shortly after, they were found in three other Great Lakes. By 2005, Lake Superior's Duluth-Superior Harbor had its first confirmed quagga mussel.

Over the years, much as been learned about these species and their impacts. They change the amount of phytoplankton in the water, increasing water clarity but reducing availability of plankton, a food source for other species. They change the ecological structure of lake communities, and concentrate contaminants within their tissues, increasing the exposure of wildlife to these contaminants. But one of the direct ecological impacts is the threat to native mussel populations, as they attach to the native species and colonize their shells preventing native species from moving, feeding, and breeding, and eventually killing them.

Despite all that has been learned, researchers and managers are still working to better understand these invasive mussels' role in the Great Lakes ecosystem. This understanding is complicated by the mussels' interactions with other factors impacting the food web and productivity of the lakes, including the subsequent invasion of the round goby and changes in nutrient concentrations. Along with investing in scientific research, significant investments have been made in education and outreach programs. Boaters, anglers, and other water users are encouraged to clean, drain, and dry their equipment so that they are less likely to unintentionally aid the migration of zebra and quagga mussels. Agencies and private industry have also invested in developing and implementing policies, practices, and technologies designed to prevent introduction and spread from shipping and recreational activities.

Thirty years after they first arrived, researchers are still developing effective tools to control and eradicate these invasive mussels. Recent advancements in the development of species-specific control methods, such Zequanox™,[1] and the possibilities of genetic biocontrol,[2] are generating renewed interest in management and control of zebra and quagga mussels. Government and nongovernment partners are working together through the Invasive Mussel Collaborative to further investigate and coordinate efforts to develop scientifically sound methods for invasive mussel control that, if implemented effectively and with care, will provide measurable ecological and economic benefits. Using a collaboration-based model, this group is working together to facilitate information-sharing, set priorities, and provide tools that will help advance research and management projects, as well as encourage and inspire collaboration on invasive mussel management.

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regulate ballast water discharges at the federal level. In addition, states have the responsibility and authority, pursuant to state laws and the Clean Water Act, to protect their waters and water-dependent resources through programs to manage ballast water and ensure compliance with state water quality standards. The dramatic reduction in the number of new introductions of organisms via this pathway since 2007, when ballast water exchange and flushing requirements for vessels entering the St. Lawrence Seaway were established, demonstrates the success of these policies.

The second opportunity for intervention is to detect species soon after they arrive in a new area and take steps to prevent their establishment and movement. Monitoring and response programs allow for the early detection of new, nonnative species while populations are still localized, and implementation of actions in response to these findings. Early detection increases the likelihood that response efforts to contain, control, and ideally eradicate new populations will be effective. Previous experience has shown that once new invasive species are established, our ability to manage and/or eradicate their populations diminishes considerably, and is often expensive. The Great Lakes' states and provinces worked together to establish a regional early detection and response protocol, designed to support coordination and information sharing for these activities. A mutual aid agreement between the states and provinces establishing a mechanism for sharing of staff, expertise, and resources between jurisdictions in the event of an AIS invasion also supports regional response efforts.

When prevention and early response efforts fail and a new nonnative species establishes itself, agencies, landowners, and other partners may decide to take action to manage species populations to reduce their negative impacts. For more than 60 years, the Great Lakes Fishery Commission has implemented a successful control program for the parasitic sea lamprey. An individual sea lamprey may destroy more than 40 pounds of fish during a 12–18 month period. They attach themselves to the body of fish with their mouth and use their rasping tongue to drill through the host's body, feeding on the fish's body fluids. The sea lamprey control program reduces sea lamprey populations by more than 90 percent annually in most areas. Control techniques include lampricides, barriers, traps, and the release of pheromones to increase the efficacy of the other control techniques. While the sea lamprey program is representative of a successful control effort, management and control strategies for harmful species are often limited and cost prohibitive to implement.

Also critical to preventing and slowing the spread of AIS at local, state, regional, and national levels, are successful communication, outreach, and education

Sea lampreys, a parasitic fish native to the Atlantic Ocean, were introduced to the Great Lakes via canal and waterway systems connecting watersheds. The invasive sea lamprey attaches itself to a beneficial fish, like the salmon shown here, killing its host. One sea lamprey can kill up to 40 pounds of fish in its 12–18 month feeding period. Great Lakes Fishery Commission photo by M. Gaden

strategies. Outreach campaigns and programs promote actions that prevent risks of AIS introduction and spread among public and private users. Campaigns and programs that encourage the adoption of preventative practices are fundamental to establishing long-term protection from the harmful impacts caused by aquatic invasions in the Great Lakes and beyond.

For example, watercraft inspection and decontamination is a strategy focused on prevention and education of the public on AIS issues. With more than 4 million registered boats in the Great Lakes region, boaters, anglers, and other recreational users can make a big difference by cleaning off plants, animals, and mud before leaving accesses; draining water from boats and other equipment; and disposing of unwanted bait in the trash, not in the water. Through either mandatory or voluntary watercraft inspections, agencies and volunteers can educate boaters and anglers about the threat of AIS, reduce the spread of potential invaders, and instill a sense of stewardship to protect the natural resources boaters and anglers enjoy.

While progress has been made, there are a number of persistent and complex problems that still need to be addressed. Pathways like recreational activities and organisms in trade remain a diffuse and widespread threat for introducing and spreading harmful AIS. Myriad outreach programs and activities are being implemented targeting a wide variety of audiences to encourage behaviors that will minimize the potential introduction and spread of AIS. Also, ongoing investments are being made in the research community to develop improved detection, monitoring, response, and control technologies. Federal, state, and local agencies continue to pursue opportunities to strengthen,

coordinate, and enforce AIS polices and regulations, using a coordinated and collaborative approach to ensure effectiveness and efficiency.

Coordinating Federal and Regional Action on Invasive Species

Prompted largely by damage caused by invasive zebra mussels, Congress enacted the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) in 1990. NANPCA created a framework for federal and regional coordination of AIS programs and activities through the Aquatic Nuisance Species Task Force (ANSTF) and six regional panels. The ANSTF, an interagency committee comprising 13 federal agencies and 13 ex-officio members, including the U.S. Coast Guard, is charged with implementing NANPCA. Co-chaired by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration, the task force works together, and with outside partners, to protect U.S. waters by creating a coordinated network that raises awareness and takes action to prevent and manage AIS.

The Great Lakes Panel on Aquatic Nuisance Species (GLP), one of six regional panels convened under the ANSTF, has worked for more than two decades to advance AIS prevention and control through regional coordination. The geographic scale of the region is one of the most significant challenges in preventing new AIS invasions in the Great Lakes. Consistent and coordinated action across all Great Lakes states and provinces is essential to preventing new species invasions, containing established AIS, and mitigating existing damage.

The GLP coordinates education, research, management, and policy efforts to prevent new AIS from entering the basin and to control and mitigate those invasive populations already established. Administered by the Great Lakes Commission, the GLP and its membership includes government agencies in both the U.S. and Canada, as well as academic, tribal, regional, nongovernmental, and private sector stakeholders. Its initiatives are developed and implemented to address priority AIS problems and their negative impacts on the ecological and economic resources of the region.

NANPCA also encourages states to develop and implement state-specific management plans on AIS prevention and control. These plans focus on prevention strategies and early detection and response for new invasions, and control of existing infestations. Each of the eight Great Lakes states has an established state management plan that identifies its specific goals, objectives, and actions for managing AIS within their borders. These plans also indicate mechanisms for coordinating with other states, agencies, and nongovernmental partners to increase the effectiveness of their activities.

Prevention and control of aquatic invasions is fundamental to protecting the Great Lakes—the world's largest freshwater ecosystem—and sustaining the economic health of the communities that depend on healthy lakes. This is made more challenging by the expansion of global trade, changes in human populations, land use, and climate, which present ongoing risks for AIS introduction and spread. Over the past two centuries, many AIS threats have emerged, and individuals, organizations, and government agencies ranging from local to federal have stepped up to take on these challenges. The threat is still present but, by working together, we can protect the Great Lakes' ecosystem and economy from AIS.

For more information

To learn about invasive species of the Great Lakes, go to www.glerl.noaa.gov/glansis/index.html

About the author:

Erika Jensen was appointed executive director of the Great Lakes Commission in July 2021. In this role, she directs operations, manages relations with the Commission's Board of Directors and Commissioners, oversees policy and advocacy efforts, and collaborates with the agency's numerous partners to advance strategic regional priorities, among other duties. Ms. Jensen has been a member of the Commission staff in various roles since 2006. She holds a bachelor's degree from Michigan State University, and a master's degree in environmental management from Duke University

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Understanding Great Lakes Water Level Fluctuations and the Need for Coastal Resiliency

by Keith Kompoltowicz
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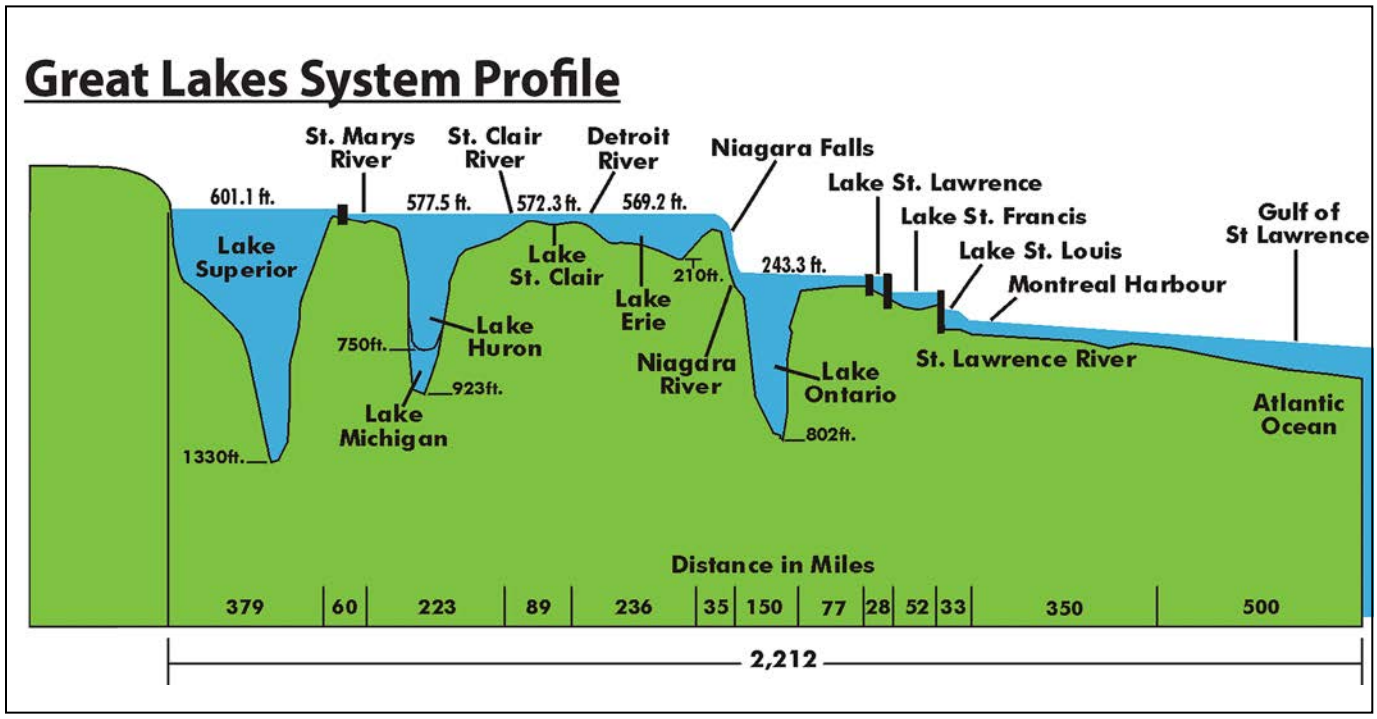
A natural wonder, the Great Lakes system is an important source of commerce and recreation, both of which are impacted by fluctuating water levels. These fluctuations are primarily driven by the natural hydrologic cycle.

Profile of the Great Lakes

The Great Lakes and St. Lawrence River comprise a dynamic system with a basin that covers more than 94,000 square miles of water spanning part or all of eight U.S. states and two Canadian provinces. The profile of the system can be depicted as a series of steps leading from Lake Superior at the headwaters down to the Atlantic Ocean. The St. Marys River flows from Lake Superior to Lake Huron. Lakes Michigan and Huron are connected by the broad, deep Straits of Mackinac and are hydraulically considered one lake, with levels rising and falling together. The St. Clair and Detroit rivers, with Lake St. Clair in between, connect Lake Huron with Lake Erie. The Niagara River then links Lake Erie with Lake Ontario, including the dramatic drop over Niagara Falls. The manmade Welland Canal also links Lakes Erie and Ontario, providing a detour around the Falls. From Lake Ontario, water flows into the St. Lawrence River, which converges with the Ottawa River and flows on to the Atlantic Ocean.

Since the retreat of the glaciers, water levels have undergone dramatic fluctuations by as much as hundreds of feet. One hundred and four years of international records noting monthly water levels of the Great Lakes show water level ranges of 4 to 6 feet from record low to record high, depending on the lake. On a seasonal



U.S. Army Corps of Engineers, Detroit District

basis, the lakes average a 12- to 16-inch fluctuation.

After hitting record and near-record low water levels in 2012 and early 2013, an extremely wet spring caused the water levels of all of the Great Lakes to rise significantly. In 2014, lakes St. Clair, Erie, and Ontario saw significant rise in water level, while lakes Superior, Michigan, and Huron rose above their respective long-term average (LTA) levels for the first time in more than a decade.

Wet conditions continued, pushing water levels to record highs in 2019 and 2020, though drier conditions since have allowed levels to decline. Despite this decline, Lake Superior is currently very near its long-term average, and the other lakes, including Lake St. Clair, remain above their respective long-term averages.

Hydrologic Drivers

The Great Lakes are in a multiyear stretch of nearly continuous above average water levels. Forecasted water levels for May through October are displayed in Figure 1, along with 2021 and 2022 conditions.

Hydrologic conditions are the primary driver of Great Lakes water level changes. Precipitation, generally high between 2013 and 2019, caused a substantial rise in the Great Lakes' water levels. NOAA's National Centers for Environmental Information estimated that the total precipitation in the U.S. portion of the Great Lakes basin from 2015–2019 was the highest five-year total since 1895.

Drier weather in 2021 caused lakes Superior and Ontario to experience portions of the year below long-term average levels. The last time Lake Superior's water level was below LTA was in spring 2014. For Lake Ontario, the last time the water was below LTA levels was fall 2018. Conditions varied throughout the Great Lakes basin in 2021, with the first half of the year experiencing drier conditions. Accordingly, the lakes experienced a greater than average seasonal decline and a less than average seasonal rise.

However, conditions transitioned from generally dry to generally wet in the lakes Michigan, Huron, St. Clair, Erie, and Ontario basins in the summer. The Lake Superior basin continued to experience drier than normal conditions and water levels eventually fell below LTA levels.

Weather's Influence

Weather patterns have a direct influence on the Great Lakes' levels. Moisture is carried into the basin by continental air masses originating in the northern Pacific Ocean; tropical systems originating in the Gulf of Mexico; and Arctic systems originating in the far north. As these weather systems move through the region, they deposit moisture in the form of rain, snow, hail, or sleet. Water also enters the lakes through runoff from surrounding land, groundwater inflow, as well as inflow from upstream lakes. Conversely, water leaves the lakes through evaporation, groundwater outflow, consumptive use, diversions, and outflows to downstream lakes or rivers. Evaporation is the biggest factor during the fall and early winter as cool, dry air moves over the relatively warm lake surfaces. (See Figures 2 and 3).

Lasting a couple of hours to several days, winds and changes in the barometric pressure can cause short-term water level fluctuations. Seasonally, the lakes fluctuate, with levels declining in the winter months due to evaporation and snow accumulation and rising in the spring due to snowmelt and rains. The water levels peak in the summer, when more water enters than leaves the lakes. Long-term fluctuations occur over periods of consecutive years.

Geomorphological Influences

Crustal movement, the rebounding of the earth's crust from the removed weight of the glaciers, does not change the amount of water in a lake, but rather the water depths along the shoreline.

Rebound rates vary across the Great Lakes basin, with the crust rising at the highest rate in the northern portion of the basin, where the ice was thickest, heaviest, and last to retreat. In the southern portion of the basin, rebound rates are much slower.

Controlling the Lakes

There are five diversions in the Great Lakes basin. The Long Lac and Ogoki diversions bring water into Lake Superior from the Hudson Bay watershed. The Lake Michigan Diversion at Chicago removes water from Lake Michigan for water supply, sewage disposal, and commercial navigation. The Welland Canal provides a shipping route around Niagara Falls and moves water that would have naturally flowed into Lake Erie down the

Seasonal Declines and Rises in 2020–2021

Lake	Seasonal Decline	Seasonal Rise	Average
Superior	15"	6"	12"
Michigan and Huron	21"	4"	12"
St. Clair	22"	10"	16"
Erie	21"	9"	14"
Ontario	34"	14"	21"

Seasonal declines calculated from seasonal peak in 2020 to seasonal low in 2021. Rises calculated from seasonal low to seasonal peak in 2021, based on monthly mean water levels. Average is range from seasonal low to seasonal peak.

Figure 1

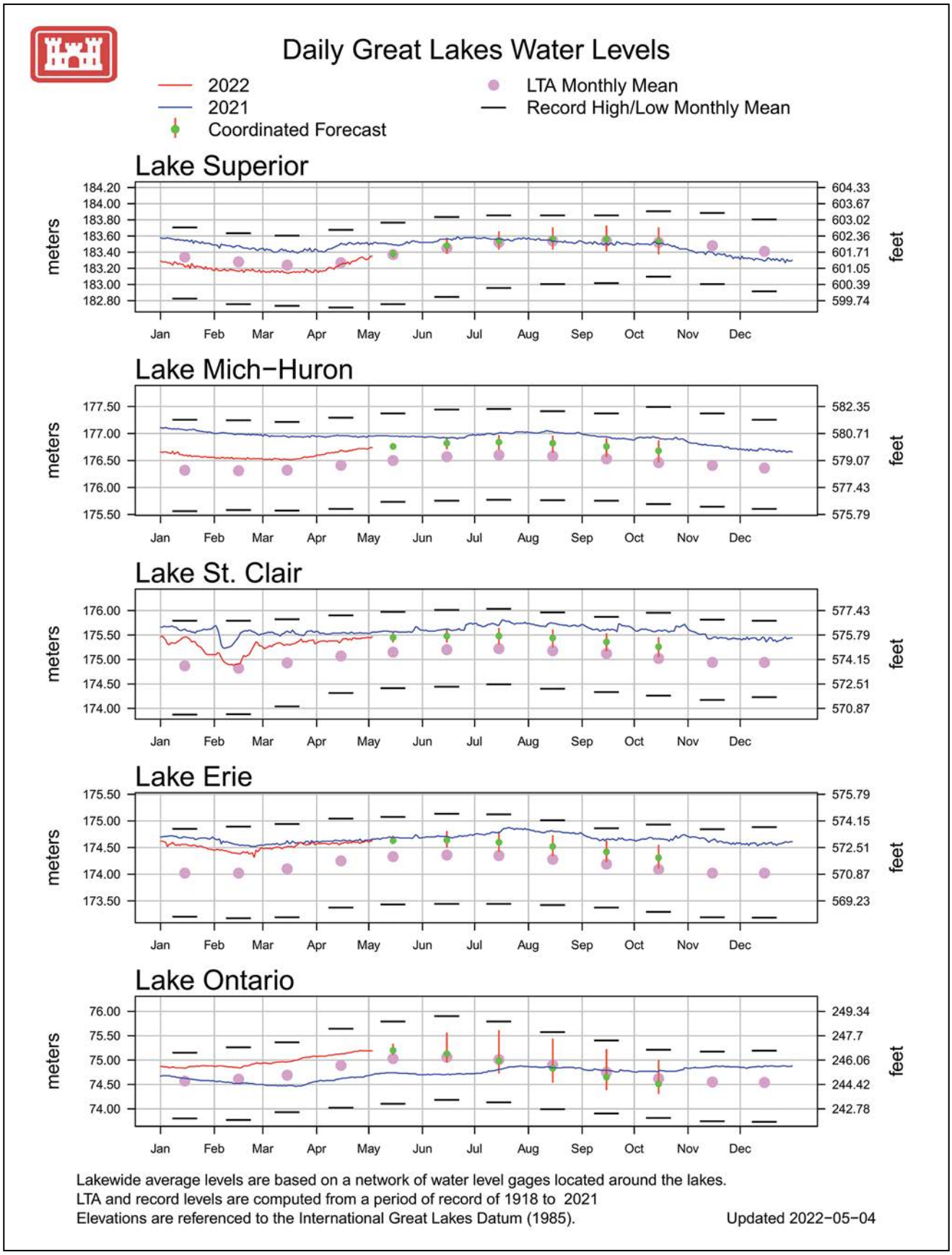


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Figure 2

The Great Lakes monthly precipitation values for 2013 to 2021 as compared to their monthly averages (2019 to 2021 data are provisional).

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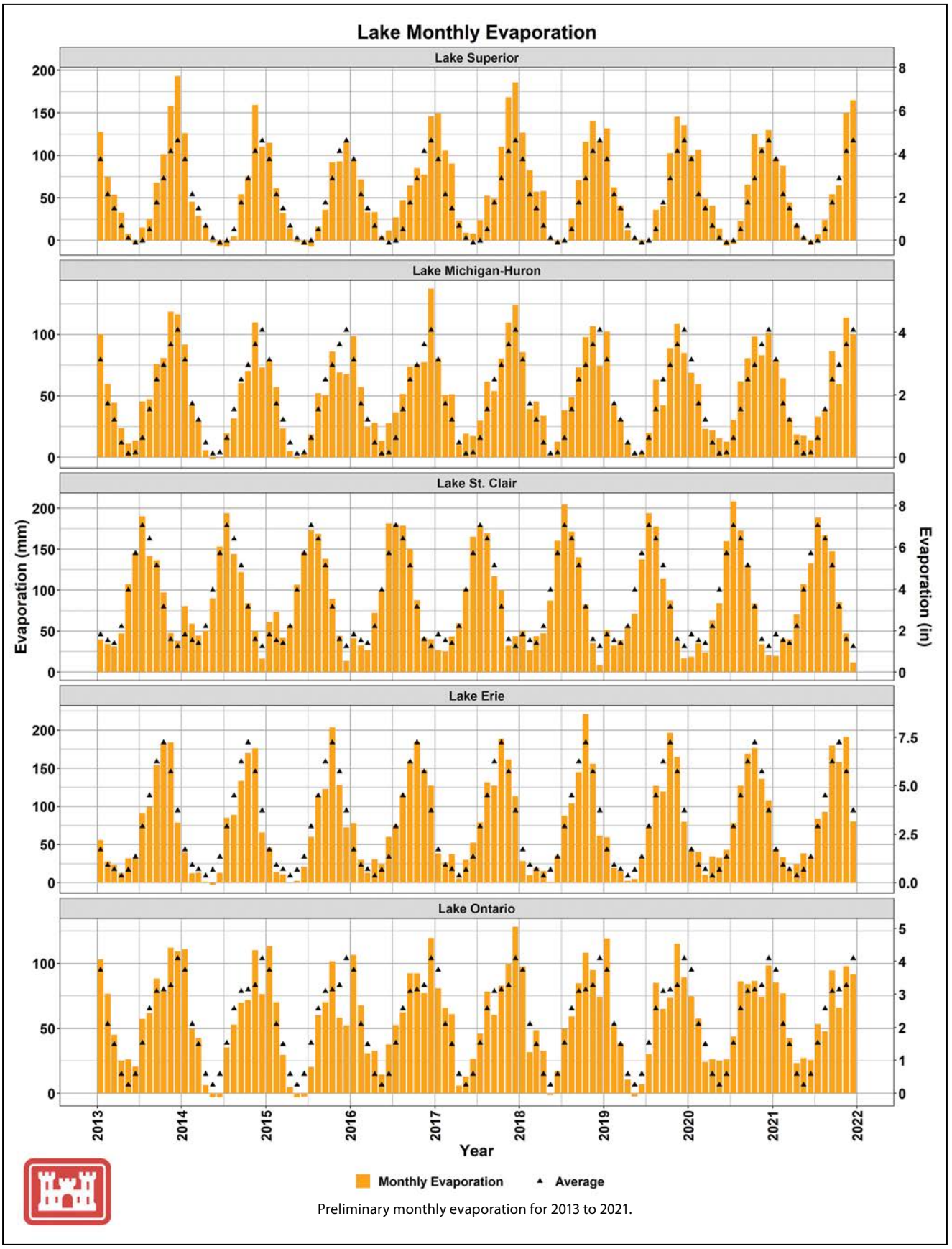
Figure 3



Preliminary monthly evaporation for 2013 to 2021.

U.S. Army Corps of Engineers, Detroit District

Niagara River to Lake Ontario. The New York State Canal System also diverts a small amount of water from the Niagara River, ultimately returning it to Lake Ontario.

In all, the net amount of water diverted into the Great Lakes basin exceeds that diverted out.

Lake Superior outflows are regulated near the twin cities of Sault Ste. Marie, Michigan, and Ontario, with the current control facilities consisting of three hydropower plants, five navigation locks, and a 16-gate control structure called the compensating works. The International Lake Superior Board of Control has regulated the lake's outflows since 1921 in accordance with conditions specified by the International Joint Commission (IJC). Outflows are adjusted monthly, taking into consideration the water levels of lakes Superior, Michigan, and Huron. The objective is to help keep the lakes in relative balance compared to their long-term seasonal averages. Regulation of Lake Superior's outflow has an effect on water levels, but to a far lesser extent than natural factors.

The IJC, a binational U.S.-Canadian agency, is responsible for oversight of the terms of the 1909 Boundary Waters Treaty between the two nations.

Lake Ontario outflows are regulated via the Moses-Saunders hydropower dam, which spans the St. Lawrence River near Massena, New York, and Cornwall, Ontario. Regulation has occurred since 1960 and the International Lake Ontario-St. Lawrence River Board, also established by the IJC, manages the process. The current regulation, Plan 2014, was implemented in 2017 and specifies weekly outflows based on Lake Ontario's water level, the water supplies to the lake, and conditions upstream and downstream on the river. The plan has a number of flow limitations to protect various interests in the St. Lawrence River that extreme flows or levels may affect. These limits maintain adequate flows for hydropower production, minimum depths for municipal water intakes and navigation, and protection against flooding.

The St. Clair River

There have been numerous alterations, primarily in the form of dredging, made to the St. Clair River since the mid-1800s, mainly in support of commercial navigation, with the last major deepening completed in 1962. As a river is deepened by dredging or other means, its conveyance, or capacity to carry water, is increased. Studies by the IJC have determined that all the deepening in the St. Clair River lowered lakes Michigan and Huron water levels 10 to 16 inches. Commissioned by the IJC, the International Upper Great Lakes Study investigated changes in flows through the St. Clair River and possible drivers for changes in water level relationships between lakes Michigan, Huron, and Erie.

Coastal Resiliency

Recent events illustrate the region's vulnerability to widespread flooding and coastal erosion while underscoring the need for resiliency planning. Trends indicate events like these are likely to occur more frequently and with increased intensity in the future. Without intervention, aging infrastructure will eventually fail, increasing the damages caused by coastal stressors. Rather than waiting for disaster to occur before investing in sustainable solutions, The Great Lakes Coastal Resiliency Study (GLCRS) will provide national value as a proactive Great Lakes infrastructure investment strategy.

Leveraging previous work, this study will integrate and build upon substantial regional efforts like:

- NOAA's Digital Coast website
- the Environmental Protection Agency's Great Lakes Restoration Initiative
- the Federal Emergency Management Agency's Great Lakes Coastal Flood Study
- state coastal management plans and other partnerships funded through federal and state programs

The watershed study will engage additional stakeholders including regional and local governments, nongovernmental organizations, industry, and the public. The public encompasses about 4.2 million people living within 2 miles of a Great Lakes coast, and many more working and recreating in the region.

The Great Lakes Coastal Resiliency Study is envisioned as a collaborative regional effort between the eight Great Lakes states, U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration, U.S. Geological Survey, Federal Emergency Management Agency, and the Environmental Protection Agency.

Trends suggest coastal resources will be at greater risk from flooding, erosion, and accretion. This watershed study will investigate opportunities to improve

Coastal Resiliency is defined as the ability of coastal areas to withstand, recover from, and adapt to disturbances and underlying stress while maintaining economic, environmental, social, and cultural values. The Great Lakes Coastal Resiliency Study is a collaborative effort to investigate opportunities to improve resiliency within both the built and natural coastal environments. U.S. Army Corps of Engineers photo

resilience by identifying vulnerable coastal areas and possible actions to bolster their ability to withstand, recover from, and adapt to future hydrologic uncertainty with respect to the built and natural coastal environments. The study will provide design parameters to inform federal, state, and local agencies on sustainable coastal projects and establish a risk-informed decision framework to support the identification and prioritization of coastal investments. In doing so, it will help protect the immense economic, environmental, and social value of the Great Lakes shoreline.

Taking into account uncertainties associated with precipitation, temperature, lake levels, wind velocities, and wave/surge and ice conditions, the GLCRS will explore a range of potential future conditions. An assessment of these conditions will be used to classify and map the Great Lakes coast based on existing infrastructure, habitat, land use, and other data points. Vulnerability analyses will be performed based on the shoreline characteristics and the range of potential future conditions. A risk-based decision framework will assist coastal stakeholders in evaluating an array of structural, non-structural, natural, nature-based, institutional, and regulatory measures to address identified coastal vulnerabilities.

For more information

The International Joint Commission's study, *The Impacts on Upper Great Lakes Water Levels: St. Clair River Final Report*, can be viewed at www.ijc.org/en/impacts-upper-great-lakes-water-levels-st-clair-river-final-report

For more information on Great Lakes water levels, please visit www.lre.usace.army.mil/Missions/Great-Lakes-Information/ or contact Keith Kompoltowicz at (313) 226-6442 or keith.w.kompoltowicz@usace.army.mil

Great Lakes Coastal Resiliency information can be found here: www.lrc.usace.army.mil/Missions/GLCRS/

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Collaborative Governance and the Protection and Restoration of the Great Lakes

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The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the author(s) and do not necessarily reflect the views of NOAA or the Department of Commerce.

The Great Lakes region is collaboratively governed, but it was not always this way. More than 100 years of change, conflict, and crisis have created a unique system of multijurisdictional natural resource management that has become a model for the world.

The Laurentian Great Lakes of North America are a unique ecosystem formed by the retreat of glaciers more than 8,000 years ago, and its magnitude can be difficult to appreciate. The connected lakes of Superior, Huron, Michigan, Erie, and Ontario together hold enough water to cover the continental U.S. under nine feet of water. They have a surface area of 94,000 square miles, are bordered by more than 10,000 miles of coastline, and are the largest system of fresh surface water on Earth, containing 90 percent of North America's fresh surface water.

Country borders and political lines have never been formed on a watershed or ecological basis, making many large water systems a resource shared between two or more countries. The same is true for the Great Lakes. At the federal level, the Lakes are shared by the United States and Canada. These governments have concurrent jurisdiction over the waters and their resources with the Canadian provinces of Ontario and Québec; and the U.S. states of Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, and New York. Although the states and provinces have exclusive jurisdiction over lake bottomlands, there are treaties and other instruments that guarantee U.S. and Canadian indigenous nations access to fisheries and other natural resources.

An April 1999 satellite image shows the Great Lakes region looking East. Photo courtesy of NASA

Flags of Great Lakes states and Canadian provinces represent just how many governments—international, federal, state, and local—have an interest in the health and viability of the Great Lakes region. Photo courtesy of Great Lakes St. Lawrence Governors & Premiers

GREAT LAKES ST. LAWRENCE GOVERNORS & PREMIERS

Great Lakes Commission des Grands Lacs

In addition, local communities, members of the recreational industry, shipping and transportation, and non-governmental organizations have concerns with how management of the lakes may affect their economic interests, bring harm to the environment, or threaten human health.

The size of the Great Lakes system and the inherent environmental, social, and economic issues are complex. The fact that no single jurisdiction can solve or manage them alone requires collaboration. This is especially true when the natural resource is a body of water that can freely flow across borders and the actions of one government can directly impact the other. The Great Lakes' abundant fresh water has always been the region's economic driver and increasingly, continued economic growth depends on the development and sustainability of its water resources and an effective form of collaborative governance to manage them.

Governance

In modern society, the use of the term governance is almost ubiquitous and can mean different things to different people, depending upon the context. The fourth edition of *The American Heritage Dictionary* (2000) defines the word governance as, "The act, process, or power of governing; government." However, the term can be used to describe the general use or structure of authority and the institutions in place to allocate resources and coordinate activity in both the public and private sector. The concept of governance affects the organization of public sector government, the institutions that affect the process of government, and what has, over time, influenced changes to governance regimes.

Governance is not static. It has evolved from a more traditional government framework to one that, during the past few decades—with emergence of collaboration as an alternative method of management—has been referred to as collaborative federalism, management, or governance. These terms describe the recognized interdependencies between different levels of government and the need to work in partnership with other stakeholders who have an interest in the management of an area or issue of mutual concern.

The current governance model of the Great Lakes is built on this past and must take all that has come before into consideration as the region moves forward. Many of the environmental problems that emerged during the late 19th and early 20th centuries primarily addressed a single environmental medium—land, water, or species—in a specific area, making oversight by a single organization workable and appropriate. In the United States, many government agencies were formed over this time to address different environmental issues. Now, just on the U.S. side of the border, more than 15 federal agencies have complementary but different responsibilities and authorities for the management of Great Lakes environmental issues.

So how did this all get started?

Conflict

When multiple government jurisdictions share a natural resource, conflict often arises, and the United States

and Canada are not immune. The countries share the longest unprotected border in the world—5,525 miles—and more than half of it passes through water. Toward the end of the 19th century, human development in and around these shared boundary waters became a constant source of conflict concerning both the quantity and quality of the water. Pollution from industrialized cities on or near shared waters like Detroit; Buffalo, New York; and Sarnia, Ontario; and drinking water contamination by human sewage and animal waste from stockyards, brought increasing attention to the "tragedy of the commons."

A legal mechanism and process was needed to address issues of concern and conflict between the two parties. To this end, the *Treaty Between the United States and Great Britain Relating to Boundary Waters, and Questions Arising Between the United States and Canada* was signed in 1909. Otherwise known as the *Boundary Waters Treaty*, it recognizes that each country may be affected by the other's actions in the watersheds that cross the border and that disputes should not only be resolved, but prevented. It also created the International Joint Commission to address and prevent conflict. This was the start of collaborative governance between the two countries.

Pollution prevention and environmental restoration were not the exclusive domain of early collaborative efforts. The building of the St. Lawrence Seaway to facilitate shipping and the global movement of goods in and out of North America's heartland was recognized as a means to make the Great Lakes region an economic powerhouse. It also created another opportunity for the states and provinces to work together.

In response, the Great Lakes Commission (GLC) was established in 1955 to represent the region as a political entity to agencies of the federal government and Congress. It was also empowered to inform, advocate, and actively lobby Congress on behalf of the eight Great Lakes states. It was granted Congressional consent in 1968, officially creating the *Great Lakes Basin Compact*. The provinces of Ontario and Québec were later added as associate members through a Declaration of Partnership, making it a binational entity. Though the GLC was established with economic and transportation policy issues as the principal focus, its broad mandate included a variety of environmental issues as well.

Crisis

By the mid-20th century, the growth of collaborative governance in the Great Lakes came less from conflict than crisis; and the initial crisis was the sea lamprey. While other invasive species were present in the Great Lakes, none had such a significant negative impact on the shared fishery. The sea lamprey is an aggressive parasitic lamprey native to the Atlantic coasts of the United States and Europe. It is tolerant of freshwater and was first found in Lake Ontario in 1835. Niagara Falls served as a natural barrier to further spread, but the Welland Canal's construction during the same century allowed the lamprey to bypass the Falls and enter all of the lakes.

The sea lamprey reduced stocks of lake trout to virtual extinction in the upper lakes of Huron, Michigan, and Superior. The enormity of the crisis drove the United States' and Canadian governments to take action by negotiating and ratifying the 1954 *Convention on Great Lakes Fisheries*. This treaty created the Great Lakes Fishery Commission, a quasi-governmental, binational, collaborative organization primarily established to formulate and implement a program to control the sea lamprey.

Solving the Wicked Problem

The behavior of government can often be explained through its inherent nature to manage in response to crisis. In this response there is often political preoccupation for newness and an appeal in creating, or indeed mandating, new, collaborative arrangements in the form of task forces, panels, or commissions. The Great Lakes region is no exception to this rule.

Native to the Atlantic Ocean, the parasitic sea lamprey has been found in the Great Lakes since 1835. Today, it is successfully managed to prevent it from decimating native fish species. Photo courtesy of the Great Lakes Fishery Commission

The U.S. Army Corps of Engineers, Buffalo District hosted a planting ceremony for the Seneca Bluffs Ecosystem Restoration project in Buffalo, NY, October 30, 2018. The project, funded through the Great Lakes Restoration Initiative, will enhance community and restore ecosystems along the Buffalo River. Courtesy of U.S. Army Corps of Engineers/Buffalo District

The use of collaboration as a formal arrangement among government and various stakeholders for joint problem solving is particularly well-suited to the problems of natural resource management, because decision-making within this realm is inherently complex and uncertain. This complexity comes from working in an environment that includes complicated issues, multi-jurisdictional layers, and various forms of conflict and evolving crises. These types of convoluted quandaries can be referred to as "wicked" or problems with no perfect solutions that may have temporary and incomplete resolutions.

These problems deal with ambitious policy goals and layers of mandates from both federal and state or provincial governments that are embedded in a context of dispersed power that cuts across the boundaries and jurisdictions of government agencies. It also incorporates the political demand for the inclusion of the nongovernmental sector. These types of problems require a management process, such as collaboration among multiple organizations, and the formation of formal collaborative management structures.

Within this model of collaboration, law and regulations are not circumvented, nor is the authority and accountability of government agencies. However, it gives civil society meaningful participation in a deliberative process with government agencies to generate innovative solutions to highly complex environmental and transportation-related problems. For these wicked problems, agreement on how to successfully solve them is more often forged by jointly steering courses of action and delivering policy outcomes that are consistent with the multiplicity of societal interests with involvement in the resource.

The Great Lakes Water Quality Agreement

Eutrophication of shallow portions of the Great Lakes, along with the continued use of the lakes to dispose of industrial waste, runoff pollution, and heavy metals sparked an environmental wakening across the two countries. This awakening drove the United States and Canadian governments to ask the International Joint Commission to study the pollution issues. The results of these studies informed the subsequent negotiations which led to the 1972 Great Lakes Water Quality Agreement under the authority of the *Boundary Waters Treaty*.

This Agreement has been characterized as one of the most forward-thinking diplomatic achievements for the environment in modern times. It includes a structure and process that places the focus on strategies for restoring and protecting the ecosystem as a whole, rather than achieving or protecting national agendas. It establishes the Great Lakes as a "shared commons" with both nations as jointly responsible stewards.

The Agreement has been amended and updated many times over the past 50 years. The addition of remedial action plans and specific lakewide management plans created collaborative institutions at the local and lakewide level. This increased the understanding and positive impact of using a collaborative process that began

Britannica.com defines eutrophication as the gradual increase in the concentration of phosphorus, nitrogen, and other plant nutrients in an aging aquatic ecosystem such as a lake.

to transfigure the region into the governance model in use today.

In 1987, the governments created a Binational Executive Committee as a discussion forum composed of senior-level representatives of Canadian and U.S. federal, state, and provincial agencies. These agencies are accountable for delivering major programs and activities under the terms of the Agreement. In 2012, the latest major update settled on 10 annexes focusing on specific sources of pollution, stressors, and lake restoration objectives, as well as climate change impacts. The Committee was expanded to include a wide array of organizations, levels of government, indigenous governments, and public interest groups which now make up the current Great Lakes Executive Committee (GLEC).

Collaboration and Powering the Blue Economy

Because of the abundant water, heavy industry flourished along the shores of the Great Lakes and created good jobs across the region. When this industry closed, it left many towns and cities across the region with many empty facilities and hollowed out economies.

The legacy of the Great Lakes as the so-called "rust belt" unites the region to continue building its economy based on the Great Lakes' "Blue Economy." With roots extending back to 1983, the Conference of Great Lakes and St. Lawrence Governors and Premiers, works to grow the region's $6 trillion economy while using and protecting the Great Lakes and St. Lawrence River. Its portfolio includes addressing issues that affect the region related to maritime transportation, protection and restoration, aquatic invasive species, international trade, and tourism.

In 2005, the Conference responded to interest in exporting water from the Great Lakes to areas outside of the basin by creating a binding, regional framework to manage and protect the water supply of the Great Lakes and St. Lawrence River Basin. The Governors and Premiers signed the *Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement* and the Governors endorsed the companion *Great Lakes Compact*. This Compact was enacted into United States law in 2008 following approval by the state legislatures and the United States Congress.

The Great Lakes collaborative governance model has extended to the local municipal level via the *Great Lakes St. Lawrence Cities Initiative*, a 25-year-old binational coalition that unites mayors and other local officials in protection of the Great Lakes. From this perspective, they address and integrate environmental, economic, and social agendas and work with other levels of government towards Great Lakes restoration and protection, recognizing that the lakes are the foundation for a strong regional economy.

The Great Lakes Restoration Initiative

The next important addition to regional governance had its beginnings in political expediency and a 2004 White House Executive Order that created a Great Lakes Regional Collaboration. It created a structure for the different jurisdictions to come together with the federal agencies to develop a formal plan for restoration of the lakes. The problem was that, while there was consensus on the way ahead and the issues and potential recommendations for restoration were identified, there was no funding available for implementation.

That all changed in 2009 when the United States implemented the Great Lakes Restoration Initiative (GLRI) with large annual appropriations for the restoration and protection of the Great Lakes and its resources. The management of projects funded by the GLRI required federal cooperation and collaboration. Since the region had an outstanding track record of collaborative governance, the administration decided to mobilize an existing decision-making structure to organize the agencies and find a way to allocate the unprecedented funding for the Great Lakes ecosystem.

The structure used by the federal agencies under the Great Lakes Regional Collaboration was used to assemble a team called the Regional Work Group. This federal agency Regional Work Group cooperatively developed plans for the annual multimillion-dollar GLRI appropriations for the remediation of areas of concerns, habitat restoration, removal of invasive species, and many other initiatives for this magnificent ecosystem.

The Great Lakes as a geographic region is arguably the most collaborative as there is a common vision and mission to restore and protect the Great Lakes. Organizations in the region are linked through decades of partnership, collaboration, and work. While there is some overlap and redundancy in these organizations' charters, it provides a de facto "safety net," ensuring the most critical issues are addressed. Almost all environmental policy, decision-making, and implementation concerning the lakes is conducted through some sort of regional, collaborative effort. Every day we thank each other for helping to make the Great Lakes great!

About the authors:

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Ninth Coast Guard District's Unique Operations

Coast Guard's Ninth District

A short history of the Guardians of America's inland seas!

by Lorne W. Thomas
External Affairs Division
Ninth District
U.S. Coast Guard

Bob Desh
Foundation for Coast Guard History

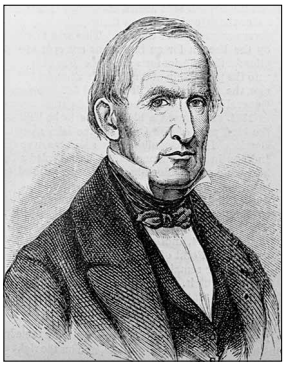
As is the case with the service as a whole, the early history of the Coast Guard on the Great Lakes is the story of its predecessors.

The U.S. Coast Guard's District 9 is located within an area occupied by the states bordering the Great Lakes. The service's presence there began in the 19th century with the appearance of four Coast Guard predecessor agencies, the U.S. Revenue Cutter Service, the U.S. Lighthouse Service, the Steamboat Inspection Service, and the U.S. Life-Saving Service.

The Revenue Cutter Service

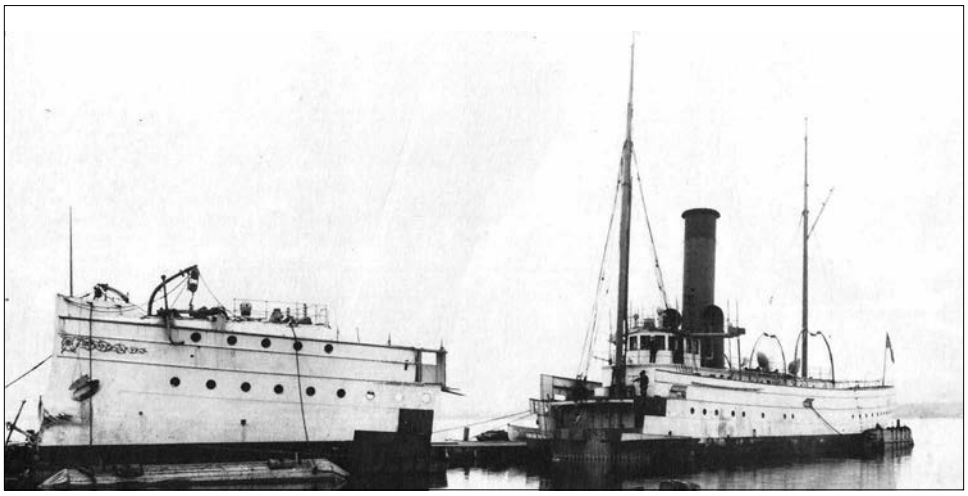
The U.S. Revenue Cutter Service (USRCS) enforced U.S. laws on the Great Lakes ensuring compliance with customs requirements. Soon after the War of 1812, a revenue cutter was stationed on the Lakes with the number of cutters increasing throughout the 19th century. These cutters were also charged with rescue operations, and patrolling regattas. Several left the Great Lakes to support combat operations in the Civil and Spanish-American wars.

Captain Daniel Dobbins, a renowned Great Lakes merchant mariner and navigator in the early 1800s, was one of the more interesting figures in the early history of the USRCS on the Great Lakes. While in port at Mackinac Island at the onset of the War of 1812, he was captured by the British, though he was later paroled and returned to his home in Erie, Pennsylvania. He later traveled to Washington to brief the Secretary of the Navy on Great Lakes happenings and returned having been appointed sailing master in the U.S. Navy and tasked with construction of a Great Lakes naval fleet. His efforts resulted in the squadron, led by Commodore Oliver Hazard Perry, that defeated the British fleet in the Battle of Lake Erie. He resigned his Navy commission in 1826 and was appointed commanding officer of the Revenue Cutter *Benjamin Rush* in 1829, serving in the USRCS until 1848.



Captain Daniel Dobbins, 1776–1856. Naval History Heritage photo

The saga of the Cutter *Gresham* is yet another intriguing chapter in USRCS and USCG history on the Great Lakes. Constructed at Globe Iron Works in Cleveland, she was a cruising cutter and auxiliary gunboat built for Great Lakes service. Shortly after her May 30, 1897, commissioning, the Canadian government protested that her construction and deployment violated both the 1817 Rush-Bagot Treaty and the 1842 Webster-Ashburton Treaty, which governed militarization of the Great Lakes. There was a need for naval vessels for the Spanish-American War, so



The Coast Guard Cutter *Gresham* was cut in half and transported on barges out of the Great Lakes through the Welland Canal during the Spanish-American War. She also saw service in both world wars. Coast Guard photo

rather than reduce her armament, *Gresham* was cut in half and transported through the locks on the Welland Canal and St. Lawrence River for duty on the Atlantic Coast. Decommissioned April 7, 1944, *Gresham* had a long, fascinating career including service in both world wars.

The Lighthouse Service

Keeping pace with the region's settlement and the growth of shipping, the Lighthouse Service expanded rapidly along the Great Lakes from east to west, with 20 lightships stationed on the Lakes by the late 1800s. Records indicate the first appropriations were made for lighthouses in eastern Lake Erie and western Lake Ontario. The first lighthouse tenders also began servicing the region's floating aids-to-navigation and fog signals.

Many of the earliest lightships in the service were assigned to warn mariners of the many shoals and reefs speckling the Great Lakes, but serving on them could be dangerous duty as they were completely exposed to the whims of winds and waves. In 1913, the lightship *Buffalo* (LV-82) was lost with all hands in the November storm that is sometimes called the "White Hurricane."

However, as engineering and construction methods evolved and improved, most of the lightships were eventually replaced with lighthouses constructed atop stone, steel, or wood frameworks called "cribs" at the top of a shoal. Many lighthouses—Michigan claims more than any other state in the nation—were far from shore and it took dedicated keepers to man these lonely, isolated light stations

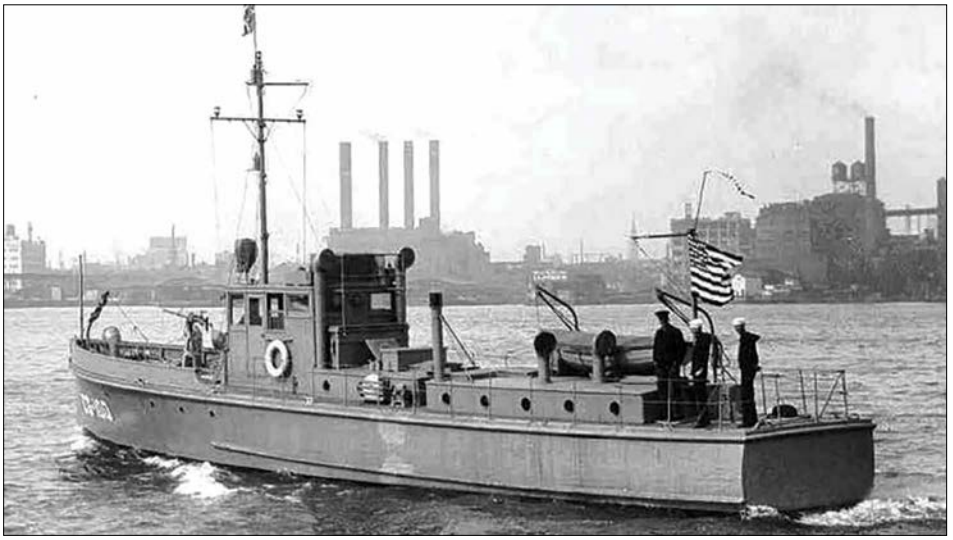
The Steamboat Inspection Service

The advent of steam-propelled vessels came with increased risks of boiler explosions and marine casualties. In 1838, hull and boiler inspectors were granted federal authority to survey and certify passenger vessels. In 1871, increasing casualties resulted in additional laws that gave rise to the Steamboat Inspection Service (SIS) under the Treasury Department. In addition to boiler and hull examinations, subsequent laws required lifesaving, firefighting, manning, and safety measures. These requirements included the licensing of commercial operators and engineers, and were later extended to passenger vessels. Two SIS districts were established on the Great Lakes to provide inspection services. Headquartered in Detroit, one oversaw the western Lakes, while the Cleveland office managed inspectors on Lakes Erie and Ontario and the St. Lawrence River.

The U.S. Life-Saving Service

The high concentration of shipping activity, and consequent increase in commercial shipwrecks, combined with the unpredictable and rapid rise of severe storms on the Great Lakes, set the stage for countless dramatic rescues, particularly along the rugged coast of Lake Superior. These circumstances precipitated in the informal tasking of the Revenue Cutter Service and the Lighthouse Service with providing rescue services beginning in the 1840s. Unfortunately, a lack of organization, funding, and training resulted in ineffective operations. To remedy this, 28 dedicated and properly funded lifesaving stations were established on the Great Lakes between 1876 and 1877. Some were co-located with lighthouses and staffed with a mix of full-time and volunteer crews.

The U.S. Life-Saving Service was formally established under the Treasury Department in 1878, and by 1893 there were 47 manned stations on the shores of the Great Lakes, which grew to 60 stations by 1900. By the early part of the 20th century, the Life-Saving Service had adopted motorized lifeboats for use across the Great Lakes after the first was assigned to Marquette, Michigan.



A "six-bitter" 75-foot patrol boat. Coast Guard photo

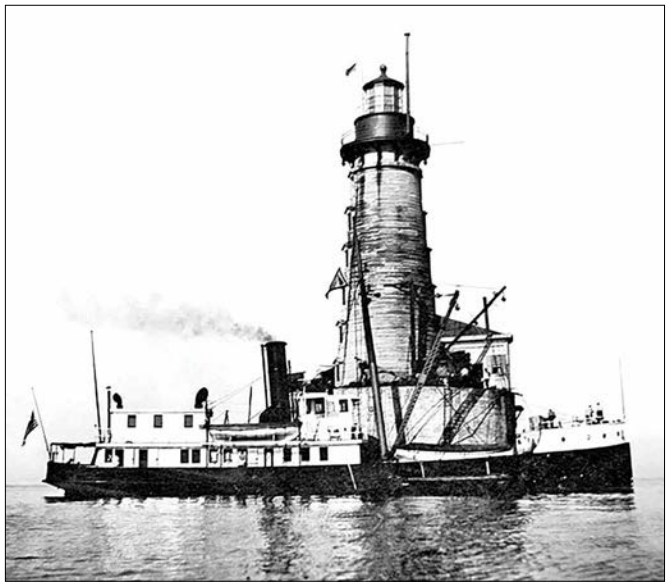
In 1915, legislation combining the Life-Saving Service and the Revenue Cutter Service established the modern-day Coast Guard and increased the service's scope and capabilities on the Great Lakes. The passage of the Volstead Act in 1920 implemented Prohibition, which lasted for 14 years and exponentially increased the service's law enforcement mission on the northern border. Coast Guard small boats and larger patrol boats intercepted illegal alcohol smuggled from Canada at various

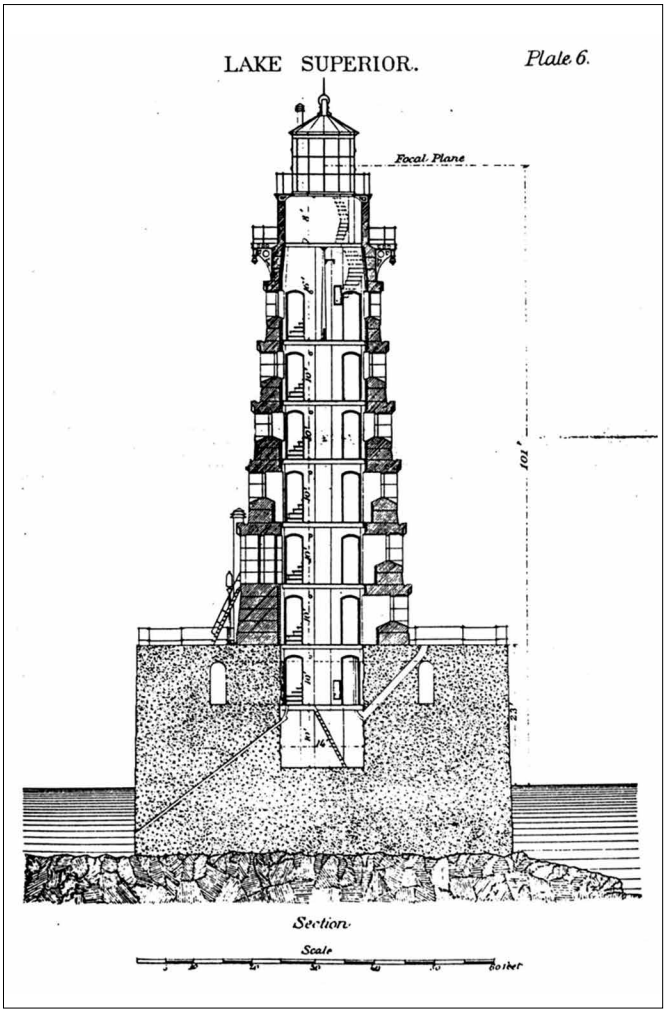
Counterclockwise from left: Lightship No.77, the Peshtigo Reef Lightship, on station in 1832 near Green Bay, Wisconsin.

Personnel from Coast Guard Station Sturgeon Bay, Wisconsin, engage in a surfboat drill.

Stannard Rock is described as the loneliest place on the continent. Completed in 1883, the Stannard Rock Light lighthouse sits 24 miles off the coast of Michigan marking one of the most hazardous reefs on Lake Superior. Shown here, a rendering of the interior of the lighthouse and a lighthouse tender passing the Stannard Rock Light in 1924.

Coast Guard photos





border crossings on the Lakes. In addition, the service's search and rescue mission grew in response to the arrival of recreational boating during the warmer months.

The close proximity to Canada made "the rum war at sea" on the Great Lakes both challenging and dramatic. In many locations, including the Detroit, St. Clair, and St. Marys rivers, smugglers needed to merely race a fast boat a few hundred yards across smooth open water to deliver their wares. At times, it was a wild and woolly shooting war!

Domestic Icebreaking Mission

In the early 1900s, steel-hulled Coast Guard cutters were tasked with breaking ice on the Lakes in an effort to extend the shipping season. This became a national priority from the late 1930s through World War II as a means of ensuring the year-round transport of heating oil and the shipment of iron ore and other raw materials. In 1936, President Franklin Roosevelt signed Executive Order 7521 assigning domestic icebreaking to the Coast Guard. This mission resulted in the acquisition of additional Coast Guard icebreaking vessels, including 110-foot icebreaking tugs, a class of 180-foot light icebreaking buoy tenders, and the Great Lakes icebreaker *Mackinaw*, built in 1943.

The Coast Guard at War

During World War I, the areas, districts, and divisions of predecessor agencies were amalgamated into Naval Districts and the Ninth District was established encompassing the Great Lakes and the St. Lawrence River. At the same time, threats of espionage and explosive handling mishaps drove Congress to increase the port safety and security authority for the Coast Guard, which led to the creation of Captain of the Port (COTP) position. During the wartime transfer of the service to the U.S. Navy, Coast Guard cutters on the Great Lakes and elsewhere provided a coastal defense presence and conducted merchant ship convoy escorts across the Atlantic.

The Great Lakes icebreaker Mackinaw, built in 1943. Coast Guard photo

Of Note During World War II

- Two captains served as the first Ninth District commanders, followed in 1944 by the first Ninth District flag officer, Commodore James Hirshfield.
- On June 13, 1943, the Grand Haven, Michigan-based Coast Guard Cutter *Escanaba*, below, was lost during convoy escort duty in the Atlantic Ocean. Of the 105-man crew, only two survived. Each year during the annual Coast Guard Festival, Grand Haven holds a memorial service honoring the 103 men lost aboard the cutter. Coast Guard photo

The Coast Guard Reserve and the Auxiliary, created during World War II, became critical components for the safety, security, and stewardship of the Great Lakes. In fact, the Auxiliary was called into part-time military service at the beginning of the war.

Temporary Reservists on duty at a Coast Guard Station near Detroit. Coast Guard photo

Originally conceived as a way to militarize the civilian Auxiliary, a June 1942 amendment to the Coast Guard Reserve and Auxiliary Act enabled direct enrollment of volunteer personnel in the Coast Guard Reserve on a part-time basis. It was a triumph of imagination as the Coast Guard used it to meet a plethora of port security and homeland defense demands. As elsewhere, hundreds of personnel stepped forward to join the Volunteer Port Security Force. On the Great Lakes, merchant marine officers were also enrolled as Temporary Reservists to provide extra security against enemy infiltration or acts of sabotage aboard lake carriers transporting raw materials vital to the war effort.

The Coast Guard's mission set for the Great Lakes expanded after World War II. This was due in part to the 1939 transfer of the U.S. Lighthouse Service to the Coast Guard and the 1946 absorption of the Bureau of Marine Inspection and Navigation, formerly the SIS, which coincided with the establishment of the District's first air station at Traverse City, Michigan. The mergers increased the Coast Guard's Great Lakes inventory by two thousand aids-to-navigation and 10 lighthouse tenders, in addition to Air Station Traverse City's one fixed-wing aircraft and subsequent helicopters.


Temporary Reserve Merchant Marine Captain A.G. Waurzyniak

Post-War Era

During the 20 years following World War II, Ninth District's field units were organized under 11 Groups with 29 Captains of the Port and Marine Inspection Offices (MIO). Several Group commanders oversaw two or three commands simultaneously and, during this period, the District maintained two icebreakers, seven 180-foot buoy tenders, a lightship, five icebreaking harbor tugs, 51 stations and 80 manned lighthouses.

In the 1960s, the Ninth District experienced further changes. In 1959, the St. Lawrence Seaway had opened allowing foreign-flagged vessels into the Great Lakes, along with invasive species carried in their ballast tanks. Discharges from these vessels eventually led to the enforcement of ballast water and waste water regulations on the Lakes in the following decades. Meanwhile, in 1966, the Coast Guard established Air Station Detroit and, a year later, the Coast Guard was transferred from the Treasury Department to the Department of Transportation. Two years later, in 1969, the service also established Air Station Chicago.

The next significant mission added to the Coast Guard and Ninth District was marine environmental protection. Several high-profile oil spills and events, including the infamous 1969 Cuyahoga River fire in Cleveland, increased environmental awareness resulting in legislation, such as the Federal Water Pollution Control Act, as well as other marine pollution laws and treaties. In 1972, this led to a merger of COTP and MIO commands into Marine Safety Offices (MSO) located in

ports across the Ninth District.

Over the next 30 years, the organization of field units evolved and consolidated due to advances in technology and asset capabilities. The 11 groups merged into five and the marine safety program consolidated into eight MSOs and three Marine Safety Detachments. Meanwhile, the service closed Air Station Chicago and opened air facilities in Waukegan, Illinois, and Muskegon, Michigan, during the summer months. Five 140-foot WTGB icebreaking tugs and two 225-foot buoy tenders replaced the World War II-era 180-foot icebreaking tenders and older harbor tugs.

The Ninth District Today

The terrorist attacks of September 2001 not only precipitated the establishment of the new Department of Homeland Security, but helped establish a homeland security mission in the Ninth District that focused attention on the 1,500 miles of international border along the Great Lakes. In addition to growing the Coast Guard, the service's 2003 transfer to the new Department of Homeland Security created more opportunities to work with Customs and Border Protection and other DHS agencies on the Lakes. This resource-intensive mission resulted in another field unit reorganization in 2005. Groups and MSOs were combined into four Sector Commands established in Buffalo, New York; Detroit; Sault Ste. Marie, Michigan; and Milwaukee. Marine Safety Units, formerly called MSOs, remained located at Duluth, Minnesota; Cleveland; Toledo, Ohio; and Chicago.

In 2005, the service also replaced the World War II-era icebreaker *Mackinaw* with *Mackinaw* (WLBB-30), a modern icebreaker with buoy tending capabilities. Later, the service also transferred the icebreaking tug *Morro Bay* to Cleveland from the First Coast Guard District in Boston. In 2016, MH-60 helicopters returned to the Great Lakes replacing the MH-65 aircraft at Air Station Traverse City and, most recently, eight Great Lakes small boat stations were converted to seasonal use, operating from Memorial Day to Labor Day.

Today, District 9 is headquartered in Cleveland and hosts four sectors—Buffalo, Detroit, Sault Ste. Marie, and Milwaukee—as well as air stations Traverse City and Detroit, with seasonal aviation facilities located in Muskegon, and Waukegan. Additionally, bases and stations located throughout the Ninth District area of operations host icebreaker *Mackinaw*, three buoy tenders, six icebreaking tugs, afloat assets for seven Aids-to-Navigation Teams, and numerous smaller watercraft.


THE

Commandant of the United States Coast Guard

Expresses sincere appreciation for the loyal service rendered by

JOSEPH E. KONKEL

on active duty as a temporary member of the United States Coast Guard Reserve during World War II

in the capacity of Officer of Great Lakes Merchant Vessel without military pay, and holding the rank of Commander as a Temporary Member of the Coast Guard Reserve.

In testimony whereof I am privileged to bestow this

Certificate of Satisfactory Service

Done in the City of Washington, D. C. this thirtieth day of November, Nineteen hundred and forty-five

Commandant
United States Coast Guard

NAVCG 10009 (8-45)

Temporary Reserve Certificate. Coast Guard photo

About the Authors:

Lorne Thomas serves as the External Affairs Officer for the Ninth Coast Guard District. He is responsible for direct oversight and execution of the Ninth District's public, Congressional, international, and tribal affairs programs. He is also a retired Coast Guard captain with 27 years of service in marine safety and prevention positions across the country, including the Great Lakes.

Bob Desh is the former Executive Director of the Door County Maritime Museum. Prior to joining the museum, he served for more than 36 years in the Coast Guard, seeing duty on five cutters and a variety of shore assignments, before retiring with the rank of captain. A long-time history buff, he continues to serve on the Foundation for Coast Guard History's board of directors.

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Search and Rescue on the Inland Seas

A look at the unique challenges of search and rescue on the Great Lakes

by LCDR Megan Mervar
Command Center Chief
Ninth District
U.S. Coast Guard

Karl Willis
Search and Rescue Specialist
Ninth District
U.S. Coast Guard

When they received a 911 call around 8 p.m. on a mid-September evening in 2021, the Alger County dispatchers could only make out a few words through panicked breathing and the sound of water lapping against the phone. Though the call dropped, their system located the cell phone near Lake Superior's Pictured Rocks National Lakeshore on the north shore of Michigan's Upper Peninsula. Notified of the call, search planners from Sector Sault Ste. Marie and Ninth District command centers immediately dispatched a 45-foot response boat from Coast Guard Station Marquette and an MH-60 helicopter from Air Station Traverse City. Alger County and the National Park Service also launched vessels to support the search, not knowing the nature of the caller's distress or how many people might be involved.

While responders hurried to the scene, search planners plugged the information into the Search and Rescue Optimal Planning System (SAROPS). The system incorporates data inputs to produce a drift simulation "heat map" that gives the search planner an idea of where the object may have drifted from its last known position over a given amount of time. The planners built initial search patterns, passed this information to responding assets, and simultaneously began pursuing leads to gather more information. A second cell phone "ping" failed to generate an updated position, but a family member was identified who confirmed that two people had been kayaking near Pictured Rocks that evening. This information refined the search effort considerably.

It was the beginning of gale season on Lake Superior, and the National Weather Service had issued a warning that evening. In the face of 50-knot winds and seven-foot seas, the Alger County marine unit was forced to stand down its search effort.

"The winds were ripping from the south, and what made this so challenging was that our search area was just north of the Pictured Rocks cliffs, so the wind created eddy down drafts that caused turbulence for us in the helicopter," LCDR Chris Clark, an MH-60 pilot from Air Station Traverse City, said. "The stronger the winds, the worse the down draft, which made it especially difficult to fly our search pattern just a few hundred feet above the water."

Efforts to counter the wind's dynamics required

The towering sandstone cliffs of Pictured Rocks National Lakeshore in Munising, Michigan, attract tourists all year. Photo courtesy of the National Park Service

careful focus and precision. Nearly the entire crew became sick from the erratic movement of the aircraft. Exacerbating the weather was the disorienting nature of the darkness and that the crew was fighting its own circadian rhythms. Any one of these factors elevates risk for an aircrew, but this combination of factors presented a perilous scenario, mitigated only by the crew's expert training, experience, and professionalism, combined with the determination to find the two missing mariners.

Just after 11 p.m., the helicopter located an overturned kayak in the search area, and vectored Station Marquette's response boat to the position. With this new information, search planners narrowed down the search area and developed a "reverse drift" that projected the likely origin of the kayak and its passenger.

Overnight, search planners continued aggressively seeking and validating details that might further refine the search effort. By morning, a Canadian C-130 had joined the fresh Coast Guard response teams from Station Marquette and Air Station Traverse City. Just before 11 a.m., the Canadian aircraft located another unmanned kayak and vectored in the Station Marquette response boat. Less than an hour later, the C-130 spotted a yellow life jacket and the Station Marquette response boat discovered the body of one of the missing individuals.

Throughout the early afternoon, on-scene Coast Guard assets continued searching with new crews. The Canadian C-130 was replaced by a Coast Guard C-130 out of Air Station Elizabeth City, North Carolina. A fixed wing aircraft from the Civil Air Patrol also joined the search effort, coordinated with the help of the Air Force Rescue Coordination Center out of Tyndall Air Force Base, Florida. Meanwhile, the National Park Service continued searching along the shoreline and Alger County Sheriffs assisted with the investigation shoreside.

Just before 2 p.m., after a search that ultimately covered more than 516 square miles, the Station Marquette response boat crew located the second body.

Coast Guard Search and Rescue (SAR) is the soul of the Ninth District. The District's SAR Ethos, to "treat every person in distress as one of our own family," organically frames the decisions of every search planner, aircrew member, small boat coxswain, and decision-maker in the chain of command. SAR planners train rigorously on the policy and tools available, but truly pride themselves on the "art" of SAR that comes with experience. It is the instinct to explore an angle not yet considered; the intuition to apply a seldom-used tool; and the foresight to realize, seek, and validate the facts needed to plan an optimal search with limited, and possibly inaccurate, information from the outset.

While the search for the kayakers near Pictured Rocks ended in a terrible tragedy, every member of the team involved in the search effort embodied the Ninth District's SAR Ethos. The coordination of an international, multi-agency effort converted the limited bits of initial information into search plans that enabled the resources on scene to find both victims, ultimately bringing closure to their families.

The antagonist in this story is the harsh, dynamic, and often unpredictable, weather that characterizes the Great Lakes. From early fall until late winter, gale watches and warnings are routinely issued. Gale winds, defined by the National Weather Service as sustained or gusting winds between 34 and 47 knots,[1] inspired the ominous nickname, the "Gales of November." One of the most famous Great Lakes shipwrecks, the November 10, 1975, sinking of the SS *Edmund Fitzgerald*, which killed all 29 men on board, serves as a reminder of the lakes' unrelenting power. Loaded with taconite pellets, the freighter was caught in gales up to 45 knots and seas reaching 30 feet as it approached Whitefish Bay in Lake Superior.[2] It sank quickly and Coast Guard cutters and aircraft conducted an extensive search, but weather conditions excluded small boat response. Following the tragedy, a Marine Board of Investigation recognized this gap and

The SS *Edmund Fitzgerald* sank in a storm on Lake Superior on November 10, 1975. The tragedy highlights the powerful weather systems that occasionally emerge across the Great Lakes. Photo courtesy of Greenmars

recommended a SAR standby cutter be designated and equipped to respond to SAR cases during the fall and winter months. To this day, the Cleveland SAR Plan assigns Coast Guard buoy tenders and icebreakers, equipped to divert for a rescue call, to areas of the Great Lakes from November 1 to April 1 each year.

Though not subject to the lunar tides like saltwater oceans, the Great Lakes experience seiche, "an oscillation of the surface of a landlocked body of water, like a lake, that varies in period from a few minutes to several hours."[3] Seiche occurs when strong winds and abrupt changes in atmospheric pressure force water from one side of a body of water to the other.[4] Similar to water sloshing back and forth in a bathtub, a seiche can result in high waves, water levels surges, and erosion, creating the potential for flooding and boat groundings. In Lake Erie, where shallow water depths and an expansive fetch provide a canvas for easterly or westerly winds to form large waves, the windy seasons often see flooding on the far ends of the lake. Variations in rainfall, snowfall, temperature, intensity of weather systems, and various other meteorological influences also affect overall water levels. In March 2022, the U.S. Army Corps of Engineers measured Lake Superior at three inches below chart datum, while the remaining four lakes were all well above—up to 40 inches above in Lake Erie—with levels fluctuating month-to-month.[5] These dramatic and frequent changes could periodically restrict waterside SAR response assets' access in certain areas.

A U.S. Coast Guard small boat makes its way through a crowd of swimmers and boats rafted together during a Jobbie Nooner party, an unsanctioned marine event that takes place twice a year on Lake St. Clair's Gull Island. The beautiful summers on the Great Lakes attract crowds of boaters to events like this and, as part of a unified command that includes state and local agencies, the U.S. Coast Guard monitors safety. Coast Guard photo by Chief Petty Officer Nick Gould

The CG-22156, a Special Purpose Craft–Ice Rescue Transport, deploys on the ice in Lake Erie. Units across the Great Lakes received 10 new special purpose crafts designed specifically for ice rescue transport up to 10 miles offshore. Coast Guard photo

The Great Lakes see an annual rotation of weather trends. Beautiful, calm summers attract boaters, resulting in the Ninth District having the busiest summers of any Coast Guard district. Summers gradually shift to the gale force winds of the fall, and the ice and frigid temperatures of winter. The melting spring ice attracts both novice and experienced boaters, with summers on the Great Lakes possibly seeing more than 40 SAR cases in one day. The completion and oversight of these are only possible through the rigorous training, practice, and fluid international and multi-agency coordination that support a highly proficient team. The Ninth Coast Guard District, the second busiest of the nine Coast Guard districts for SAR, participated in a total of 2,413 SAR cases, resulting in 4,390 lives saved or assisted by the end of fiscal year 2021. The summer months, between Memorial Day and Labor Day, are by far the busiest, and result in around

70 percent of the year's SAR cases. With a 1,500-mile international border and an international boundary as little as 100 yards from U.S. shorelines on many of the lakes' interconnecting rivers, the relationship with Canada for SAR cooperation is seamless. International SAR cases with Canada average 100 per year, with a near-equal distribution of each country providing assistance to the other, making this cooperation an essential component of SAR capability across the Great Lakes.

Two U.S. Coast Guard members practice an ice rescue technique during a training session in Ashtabula, Ohio. During the winter months, ice rescue becomes the main mission for U.S. Coast Guard small boat stations across the Great Lakes. Coast Guard photo by Petty Officer Levi Read

Nudging up against the busy summers are what those native to the Ninth District call "shoulder seasons." This is the period before heavy summer boating begins, while ice is still thawing, and after the busy summer tapers off when ice begins to develop. This curse of seasonality presents a trickle-down effect to Coast Guard SAR operations, with a shift in training focus, maintenance, and logistical requirements to transition between "frozen" and "open" water SAR. Leading into the winter, small boats must be winterized, trailered, and stored, and small boat station personnel must quickly requalify on their ice rescue platforms once ice develops. SAR planners dust off ice rescue policy and practice running ice rescue scenarios in SAROPS, a type of SAR planning more akin to searching on land than on water. During the spring shoulder season, small boats are "splashed" on a schedule that is ideally driven by the pace of thawing ice and the projected return of boaters to the lakes, but is often delayed by local, seasonal road restrictions for the heavy cranes needed to lift Coast Guard boats into the water.

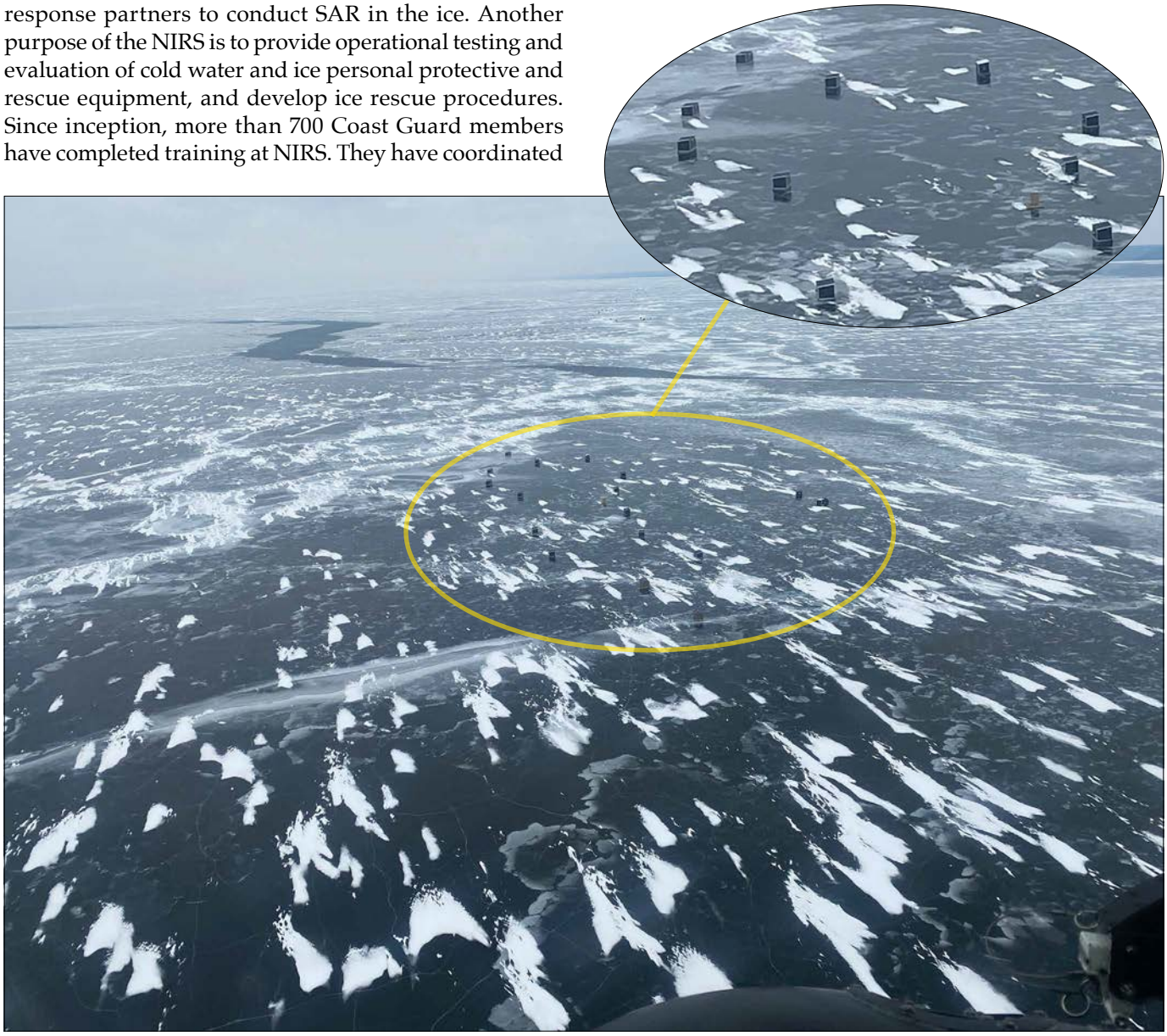
In the Ninth District, 47 Coast Guard small boat stations, 10 Coast Guard cutters, and two air stations serve the Great Lakes community in both frozen and open water SAR, presenting unique challenges for our first responders. From the majesty and vastness of Lake Superior, to wind-whipped Lake Erie, each of the five lakes and their associated harbors, rivers, and tributaries are unique and feature characteristics that test both U.S. Coast Guard and Canadian response. The most difficult and dangerous rescues occur during the four-month period from December to March each year. Frigid temperatures, gale force winds, and whiteout conditions hamper first responders' efforts, putting them at much greater risk while working to save lives on or through the ice. Varying temperatures, as well as wind velocity and direction, can quickly open fissures, or "rot" the ice, to the unsuspecting ice fisherman or snowmobiler.

An ice rescue team member from U.S. Coast Guard Station Grand Haven, Michigan, holds the trail line as he prepares to receive the Stokes litter from the aircrew aboard an MH-65 from Air Station Traverse City, Michigan. Coast Guard photo by Seaman Abigail Moore

Communities on more remote islands, such as Madeline Island, off the north coast of Wisconsin, traverse the ice as "roadways" back and forth to the mainland. Ice shanties pepper western Lake Erie, Saginaw Bay, and Green Bay. Winter sports and festivities serve as a welcomed distraction from the long winter, but no ice is considered safe.

Recognizing the unique need for ice rescue training, the Coast Guard established the National Ice Rescue School (NIRS) in 2014. It is strategically co-located with Coast Guard Station Saginaw River in Essexville, Michigan, where substantial early seasonal ice growth provides an ideal training platform. The school delivers the in-person Ice Rescue Trainer Course, which prepares experienced ice rescuers to train unit personnel and local response partners to conduct SAR in the ice. Another purpose of the NIRS is to provide operational testing and evaluation of cold water and ice personal protective and rescue equipment, and develop ice rescue procedures. Since inception, more than 700 Coast Guard members have completed training at NIRS. They have coordinated with and trained thousands of other Coast Guard members and first responders, including local fire, police, and sheriff's departments in and around their local communities throughout the Great Lakes. Since the NIRS was established, the Coast Guard and its partners have safely conducted 414 SAR cases in the ice environment, saving 416 people and assisting 252 others. Fourteen of these were mass rescue operations, requiring a response that taxed available resources.

One of these operations took place in February 2021 in Green Bay, Wisconsin, in the heart of ice rescue season. The Coast Guard's Sector Lake Michigan Command Center, the central information hub responsible for the command, control, and coordination of SAR responses in



A U.S. Coast Guard Air Station Traverse City, Michigan, MH-60 helicopter, flies above a group of ice fishermen stranded on an ice floe in Green Bay when the floe separated from the Wisconsin shoreline, in February 2021. Coast Guard photo

the Green Bay area, received a report of multiple people stranded on several different ice floes that had broken off from the main ice sheet. Details were vague, though, and it was unknown how many people and how many ice floes were involved, or exactly where the floes were located.

Through an extraordinary coordination effort, responders from the Coast Guard, and Wisconsin state and local sheriff's offices, converged with their ice rescue training on display. While information trickled in to the command center, watchstanders began deploying assets. An airboat from Coast Guard Station Sturgeon Bay and two MH-60 helicopters from Air Station Traverse City launched. Members of an ice rescue team from the nearby Coast Guard Cutter *Mobile Bay* positioned themselves to rescue any stranded individuals on the outer edges of the floes using an ice skiff. The Wisconsin Department of Natural Resources and the local fire department responded to an ice floe at Sherwood Point in airboats, while the Brown County Sheriff's Office took its airboat to the Sand Bay floe. The Coast Guard also had a ground team at Sherwood Point to manage accountability of survivors and report sightings of people stranded on a third floe at Little Harbor.

A rescue swimmer from U.S. Coast Guard Air Station Traverse City coordinates with a group of stranded ice fishermen near Sturgeon Bay during a mass rescue operation in February 2021. By the end of the mission, 66 individuals were rescued from three separate ice floes in Green Bay, Wisconsin, after the floes had separated from the mainland. Coast Guard photo

Used to transport victims rescued from icy waters, an ice skiff is a small, inflatable boat designed to slide across the ice.

Each of the Coast Guard helicopters took one ice floe and provided cover for the airboats, while searching for remaining people on the floes, which can be massive. In many cases, people trapped on them may not realize there is no exit until the rescuers arrive. During this case, some of the victims, not believing they were in distress, initially resisted rescue, and many did not have proper lifesaving equipment with them. By the end of the incident, 66 ice fishermen, who'd started the day with no intention of taking part in a massive rescue effort, were rescued from ice floes, and the Coast Guard accounted for all victims.

It is days like these that serve as a veritable reminder that these survivors are fathers, mothers, sons, and daughters, and that the Coast Guard SAR Ethos is the reason they return to their families at the day's end. Each piece of the SAR chain is crucial, as is proficiency at every level of the team. Responding units could not safely accomplish these complex, dynamic responses without SAR planners coordinating the hundreds of details flowing through the command center. Search and rescue on the Inland Seas is a team effort, and the Ninth District team continues to raise the bar on achieving this shared purpose.

About the authors:

LCDR Megan Mervar is the supervisor for the Coast Guard Ninth District Command Center. Located in Cleveland, Ohio, the Center oversees command and control of all 11 Coast Guard missions across the eight-state Great Lakes region, including a 1,500-mile international border with Canada.

Karl Willis is the SAR Specialist for the Coast Guard Ninth District, in Cleveland, Ohio. In this capacity, he develops SAR policy, coordinates with federal and international partners in support of SAR, and serves as a subject matter expert across the Ninth District on SAR prosecution.

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Maritime Law Enforcement, Security on the Great Lakes' Binational Internal Waters

The Ninth Coast Guard District rises to the challenge

by Senior Chief Petty Officer Jonathan Bowden
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The Ninth Coast Guard District (D9) area of responsibility (AOR) is wholly unique from the Coast Guard's other eight operational districts. However, many of the factors that distinguish D9—namely its size, geography, and binational working environment—impose incredible challenges in executing the Coast Guard's law enforcement and maritime security missions.

The states that comprise D9 support one-third of the United States' registered recreational boaters. The area is an economic heavyweight. If the U.S. states and Canadian provinces surrounding the Great Lakes were one country, it would have a GDP of $6 trillion and rank as the third largest economy in the world.[1] As President George W. Bush succinctly put it in 2004 when establishing the Great Lakes Interagency Task Force, "The Great Lakes region is an economic engine and recreational haven."

Like all other Coast Guard Districts, D9 has a codified homeland security mission set. As the premier U.S. maritime law enforcement agency, D9 is tasked with protecting the United States' maritime borders and sovereignty, facilitating legitimate water usage, and suppressing violations of the U.S. Federal law on, under, and over the seas. As a lead agency for maritime security operations, the District has a mission to detect, deter, prevent, and disrupt terrorist attacks, and other criminal acts in the maritime domain. However, its ability to exercise authorities and apply "tools" the rest of the Coast Guard relies upon is complicated by the aforementioned challenges.

This article seeks to provide a window into D9's operating environment and operational challenges, specifically those tied to law enforcement and maritime security. It will also outline how the District is working to meet the challenges—today and in the future—by leveraging strong partnerships and seeking new and innovative ways to solve old problems.

The Ninth District's Area of Operations

The District's AOR is immense. Encompassing all U.S. portions of the five Great Lakes, it covers approximately 5,000 miles[2] of shoreline, stretching over eight states. For comparison, the shoreline is greater than the Atlantic and Gulf Coast shorelines combined,[3] a respective 2,069 and 1,631 miles.

The Great Lakes are entirely comprised of the internal

Boat crews from the U.S. Coast Guard and Royal Canadian Mounted Police conduct shiprider training along the shared U.S.-Canada border on the Detroit River in December 2012. Coast Guard photo by Petty Officer 2nd Class Jerry Minchew

waters of the U.S. and Canada with a 1,500 mile international maritime border dissecting most of the region. The United States has near complete authority over the waters and the vessels in its portions of the Great Lakes,[4] tempered only in instances where there has been an agreement to cede authority, for example, by treaty. However, Canada's authority over people and vessels within the internal waters of Canada, to include U.S. Coast Guard personnel and vessels, mirrors that of the United States'. To add to the complexities, the District is home to tribal nation territories, some of which span the international border.

The AOR encompasses much more than just the five Great Lakes. In fact, a great deal of the District's operational resources—ice breaking, law enforcement, security, and search and rescue—target its internal river systems, most notably the Detroit-St. Clair River system connecting Lake Erie to Lake Huron, and the St. Marys River system connecting Lake Huron to Lake Superior. The international border bisects the rivers in a manner similar to that of the lakes; generally straight down the middle. In the relatively narrow river systems, the unique geography can impact operations, especially law enforcement and maritime security missions.

If people and vessels restricted their movement to one side of the border—similar to the way they would with a land border—the Coast Guard would encounter few issues. However, recreational and commercial vessels weave in and out of U.S. and Canadian waters, taking the most expeditious or preferred route with little regard to the international maritime border.

The Coast Guard is able to execute certain mission sets—search and rescue, ice breaking, aids to navigation, etc.—without significant concern for the international border. However, Canada and the U.S., generally, prohibit each other from carrying out national security or law enforcement functions in each others' waters. The complexities of engaging in prolonged security or law enforcement actions on vessels in the Lakes are enormous; the complexities of security or law enforcement actions in the river systems are even greater.

For many D9 units, safe navigation requires transits through Canadian waters. Just north of Detroit, Station Belle Isle is a great example of the daily challenges some D9 units face based on proximity to the international border. The Station's docks lay less than 250 feet from the Canadian border, making it almost impossible to get underway without crossing into Canadian waters.

Challenging Areas on the Great Lakes' International Border

There are five geographic areas within the AOR where the international border creates significant challenges including:

- Alexandria Bay at the western end of the St. Lawrence River in upstate New York
- Niagara River, New York
- Put-In-Bay, Kelleys Island, and Marblehead in western Lake Erie
- the Detroit-St. Clair River
- Sault Ste. Marie, Michigan

Historical Challenges

The Coast Guard and its Canadian partners rely upon treaties, memorandums of agreement and understanding, diplomatic notes, and other related documents to outline roles and responsibilities as they relate to binational or transnational icebreaking, search and rescue, and aids to navigation work. These agreements largely allow each nation's assets to operate in the other's waters subject to appropriate notice and coordination. However, the exercise of law enforcement and maritime security—often requiring weapons—implicate special sovereignty concerns and are far more complicated.

D9's multiyear effort to obtain permission for Coast Guard members to carry weapons in Canadian waters is a powerful example of these types of challenges. In other Districts, members carrying personal defense weapons—or most any weapon—in the execution of normal operations is wholly uncontroversial. Cutters transiting through territorial waters of a foreign nation can rely on the concept of innocent passage. However, as noted above, the Great Lakes are comprised entirely of internal waters of the U.S. and Canada; where there is no innocent passage.

Until 2012, Canada's policy required that Coast Guard vessels dismantle and stow armaments, including, in theory, personal defense weapons, while in Canadian waters or ports. Deck-mounted automatic weapons (MAWs) had to be removed from weapon mounts and stowed in the boat cabin—requiring underway disassembly and reassembly—when entering Canadian waters. This held true even when that entrance was for transit only and necessitated by safe navigation with no intent to operate or remain in Canadian waters.

One can imagine the operational constraints as applied to units, like Station Belle Isle, that cannot safely leave the dock without entering Canadian waters. While D9 engaged on the issue over the years, change required more than three years of intensive engagement between the District, Coast Guard Headquarters and Atlantic Area Command, the Department of State, the U.S. Embassy in Ottawa, and Canadian officials. In the meantime, the District embarked on a pilot program to

The Soo Locks, located in Sault Ste. Marie, Michigan, and operated by the Army Corps of Engineers, ensure safe, economical transportation of raw materials and other goods between Lake Superior and industrial hubs like Detroit, Cleveland, and the Chicago region along the lower Great Lakes. Coast Guard photo by Chief Petty Officer John Masson

transit Canadian waters without stowing weapons.

In 2015, the Canadian government provided the Coast Guard and U.S. Customs and Border Protection (CBP) an exemption order allowing teams to transit certain Canadian waters while carrying specific fully assembled firearms and MAWS. However, the exemption order has certain conditions. For example, the Coast Guard and CBP must provide Canada with lists of members carrying weapons, and carriage is only allowed to transit to U.S. operational areas. This is just one example of the complications D9 faces in executing seemingly routine Coast Guard missions and policies.

U.S. and Canadian Partnerships: Maritime Law Enforcement

The most high-profile U.S. and Canadian maritime law enforcement collaboration is the Integrated Cross-Border Maritime Law Enforcement Officer (ICMLEO) program, which began as a pilot in 2005 to address maritime border security concerns. The stated goals of the ICMLEO program are to "prevent, detect, suppress, investigate, and prosecute criminal offences or violations of law including, but not limited to, illicit drug trade, migrant smuggling, trafficking of firearms, the smuggling of counterfeit goods and money, and terrorism."

The program allows Coast Guard Boarding Officers and Royal Canadian Mounted Police (RCMP) Officers to become ICMLEO officers, or cross-border maritime law enforcement officers with cross-border law enforcement authority. After completing the training, Coast Guard members can be designated as Canadian Peace Officers while operating in Canada and can enforce Canadian laws under the control and direction of a present Canadian RCMP officer. Similarly, RCMP members can be designated Customs Officers (excepted) under Title 19 of the United States Code when operating in the United States and can enforce U.S. laws under the control and direction of a present U.S. Coast Guard boarding officer. While the ICMLEO program is also conducted in the Pacific Northwest and the Northeast, the bulk of the missions are conducted on the Great Lakes due to its lengthy shared maritime border with Canada.

The ICMLEO program has strict training requirements, but the COVID-19 pandemic greatly impacted all aspects of life, including closing the U.S.-Canada border to most travel. This not only hit pause on training, but the ICMLEO mission as well.

Units came up with a solution to overcome the COVID-19 related challenges. On the Great Lakes, Coast Guard and RCMP personnel decided to conduct joint patrols by mirroring assets on either side of the border.

ICMLEO officers conducted 24 of these mirrored patrols to deter cross-border criminality and improve the maritime domain awareness. This is just one example of the creativity needed to provide the necessary enforcement activities on the Great Lakes.

Set to expand in 2022, the ICMLEO program plans to designate Coast Guard Station Duluth, Minnesota, as an ICMLEO unit. Station Duluth's primary AOR is on Lake Superior, but also includes Lake of the Woods, a remote area along the U.S.-Canada border that is popular for sport fishing and other outdoor activities. The remoteness increases the difficulty in providing federal law enforcement coverage and the chances the area could be exploited for unlawful activities. With their new ICMLEO authorities, Station Duluth will now be able to work more effectively with its RCMP counterparts.

While the Coast Guard and Canada have developed creative and effective collaborations to address law enforcement operations in the binational environment, the COVID-19 pandemic exposed many weaknesses in ICMLEO, as well as many other cross-agency initiatives. As the United States starts to emerge from the worst of the pandemic, the District is taking lessons learned and seeking to rebuild a better, more effective binational law enforcement partnership.

Further, while ICMLEO is an effective tool, it does not solve all challenges related to enforcing U.S. laws near the Canadian border. ICMLEO cannot address impromptu law enforcement situations, since a host country ICMLEO officer—an RCMP officer in the case of Coast Guard operations—must be on-board the visiting country's vessel and available to direct operations within the host country's waters. For that reason, ICMLEO activities are preplanned operations. For example, absent significant preplanned coordination, a Coast Guard boarding officer cannot pursue a subject who crosses the maritime border.[5]

Maritime Safety and Security in U.S. Internal Waters of the Great Lakes

The Ports and Waterways Safety Act (PWSA) authorities are perhaps the most important authorities in a Captain of the Port's (COTP) toolbox. The PWSA provides the Coast Guard with broad authority to regulate the movement and operation of vessels subject to the jurisdiction of the United States. COTPs may direct the movement of vessels, respond to acts of terrorism, and investigate any incident that causes damage to or affects the safety of a U.S. port or waterfront facility.

The PWSA, as codified in Title 46, United States Code, Chapter 700, and applicable U.S. and Canadian treaties permit the Coast Guard to board foreign vessels transiting U.S. internal waters of the Great Lakes, regardless the vessels' intended destination. However, the Coast Guard has, by agency policy, limited its authorities. Coast Guard policy, as outlined in the Maritime Law Enforcement Manual, prohibits Coast Guard COTPs and operators from exercising the PWSA on foreign-flagged vessels destined for a foreign port. This is the case even if the vessels are transiting internal U.S. waters, and thus,

Boat crew members from Coast Guard Station Belle Isle and Sector Detroit train with boat crew members from the Royal Canadian Mounted Police during a ICMLEO training exercise on the Detroit River between Windsor, Ontario, Canada, and Detroit in October 2012. Coast Guard photo by Petty Officer 2nd Class Levi Read

The Ambassador Bridge connects Detroit and Windsor, Ontario, Canada. Between 8,000 and 10,000 trucks transit the bridge each day. Michigan National Guard photo by Specialist Samantha Hall

by definition, not in innocent or straits passage.

In most Coast Guard districts, the existing policy wording has no consequence. However, the ramifications are significant for the internal waters of the Great Lakes since, every year a dozen or so ocean-going, foreign-flagged vessels transit the entire Great Lakes-St. Lawrence River Seaway System to the Port of Thunder Bay, Ontario, on Lake Superior. The St. Lawrence River is the single entry point for ocean-going vessels to access the Great Lakes, and the full transit to Thunder Bay takes about 119 hours. Even though they will never moor in a U.S. port, vessels come within 1,500 feet of major U.S. cities, cross under key infrastructure, including the Ambassador Bridge, and lock through the Sault Ste. Marie Locks, a critical chokepoint for the Great Lakes-Seaway system.

Conclusion

There are no easy solutions to the Ninth District's challenges. In fact, layered on top of them is the fact that persons who have never served in D9 can have a difficult time conceptualizing the AOR, its challenges, and appropriate solutions. However, through diligence and education, the District hopes to continue to move the needle closer to a safer and more secure waterway.

About the authors:

MECS Jonathan Bowden joined the Coast Guard more than 20 years ago. An operational law enforcement expert, he has station, sector, cutter, Tactical Law Enforcement Team, and Maritime Safety and Security Team experience.

CDR Geralyn van de Krol started her Coast Guard career on the Great Lakes 20 years ago, serving as a quartermaster on the since-decommissioned Coast Guard Cutter Mackinaw *(WAGB-20). She currently serves as the Ninth District's Deputy Staff Judge Advocate.*

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3. Ibid
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5. Canada does not permit the U.S. to conduct hot pursuit into Canadian waters
6. 33 C.F.R. 160.103 utilizes this same "and" language
7. For example, when discussing a COTP's authority to issue orders, the MLEM states: "PWSA COTP orders may not be issued to vessels on the Saint Lawrence Seaway, nor may they be issued to foreign flagged vessels engaged in innocent passage, transit passage or otherwise not bound for or departing a U.S. Port." Similar references are made as relate to Safety Zones, RNAs, SLRs, and vessel boardings conducted under PWSA

D9 Reservists Go Rogue!

'Rogue' response exercises facilitate preparedness

by CAPT Caroline Beckmann
Senior Reserve Officer
Ninth District
U.S. Coast Guard

The Coast Guard's Ninth District Response Division's Incident Management Branch oversees the response to all major incidents within the Great Lakes, including search and rescue, environmental, maritime law enforcement, and defense readiness, as well as ports and waterways security. It is imperative that all personnel and resources are trained and organized to respond to emergencies, regardless of size or type. This readiness enables all active duty, reserve, auxiliary, and civilian personnel to respond not only within the Ninth District, but to any national or international incident where such skilled personnel are needed.

The September 11 terrorists attacks, Hurricane Katrina, Deepwater Horizon, and many others have demonstrated the need for Coast Guard Reservists to be ready to augment the active-duty workforce in the event of a national emergency. The Incident Command System (ICS), a standardized approach to the management of an emergency response, is the common set of practices used by all federal organizations involved in a response. Within the Ninth District, the District Response Advisory Team (DRAT) reservists have initiated the Rogue series of exercises, an innovative approach to training members using ICS as the backbone. This provides opportunities for active duty and reservists to advance members seeking billet-assigned competencies and ICS qualifications, improving overall District readiness.

Reservists plan the Rogue exercises as an annual event to facilitate training and qualification on ICS response to various incidents. Executed in 2017, Rogue I was planned as a two-day event, with two operational periods encompassing communication and coordination of the plans, policies, and procedures used by entities within the Ninth District to respond to an oil spill. The scenario included a shipping vessel, *Rogue I*, which suffered an allision with an unknown object on the Cuyahoga River. This resulted in a discharge of 6,000 gallons of #2 diesel. Participants ran a simulated response to that scenario using ICS principles to overcome the challenges associated with a large-scale response.

Rogue I provided participants with the opportunity to exercise the Continuity of Operations Plan, setting up a site to test all of the assigned equipment for the first day of the exercise. This transitioned into setting up the Incident Command Post and filling all the roles of a traditional ICS structure. Each ICS section had a coach guiding and educating them to make decisions and manage the incident in a way that allowed the incident commander's priorities and objectives to be met and an incident action plan to be completed. By participating in this exercise, 45 active duty, reservists, and auxiliarists obtained sign-offs on their performance qualification standards and worked towards obtaining ICS position qualifications, with 12 members completing them. Because of Rogue I's

CDR Cory Taylor, a District 9 Incident Management Senior Reservist, conducts a planning meeting as part of the Rogue IV exercise held in April 2022. Coast Guard photo by CAPT Caroline Beckmann

initial success, the DRAT team, along with the District's Planning and Force Readiness Branch, made it an annual exercise to facilitate progress towards training, qualifications, and overall enhanced readiness throughout the District.

A great deal of planning goes into the exercise each year, including the evaluation of the aspects most useful in helping participants achieve results. The scenario is designed around participants, their ICS positions, and how much of their qualification they have already completed. This enables participants to work towards qualifications in an exercise situation and benefit from the hands-on experience.

Another key piece of the Rogue exercise is the Incident Management Software System (IMSS). IMSS is the Coast Guard's primary tool for incident management and is used in all real-life incidents. The exercises incorporate training on IMSS and participants are expected to become familiar with it prior to the start of the exercise. An IMSS coach is on hand during the exercise to provide guidance on best practices for the system.

Rogue IV, held in April 2022, had 35 participants from eight units throughout the District, and resulted in 11 total ICS qualifications. The design team presented a scenario in which division and group supervisors responded on-scene to an overturned oil truck that had caused an oil spill on the Ashtabula River, east of Cleveland. Responders used a small boat to deploy boom on the river, giving operators hands-on experience with booming strategies.

Containment boom is deployed across the Ashtabula River east of Cleveland, as part of the Rogue IV exercise held in April 2022. Coast Guard photo by Petty Officer 2nd Class Emily Duffy

Rogue IV added a new element by way of an Air Operations Branch drone providing aerial pictures of the actual incident area and adding a realistic element to the exercise.

The Rogue series of exercises have been incredibly successful in increasing the Ninth District's overall readiness. By providing scenarios for members to work towards billet-assigned competencies and ICS qualifications, more personnel are ready to deploy to a large-scale incident or national emergency, regardless of location. Ready, relevant, and responsive—D9 reservists go Rogue!

About the author:

CAPT Caroline Beckmann has served in the U.S. Coast Guard for more than 19 years. She spent five years on active duty and the remainder of her career in the Coast Guard Reserve as a Senior Reserve Officer and Emergency Preparedness Liaison Officer.

Great Lakes Environmental Response

Protecting a binational, freshwater treasure

by Jerome A. Popiel
Incident Management and Preparedness Advisor
Ninth District
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The Great Lakes are a binational treasure[1] and, together with the St. Lawrence River, form the largest freshwater system on Earth. This system greatly affects all aspects of the region's natural environment, from weather and climate, to wildlife and habitats, as well as the way of life for tens of millions of people. As just one of its stewards, we marvel at, and work to protect, the Great Lakes' incalculable value. That is "Job One" for the Ninth Coast Guard District's Marine Environmental Response program.

In light of past and present widespread public interest in the transportation of crude oil through the region, the District's preparedness for environmental response on the Great Lakes has been studied, analyzed, and reported to Congress over the past decade. This welcomed scrutiny shows that the District has continued to

Gorgeous sunsets, like this one over Lake Michigan near Glen Arbor, Michigan, are just one of the many reasons the Great Lakes are so beloved. The Coast Guard's Ninth District works to protect and preserve the lakes, not only for those who enjoy recreational opportunities, but for those who depend on them for their livelihood. Photo by Jerome A. Popiel

As part of a summer 2021 exercise, CGC *Mackinaw* deploys a U.S. Navy Supervisor of Salvage Skimming System in Lake Erie, off the coast of Cleveland. Photo courtesy of Jerome A. Popiel

meet or exceed all of its statutory and regulatory requirements, and has resulted in several noteworthy response successes. But there is still work to be done, particularly in areas of research, development, and evaluation of emerging technologies in freshwater conditions ranging from Arctic-like cold through triple-digit heat.

First Nations describes Indigenous peoples in Canada who are not Métis or Inuit.

Great Lakes, Great Stakes

Despite its size and power, the Great Lakes ecosystem is delicately balanced and can be susceptible to abuse or misuse. Stakeholders' ability to achieve the optimal balance between responsible use and holistic protection of wildlife and habitat lies at the center of a number of ongoing debates. Tensions arise between competing interests regarding environmental stewardship and commerce, often with few simple solutions. The future of crude oil transport via pipelines is just one example. The Coast Guard is a neutral party in these debates but must remain prepared to address the challenges posed. Adding to the difficulty, the governance of the Great Lakes region is divided among eight states abutting two Canadian provinces along a 1,500-mile international border overlap. Federal jurisdictions, in addition to those of several dozen tribal and First Nation entities, are also part of this mosaic.

Explored, Then Exploited

During colonization of North America, many generations of expanding populations first explored, then exploited, the Great Lakes. North America's Industrial Revolution only served to speed this exploitation, as the Great Lakes shorelines became magnets for population growth, anchoring major cities like Milwaukee, Chicago, Detroit, Cleveland, as well as Buffalo and

Rochester, New York, and Toronto, Windsor, Hamilton, and Burlington, Ontario. Tens of millions of residents now rely upon the Great Lakes for their freshwater supply.

Besides providing a source of potable water, the Great Lakes also provide water for industrial facility cooling, hydroelectric and thermoelectric generation, over-water shipping, irrigation, and a number of other consequential uses. According to a 2020 Great Lakes Commission report, approximately 38 million gallons of water per day are withdrawn from the Great Lakes, most of which are treated and returned to the source.

Harmful algal blooms, dead zones, and fish kills are the results of a process called eutrophication, This process begins with an increased load of nutrients to estuaries and coastal waters, like the one that occurred in September 26, 2017, in western Lake Erie, near Toledo, Ohio. The bloom stretched all the way to Lake Ontario. Photo courtesy of National Oceanic and Atmospheric Administration

Increase in Polluting Trends

Over the course of more than a century, the region developed massive trade, industrialization, and transportation infrastructure. This rapid, unchecked growth and lack of environmental awareness created large-scale pollution and contamination. A telling quote from immigrant Frantisek Vlcek's book, *The Story of My Life*,[2] describing the Cuyahoga River in the 1880s illustrates this point.

> *Yellowish-black rings of oil circled on its surface like grease in soup. The water was yellowish, thick, full of clay, stinking of oil and sewage. Piles of rotting wood were heaped on either bank of the river and it was all dirty and neglected… I was disappointed by this view of an American river.*

As part of a 2017 tabletop exercise with on-water demonstration, a containment boom is deployed near Manistique, Michigan. Photo by Jerome A. Popiel

This polluting trend eventually led to touchstone events, including nine reported fires on Cleveland's Cuyahoga River in the mid-1900s. These were just a few of the infamous, and spontaneous, fires on the river over several decades. In addition, heavy metals entered the Lakes and tremendous amounts of phosphorous from various sources caused the eutrophication of shallow parts of some Lakes.

Trends Reversed

After decades of the above examples of pre-modern

practices and public outcry, this trend was eventually altered to a large extent. Concerned citizen groups and key initiatives like the Clean Water Act, the Federal Water Pollution Control Act, and the 1972 and 1978 Great Lakes Water Quality Agreements, including the Canada-U.S. Joint Marine Contingency Plan, played a large role in this. Since the 1972 agreement, 43 areas of concern were identified—26 located in the United States, 12 in Canada, and five shared by both countries. As a result of collective efforts, the Great Lakes have experienced an overall rejuvenation. Environmentally speaking, the region has been through a lot historically, and has come a long way from the pollution situation of the late 19th and early 20th centuries.

These largely successful efforts have paved the way for a massive recreational and tourism economy based on use of the Great Lakes system. Today's Great Lakes sport fishing economy alone is estimated at several billion dollars annually. Additionally, large portions of regional and local economies rely on access to pristine, uncontaminated Great Lakes waters, shoreline, and wildlife species for myriad uses. A catastrophic pollution event would likely have a major negative impact, not only on these resources, but the economies that rely on them.

Because of the elevated sensitivity of Great Lakes freshwater, some spill response considerations are different from those on the saltwater coasts. The spill category classifications in the National Contingency Plan (40 CFR 300), for example, are set an order of magnitude less than in saltwater, making a spill between 1,000 and 10,000 gallons a "medium" and above 10,000 gallons a "major" spill. This contrasts with the classifications for saltwater coastal zones where a spill less than 10,000 gallons is "minor," between 10,000 and 100,000 gallons a "medium," and more than 100,000 gallons a "major." Additionally, since the Great Lakes serves as a drinking water source for millions of U.S. and Canadian citizens, there is no pre-approved use of dispersants or other chemical agents for response on the Great Lakes making mechanical methods of cleanup the norm.

Domestic Energy Renaissance

Presently, the United States relies on a system of oil and hazardous material transportation conducted by vehicle, rail, vessel, and pipeline throughout the region. The transportation and use of potential pollutants, like oil and hazardous substances, can cause conflicts between commercial practice and ecological safeguards.

Oil production from the United States and Canadian Midwest has increased dramatically over the past few decades as a result of the extraction of shale and oil sand substances from regional deposits. Significant percentages of these crude oil products are presently transported to, or through, the Great Lakes/Midwest region via several modes—primarily pipelines and rail cars. Rail shipments of crude oil products through the region have increased more than tenfold over the past decade, with some leveling-off in the past few years. These modes cross the Great Lakes or their tributaries in several places and run alongside or nearby Great Lakes shorelines in a number of other areas.

This distribution system clearly provides socioeconomic benefit to millions of regional residents, but with it brings the risk of accidental release into the environment. The ability of this oil and hazardous material transportation system to continue harmoniously depends on stakeholders' capability for preventing spills from occurring and aggressively responding when they do occur.

Acknowledging this Midwestern "energy renaissance," and the resulting increase in transportation risk, the Ninth District continues to focus on assessing the effectiveness of oil spill response activities specific to the Great Lakes. This includes evaluating new research into oil spill impacts in fresh water under a range of conditions, and ongoing evaluation of oil spill prevention and clean up contingency plans.

Coast Guard pollution responders from the Ninth District and Sector Buffalo use a remotely operated vehicle to conduct underwater detection of oil resulting from a 2022 spill at a power plant near Oswego, New York. Coast Guard photo

2010 Inland Pipeline Spill and Its Echoes

While much of the marine environmental world was watching the Deepwater Horizon disaster in the Gulf of Mexico on July 25, 2010, a segment of a 30-inch-diameter pipeline—Line 6B, owned and operated by Enbridge Incorporated (Enbridge)—ruptured in a wetland in Marshall, Michigan. According to the Coast Guard's 2018 Report to Congress:[3]

> *The rupture occurred during the last stages of a planned shutdown and was not discovered or addressed for over 17 hours. During the time lapse, Enbridge twice pumped additional oil (81 percent of the total release) into Line 6B during two startups; the total release was estimated to be 843,444 gallons of diluted bitumen, or dilbit. The lighter components of the oil evaporated into the air, leaving the heavier components to weather and drift in the water column, eventually sinking to the river bottom. The oil saturated the surrounding wetlands and flowed into Talmadge Creek and the Kalamazoo River. Local residents self-evacuated from their houses, and the environment was negatively affected. Cleanup costs exceeded $767 million per the National Transportation Safety Board's report. About 320 people reported symptoms consistent with crude oil exposure. No fatalities were reported. …*
>
> *In January of 2012, pipeline safety legislation; Public Law 112-90, Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011 was signed into law by President Barack Obama. The new law contains provisions related to public awareness, response plans, leak detection, and the transportation of dilbit. In addition, this spill brought public awareness to pipelines across the Midwest and Great Lakes region, highlighting sensitive crossings such as Line 5 at the Straits of Mackinac.*

Part of a 2013 Coast Guard research and development project, this oil-in-ice demonstration in the Straits of Mackinac, between Michigan's upper and lower peninsulas, led to the development of the Coast Guard's Oil-in-Ice guide for federal on-scene coordinators. Photo by Jerome A. Popiel

This event served as a wake-up call to concerned interests in the state of Michigan and elsewhere who were not aware of crude oil pipelines traversing the state. For many, it brought to attention the existence of Line 5 for the first time, and precipitated, among other actions, the state's establishment of a pipeline advisory board to address the issues surrounding crude oil pipelines.

In 2016, the Ninth District undertook a project to completely overhaul, update, and reissue all coastal zone Area Contingency Plans that the Coast Guard is responsible for in the Great Lakes and the St. Lawrence Seaway. During the extensive effort, Coast Guard planners incorporated best practices from around the country, coupled with freshwater and Great Lakes-specific considerations, earning full Area Contingency Plan re-approval by the Ninth District Commander.

Report to Congress

In the Coast Guard's 2016 Authorization Act, Congress directed the service to conduct a response preparedness study on the Great Lakes in an attempt to address constituents' concerns about the response to spills from crude oil pipelines in Michigan. The Commandant of the Coast Guard established a multi-agency team to conduct the study, which included a review of available research, case studies, applicable law and regulation, and lessons learned from exercises, training and preparedness assessment visits.

The report, acknowledging and reaffirming the Ninth District's extensive efforts to protect the Great Lakes, was submitted to Congress in 2018.[4] It concluded:

> *The current response plans and capabilities developed and maintained by the Coast Guard and its partners in the Great Lakes fulfill all statutory and regulatory response requirements. Because of widespread preventative measures, frequent exercises and drills, and strict enforcement, major and medium spills in the Great Lakes coastal zone occur infrequently. This track record is indicative of a system of preparedness and response that has successfully safeguarded Great Lakes waters from significant environmental damage wherever possible.*

Great Lakes Oil Spill Center of Expertise

In the Coast Guard's 2018 Authorization Act, Congress subsequently directed the service to establish a center of expertise for Great Lakes oil spill preparedness and response, which is called the U.S. Coast Guard Great Lakes Oil Spill Center of Expertise (GLCOE). The Assistant Commandant for Response Policy established an integrated project team to oversee the process of establishing the center, including studies by the Homeland Security Operations Analysis Center, site visits, and dozens of interviews with stakeholders and potential site hosts. The GLCOE is located at two sites. The first is co-located with Lake Superior State University in Sault Ste. Marie, Michigan. The second is co-located with the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan. The Center will be fully staffed by eight personnel and is focused on filling oil spill response gaps in fresh water and cold weather environments, research and development, testing of new response technologies, and training.

Endangered Species Act Compliance and Environmental Sensitivity

Initial funding for the GLCOE enabled the Ninth District to complete an Endangered Species Act Biological Evaluation. The evaluation is intended to serve as a regional, programmatic consultation with the U.S. Fish and Wildlife Service and the Department of the Interior regarding response tactics and their effects on species and habitats. This marked the first time this type of evaluation has been conducted on the Great Lakes for spill response, providing a wealth of information for both pollution responders and biologists who advise responders during cases.

In conjunction with our NOAA partners, the Coast Guard co-sponsored a complete renewal of the Environmental Sensitivity Index Maps for much of the Great Lakes, particularly the connecting waterways and high-sensitivity areas like the Straits of Mackinac, the St. Marys and Detroit rivers, and the St. Lawrence Seaway. This data greatly assists planners and responders in their efforts to adequately address the needs of sensitive areas and habitats.

New Use of Technology for Response

In addition to planning, preparedness, and exercises, the Ninth District has been aggressive in adapting technologies for spill response. While remotely operated vehicles and unmanned aerial systems are not new, Ninth District responders have been optimizing their use and are committed to working with the interagency to develop and use technology to best protect the Great Lakes, a true national treasure.

Future

Building on the long history of preparedness and response to oil and hazardous materials spills, the Ninth District is well-poised for response into the future. The Ninth District is in fact "*semper paratus*," in the Straits of Mackinac and elsewhere, and is committed to maintaining that status. Our excellent partnerships with the U.S. Environmental Protection Agency, NOAA, states, tribes, and the Canadian Coast Guard, among many others, make these efforts possible. The work is never done, as risks will exist as long as people and nature coexist, but the District's Marine Environmental Response program continues to make great strides.

About the author:

Jerome A. Popiel has served 30 years with the U.S. Coast Guard, as incident management and preparedness advisor, search and rescue specialist, group operations officer, public affairs officer, admiral's aide, 47' MLB program manager and shipboard engineer. He also served as assistant vice president of operations for The Great Lakes Towing Company.

Endnotes:

1. Executive Order 13340 Establishment of Great Lakes Interagency Task Force and Promotion of a Regional Collaboration of National Significance for the Great Lakes
2. *The Story of My Life*, Frantisek Vlcek
3. U. S. Coast Guard Report to Congress, Great Lakes Oil Spill Response and Cleanup Activities Assessment, November 21, 2018, Appendix 2
4. U. S. Coast Guard Report to Congress, Great Lakes Oil Spill Response and Cleanup Activities Assessment, November 21, 2018, p. 22

Canada–U.S. Joint Marine Contingency Plan, Great Lakes Annex

Coordinated operations are a way of life on the Great Lakes

by Jerome A. Popiel
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Amanda Greer
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Canada and the United States are extraordinary teammates in pollution response on the Great Lakes; a necessity in the event of a pollution incident which could impact both countries, especially where one nation's shoreline is visible from the other's. Through cooperative efforts, responders and planners from both nations have established an effective framework, practices, and relationships that enable operations to be closely coordinated. That framework is called the Great Lakes Operational Supplement to the Canada-U.S. Joint Marine Contingency Plan[1] (CANUSLAK Annex) and it formalizes the way coordinated marine environmental response operations are executed on United States' and Canada's shared waters, including the Great Lakes.

Canadian Coast Guard Assistant Commissioner Marc-Andre Meunier, left, and Ninth Coast Guard District Commander RADM Michael Johnston signed the CANUSLAK Annex in Montreal, Quebec, Canada, on March 14, 2022. Coast Guard photo

Great Lakes Water Quality Agreement

The Canadian Coast Guard (CCG) and United States Coast Guard Joint Marine Pollution Contingency Plan[2] was initially jointly developed for the Great Lakes region in 1974. This followed the establishment of the Great Lakes Water Quality Agreement in 1972, which formalized the requirement for the Great Lakes Annex in Article 6. In 1983, both countries agreed to add four additional geographic annexes: Atlantic Coast; Pacific Coast; Dixon Entrance, Alaska; and the Beaufort Sea. Coast Guard District Commanders and CCG Regional Directors are responsible for reviewing, updating, and exercising each regional annex, where Canada and the United States share borders. However, because there are several key Great Lakes and St. Lawrence Seaway "choke points" near population and industrial centers for both nations, binational pollution incidents have historically occurred in the Great Lakes region more frequently than in the other regions. In some of these areas, like the St. Marys, St. Clair, Detroit, Buffalo, Niagara, and St. Lawrence rivers, the distance over water between the United States and Canada can be very short indeed, making close cooperation a necessity. Because of this, the Great Lakes region remains the most frequently activated. The nations enjoy seamless coordination between their coast guards and lead all regions in notifications, activations, successful responses, and innovations.

Coordinated Response

One of the key tenets in the Joint Marine Pollution

Contingency Plan is coordinated response. The plan and annexes acknowledge that each nation has its own pollution response regime, subject to its laws, regulations, and governmental structures. These necessary sovereignty considerations frequently make a completely unified command impractical during responses. Instead, decades of regional experience have shown that a *coordinated* response is the preferred choice. Coordinated response can, and often does, include some co-location of coordinating personnel, which can also be accomplished virtually using teleconferencing tools.

Enter the International Coordinating Officer

As a best practice to achieve the international coordination contemplated in the Joint Marine Pollution Contingency Plan, the Canadian Coast Guard's Central Region and Coast Guard's Ninth District developed the International Coordinating Officer position. With some similarities to the Incident Command System's Liaison Officer and Agency Representative positions, the International Coordinating Officer elevates and transcends those responsibilities by employing a Senior Response Officer or Federal On-Scene Coordinator. Capitalizing on experience and lessons learned from two decades of exercises and real-world incidents, the International Coordinating Officer position has proven to be an effective construct to achieve coordinated response while maintaining close international cooperation.

Binational, regional experience has shown that, in instances of spills with international impacts, complete co-location of both Canadian and U.S. command structures and response organizations is usually unlikely due to funding, legal, logistical, political, media, and geographical constraints. Coordinated response, however, remains a chief tenet. Accordingly, the Great Lakes Annex specifies a "geographically separated command structure" that uses an International Coordinating Officer or team to attain the prerequisite coordination. In practice, one of two scenarios generally occur in the coverage area. Either a spill incident primarily affects the internal waters of one nation with minimal or only potential impacts to the other nation, or there is equal impact. In the case of the former, it is usually appropriate for the primarily impacted nation to establish a robust incident-specific response organization and request an International Coordinating Officer or team from the other nation for either on-site or virtual participation.

In the instance of a spill incident that produces equal effects on both sides of the border, it is expected that both nations will establish robust incident-specific response organizations and exchange International Coordinating Officers or teams as needed, for either on-site or virtual participation.

Beyond Liaison Officer or Agency Representative

Liaison Officer and Agency Representative positions are conduits of information, generally without authority to make decisions on key matters, though theoretically this can be authorized. An International Coordinating Officer is a knowledgeable, senior representative who will typically have some decision-making authority and ability to order resources and coordinate support from scientific and operational elements. Another defining characteristic of an International Coordinating Officer is fluency in the regimes of both nations.

Containment boom is deployment on the St. Clair River during a 2017 joint U.S.-Canadian exercise. The international border essentially runs down the middle of the river in this photo. Photo courtesy of Jerome A. Popiel

The extent of each International Coordinating Officer's authority will depend on the location, nature, and scope of each incident, as well as the preferences of the Incident Commander. It should be noted that an International Coordinating Officer will never exercise his or her own nation's Senior Response Officer or Federal On-Scene Coordinator authority over actions taking place in the other nation's sovereign territory. Those authorities will be exercised in accordance with the International

Coordinating Officer's own national policy in each jurisdiction, but coordinated with the other nation's actions. These officers may direct resources, like pollution overflights, across the international border in accordance with approved entry procedures specified in applicable treaties or binational memorandums of understanding.

T/B *Argo* sank in Lake Erie near the U.S.-Canadian border during a 1937 storm. In 2015, a response effort was mounted to pump out the 10,000 gallons of benzene remaining from the more than 100,000 gallons the vessel was carrying when it went down. Coast Guard photo

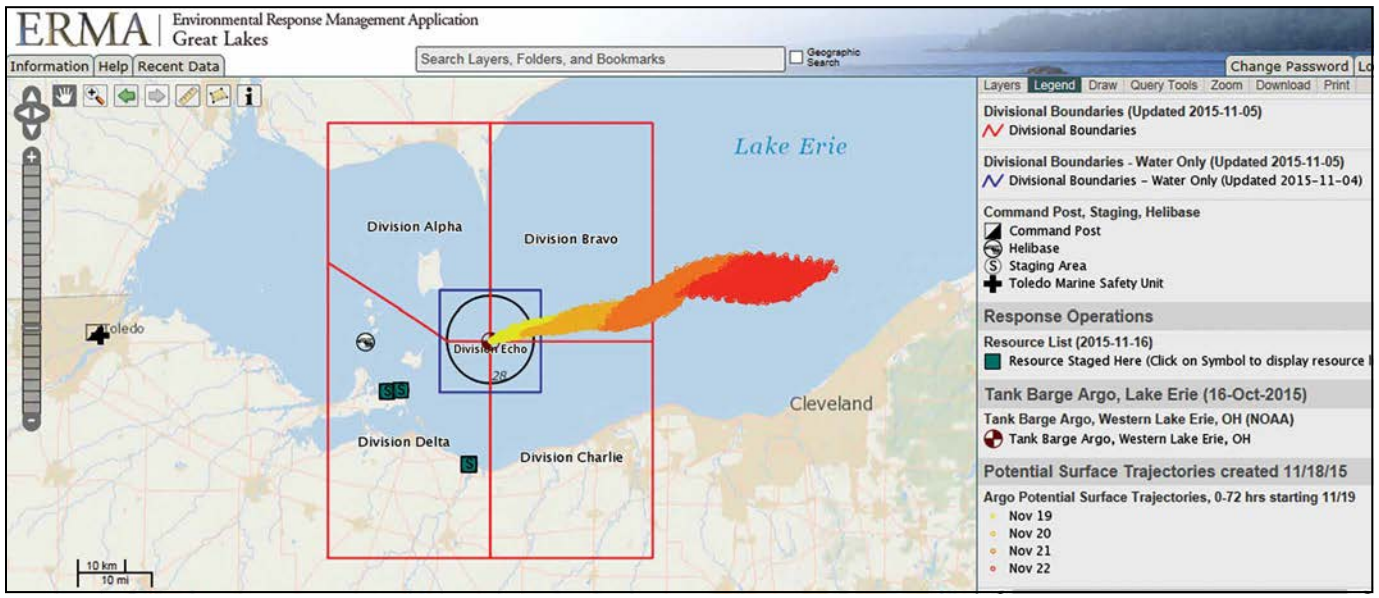
International Coordinating Officer Teams and Virtual Call Aid

The development of regular working relationships between key members of the Great Lakes Joint Response Team is critical. However, in some instances where staffing requirements dictate a larger international coordinating presence, an International Coordinating Officer team may be appropriate. These teams consist of several members who meet qualification guidance suggestions under the direction of a qualified International Coordinating Officer who is in charge of the team.

An International Coordinating Officer Virtual Incident Call job aid is another innovation. This aid is a procedural check sheet for how International Coordinating Officer personnel can employ virtual call tools to help manage binational incidents. During 2020–2021 pandemic conditions, in particular, most coordination took place virtually rather than in-person. The virtual procedures can be used during normal conditions on a variety of minor to medium incidents where physical co-location is not necessary.

Case Example: T/B *Argo*

Over the years, the CCG and the Coast Guard's Ninth District have activated the International Coordinating Officer for many exercises and real-world events. The Joint Response Team is typically notified or activated five to 10 times a year for real-world events while, on average,



Example of a binational common operating picture from T/B *Argo* response in 2015. Divisions Alpha and Bravo are in Canadian waters, while Charlie and Delta are in U.S. waters. Coast Guard graphic

this happens about once a year for exercises. Incidents range from commercial vessel groundings with potential releases, to minor spills with negligible impacts, or major responses where extensive binational coordination is required.

The response to the sunken tank barge *Argo* is a prime example of International Coordinating Officer teamwork. T/B *Argo* sank in western Lake Erie in 1937 while carrying approximately 4,700 barrels of petroleum products. The exact resting place was unknown until a Cleveland-area dive team discovered it in August 2015. The location was inside U.S. waters, but very close to the Canadian border. Initial investigation showed that product was still onboard and there had been at least one verified release of benzene detected via surface air monitoring. Because of the time elapsed since the sinking and the subsequent dissolution of any company ownership, a current responsible party could not be identified.

Containment boom is prepared for deployment during a 2019 joint U.S.-Canadian exercise on the St. Lawrence Seaway. Coast Guard photo

As Federal On-Scene Coordinator for the response, the Coast Guard established an incident command post in Toledo, Ohio. But because of the high potential for impacts to Canadian waters, the Canadian Coast Guard sent International Coordinating Officer team members to the incident command post while simultaneously maintaining their own response posture and organization structure in Canada.

The International Coordinating Officer team also worked closely regarding incident objectives, safety measures, and public affairs. News release content was jointly coordinated at the incident command post with each country releasing it through their respective press channels. The CCG team ordered and directed Canadian aircraft to conduct overflights, as well as ordering and coordinating Canadian scientific input for the incident.

The CCG's International Coordinating Officer team was able to facilitate the transmission of Canadian geographic information system data into the Great Lakes portal of the National Oceanic and Atmospheric Administration's Environmental Response Management Application. This allowed the incident command post to develop and display a truly binational common operating picture. Both U.S. and Canadian data regarding sensitive areas, species, water intakes, etc., were displayed on one geographic information system, which allowed for visualization of Canadian and U.S. pollution trajectories.

As a result of the coordination, responders successfully removed all potential polluting product from the *Argo*, thereby eliminating the threat to the environment and life, and meeting the sensitive area protection strategies of both nations.

Future

The CCG and Coast Guard recently revised and renewed their commitment to the CANUSLAK agreement in March 2022. This renews the robust cooperation that happens on a regular basis. The Great Lakes Joint Response Team continues to meet annually, as well as notify and activate for each incident as necessary. We are proud of the work that both organizations do to ensure a bright future for the environmental health of the Great Lakes, connecting waterways and tributaries.

About the authors:

Jerome A. Popiel has served 30 years with the U.S. Coast Guard, as incident management and preparedness advisor, search and rescue specialist, group operations officer, public affairs officer, admiral's aide, 47-foot MLB program manager, and shipboard engineer. He also served as assistant vice president of operations for The Great Lakes Towing Company.

Amanda Greer has been a public servant with the Canadian Coast Guard for 11 years, and is currently the Deputy Superintendent, Environmental Response. Her team is responsible for protecting the Great Lakes from pollution incidents.

Endnotes:

1. Great Lakes Operational Supplement to the Canada-United States Joint Marine Contingency Plan, signed March 14, 2022
2. Section 403, United States Joint Marine Contingency Plan, signed August 3, 2017

Emerging Technology and Response Tools

Preparedness on the Great Lakes

by Scott Binko
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The U.S. Coast Guard's Ninth District has been forward leaning in its approach to combating environmental threats to the Great Lakes. The freshwater and seasonally ice-laden environment presents response challenges like the presence of many large municipal potable water intakes, the prohibition of chemical countermeasures, and the lack of a history and capacity for in-situ burning. As such, responses required are distinctly different from those employed in saltwater. Because of this, Ninth District units have updated environmental sensitivity index maps, implemented lessons learned from salvage and marine firefighting task forces, and aggressively developed and adapted unmanned aerial systems, low-cost remotely operated vehicles, and oil-in-ice tactics and equipment.

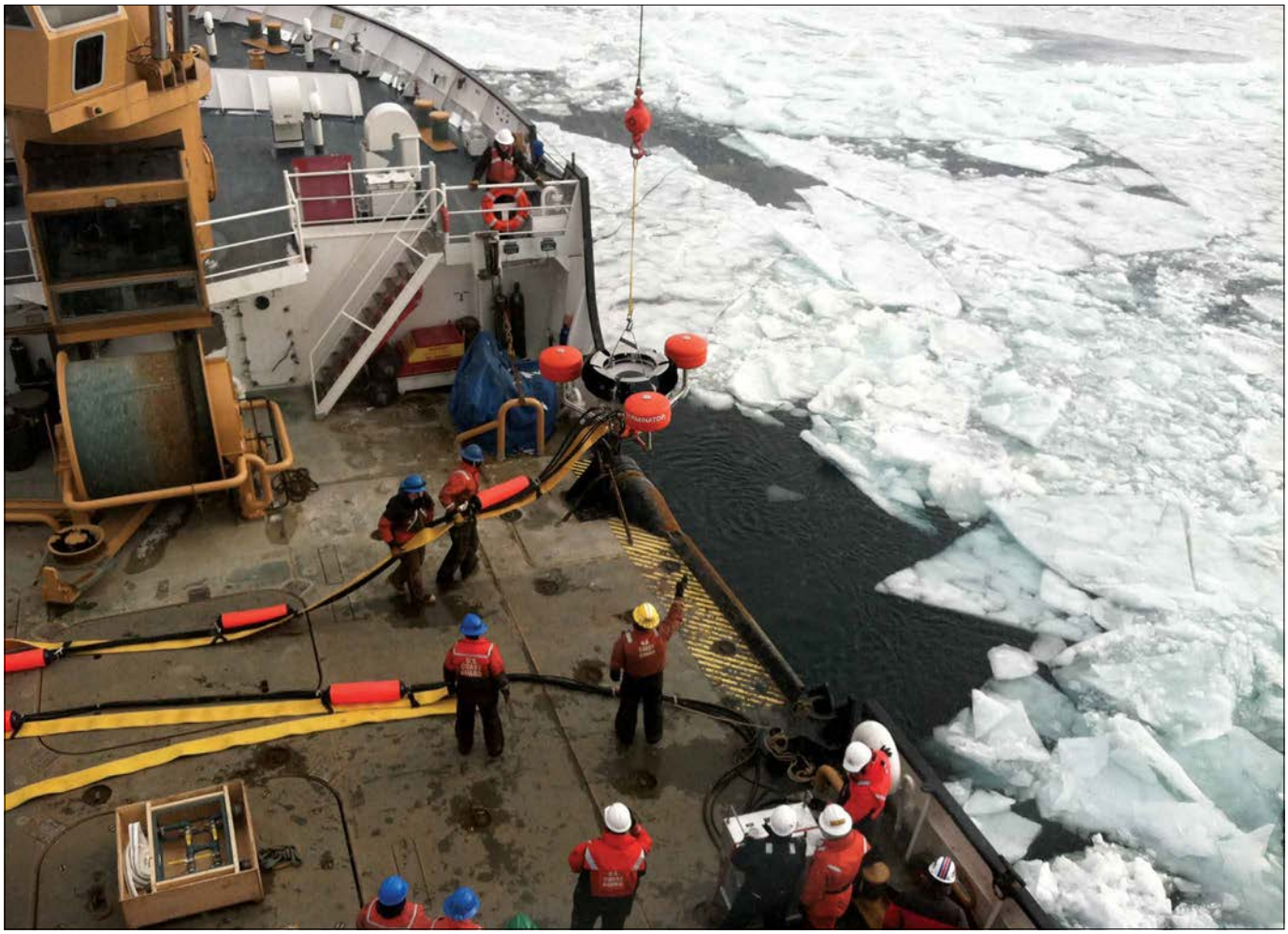
The freshwater and seasonally ice-laden environment presents response challenges … distinctly different from those employed in saltwater.

The Coast Guard's new Great Lakes Center of Expertise (GLCOE) for Oil Spill Response and Preparedness is tasked with conducting research, development, and testing surrounding freshwater oil spill response. This includes the analysis of equipment, technologies, and techniques to mitigate and respond to incidents in the region. Prior to the establishment of the GLCOE, the Ninth District initiated and maintained several programs to fulfill these goals.

Remotely-Operated Vehicles

As authorized by current Coast Guard policy and supported and funded by the GLCOE, the District, the District approved select units to procure Deep Trekker *DTG3* low-cost, remotely operated vehicles (ROV). The *DTG3* is a mini observation-class underwater ROV that allows operators to visually examine subsurface environments. Connected by a remote control and tether system, with a depth rating of more than 600 feet, the *DTG3* is highly portable and simple to deploy with a team of two operators. The District currently has 10 of these ROVs that provide environmental response capability for subsurface pollution source detection, non-floating oil trajectory tracking, post-incident damage assessment, and other response needs.

In addition to pollution response, ROVs have been used for many Coast Guard and partner agency missions, including interagency assists, underwater hull inspection in response to sunken or grounded vessels, and inspecting shoreline and subsurface impacts. Historically, ROV applications were limited to Coast Guard deployable special forces



An oil-in-ice demonstration is conducted from the Coast Guard Cutter *Hollyhock* in the Straits of Mackinac in 2013. Photo by Jerome A. Popiel

and civil engineering units. However, their use in other operational units has demonstrated their versatility and value across a broader spectrum of core missions. The GLCOE is working to establish standard operating procedures for the District which, once demonstrated to be successful, can be shared with the rest of the Coast Guard districts.

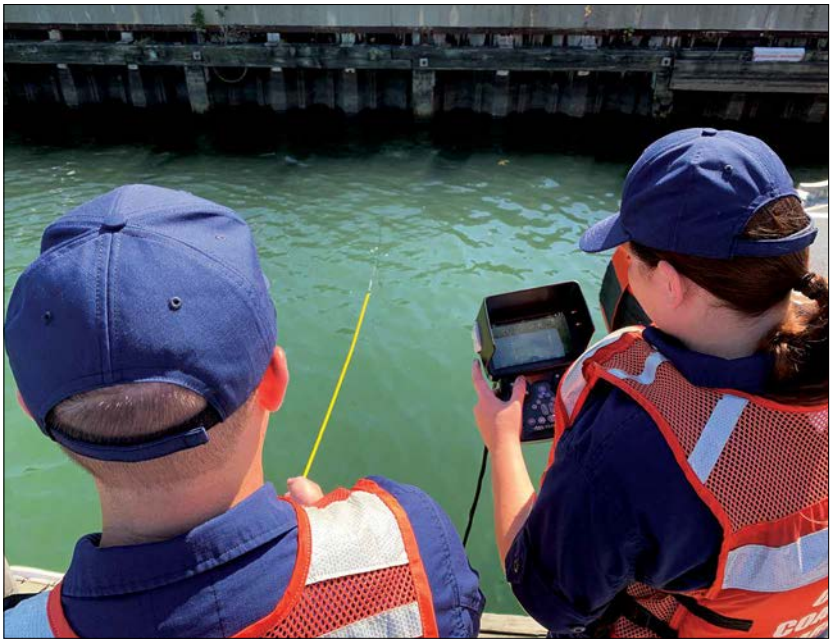
Unmanned Aerial Systems

The Ninth District was at the forefront when the Department of Homeland Security embraced the force-multiplying aspect of unmanned aerial systems (UAS). Working closely with the Coast Guard Headquarters' Office of Aviation Forces, the District built a robust UAS program with 10 pilots, a drone instructor, and a remote Federal Aviation Administration licensing facility. These forward-leaning efforts culminated in the District receiving the Coast Guard's first production model of the Skydio *X2D* UAS platform. The District leverages the system's 3D mapping and innovative sensor package, including a forward-looking infrared camera, to improve freshwater oil spill response capabilities.

A drone can deploy quickly and safely to provide hours of overflight coverage for various missions at a fraction of the operating cost of a helicopter and crew. UAS can be especially important during the Great Lakes' busy summer search and rescue season, when resources become easily strained. To date, the Ninth District UAS program has augmented operational subunits with a wide range of requests around the region. These requests include obtaining aerial imagery for booming and ice rescue exercises, critical photos detailing winter layup port statuses, aerial waterway mapping, oil spill response, and overflight of commercial vessel groundings, among others.

Expanding beyond the borders of the Great Lakes, the program has also offered ongoing support to both U.S. Coast Guard Research and Development Center and NOAA research and development projects in the Arctic. In summer 2022, District UAS pilots augmented research on sensor capabilities to detect oil-in-ice in saltwater and freshwater environments, providing vital input to NOAA and expanding the value of the Coast Guard's growing UAS fleet.

Implementing UAS and ROV to detect oil-in-ice environments, improve oil modeling and early detection, and build response capability for the Great Lakes will require working with our partners at the U.S. Environmental Protection Agency, NOAA, states, tribes, and the Canadian Coast Guard, among others.



Members of the Coast Guard participate in a remotely operated vehicle training evolution on Lake Erie's Cleveland Harbor in 2021. Photo by Jerome A. Popiel

An unmanned aerial system rests on deck during a 2022 training evolution in Cleveland. The Coast Guard's Ninth District had developed a robust unmanned aerial system program. Photo by Jerome A. Popiel

Freshwater In-Situ Burning Research and Development

Although in-situ burning (ISB) of oil is a well-documented, and commonly used, alternative response to effectively eliminate large volumes of oil, employing ISB in freshwater environments, particularly the Great Lakes and their tributaries, poses many challenges.

Large volume discharges of oil into freshwater environments, like the 2010 Kalamazoo Michigan River pipeline discharge, highlight the need for response agencies and industry partners to have a full suite of options for protecting environmentally, economically, and culturally sensitive areas. As a result of this mishap, national, regional, and area response bodies explored alternative response techniques that could be applied to large volume scenarios. The determination was that using ISB in this instance could have been a viable option due to the need for alternative response techniques appropriate to the scale.

Some of the first efforts to explore the technical viability of ISB, along with other techniques, in the coastal Great Lakes environment included a series of oil-in-ice demonstrations near the Straits of Mackinac from 2011 to 2013. The District sponsored these equipment demonstrations, which were led by the Coast Guard's Research and Development Center (RDC). The District, the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration, the Canadian Coast Guard, and state, local and tribal partners provided subject matter expertise.

After seven years of Great Lakes and Arctic demonstrations, the RDC produced a *Federal On-Scene Coordinators' Guide to Oil-in-Ice*, highlighting tactics and techniques to respond to large volume spills in ice environments, including considerations for the application of ISB. In August 2017, about the same time the Guide was released, the Northern Michigan Area Committee in Mackinaw City led a tabletop exercise focused on using ISB in a coastal freshwater environment. Regional Response Team 5 leadership, a multi-agency guidance and assistance group which has responsibility for the Great Lakes, attended the exercise, along with the state of Michigan, tribal, and federal resource trustees, as well as industry partners. The principal outcome of the exercise was that if the ISB alternative was to be used, it would have to be applied as expeditiously as possible and under the right conditions. The response agencies would have to overcome additional research and process gaps to effectively use this technique.

Response agencies supported the Coast Guard's RDC once again to address those gaps, which included public health expectations, federal resource trustee obligations, and state air and water quality permitting procedures associated with conducting ISB. Through sponsorship from the District and the Great Lakes Restoration Initiative, the RDC designed a series of controlled in-situ burns from 2019 through 2022. After consulting with industry partners, three petroleum products commonly transported in the Great Lakes region—marine-grade fuel oil, medium crude oil, and bunker C fuel oil—were used in the burns.

The first phase of the controlled burns was conducted at RDC's Joint Maritime Test Facility on Little Sand Island in Mobile, Alabama, and the U.S. Army Corps of Engineers Research and Development Center's Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, New Hampshire. The team designed these burns to increase in size and duration, giving researchers the scalability to determine the feasibility of burning oil in freshwater. The RDC-published results provided initial burn characteristics of ignitability, slick thickness, burn efficiency, burn rate, air emissions, and chemical analysis of residue and water in the freshwater environment in February 2021. This critical data enhanced the stakeholders' ability to consider ISB a viable response option.

The second phase of controlled burns will be conducted at the Army's CRREL. These burns will focus on improving air monitoring and enhancing the safety and protection of responders and the public. Using unmanned aerial systems, evaluating remote sensing options to improve air monitoring accuracy and measuring the toxicity of chemicals in smoke plumes are objectives that will aid response agencies in further bridging research gaps. The report detailing the findings of these controlled burns is anticipated in late 2022.

The Ninth District will continue to promote this research with support from various partners and the GLCOE. The resulting data, addressing effects of oil in freshwater, will provide responders with information necessary to aid agency decision-makers faced with

A freshwater in-situ test burn is conducted in Mobile, Alabama, in 2020. Coast Guard photo

A full-scale Preparedness for Response Exercise Program is conducted on the St. Lawrence Seaway in 2019. Coast Guard photo

large-volume oil spills.

The Role of Preparedness

Any oil spill occurring on the Great Lakes comes with significant consequences. The District's Response Advisory Team (DRAT) continues to emphasize oil spill preparedness to ensure all spills are removed as rapidly as possible. Throughout the Great Lakes region, spill preparedness is evaluated continually, and significant efforts are made to improve it in five key areas:

- Area Contingency Plan Development
- Strategically Pre-positioned Spill Response Equipment
- Geographic Response Strategies Validation
- Stakeholder Outreach and Engagement
- Exercises and Drills

Area Contingency Plans

Every five years, the DRAT ensures the District Commander approves each Area Contingency Plan (ACP) after incorporating recommendations from the service's National Review Panel. The DRAT also reviews all Federal On-Scene Coordinator (FOSC) post-spill reports to assist with resolving various challenges faced by FOSCs and their area committees. Additionally, the DRAT supports and assists the FOSC and their area committees so that lessons learned from real-world events and exercises following the Preparedness for Response Exercise Program (PREP) guidelines are also integrated into the ACP.

Strategic Pre-Positioned Spill Response Equipment

To minimize response time while maximizing results, the DRAT partners with U.S. Naval Station Great Lakes, Illinois, and U.S. Army at Fort Drum, New York, to store needed equipment and other resources in proximity to areas prone to pollution-related marine incidents. Spill response equipment is also stored with other government agencies around the higher-risk marine casualty areas to ensure the rapid deployment of resources.

Geographic Response Strategy Validation

All ACPs contain a geographic response strategy (GRS) that provides site-specific information to guide oil boom deployment and other on-scene resources. The DRAT is now working with Ninth District sectors to validate all GRS protection, collection, and deflection information throughout the region, starting with the highest priority

sites. GRS validation is part of every PREP equipment deployment drill and full-scale exercise. It has resulted in the revision and practical improvements of Great Lakes GRSs.

A U.S. Navy Supervisor of Salvage Vessel of Opportunity Skimming System is deployed from the Coast Guard Cutter *Mackinaw* on Lake Erie in 2021. Photo by Jerome A. Popiel

Stakeholder Outreach and Engagement

The mosaic of international, state, provincial, and tribal boundaries, each with its authorities that must be respected during any response, is a unique aspect of Great Lakes' oil spill response operations. To ensure the inclusion of these stakeholders and sovereign nations in response operations and decision-making, the DRAT maintains a robust outreach program designed to engage during area committee meetings and exercises or real-world events. Native American participation in Coast Guard equipment deployment exercises along the St. Lawrence Seaway is just one recent program success.

Exercises and Drills

The National Preparedness for Response Exercise Program has been invaluable in assessing plan-holder capabilities and improving oil spill-response preparedness throughout the region. All exercises are evaluated, and best practices and lessons learned recorded to improve the planning process, which supports more effective response efforts.

The Way Forward

The DRAT continues to work closely with partners to evaluate new technologies and methods for improving oil response operations within the Great Lakes. The RDC and the GLCOE will focus on several ambitious projects for the Great Lakes. Among these are freshwater in-situ burn research and projects, and advancing UAS and underwater ROV capabilities to characterize water column and surface oil impacts during the winter months and times of severe icing on the Great Lakes. The DRAT is also partnering directly with the RDC and the Canadian Coast Guard's in-situ burn research facility to improve the viability of in-situ burning on the Great Lakes.

In 2023, the Ninth District DRAT will host a full-scale exercise involving the deployment of a wide array of pollution response equipment. This exercise will evaluate the feasibility of deployment and equipment performance in the cold-water environment of the northern Great Lakes. The exercise will also include the U.S. Navy's Supervisor of Salvage, the Coast Guard's National Strike Force, Headquarters Office of Emergency Management, and the Headquarters Offices of Environmental Response Policy.

By improving preparedness capabilities and researching new equipment and deployment methods on the Great Lakes, the Ninth District DRAT is *Semper Paratus* for response to pollution incidents.

About the authors:

Scott Binko served 20 years with the U.S. Coast Guard in active duty, reserve, and civilian capacities. He has numerous qualifications and certifications in maritime response, prevention, transportation, and law enforcement. He has served as a consumer safety investigator for the U.S. Food and Drug Administration. Mr. Binko holds a Bachelor of Arts in environmental studies and a Master of Science in environmental policy and management, environmental health and safety.

Robert Allen has more than 42 years in the U.S. Coast Guard as a commissioned Marine Safety Officer and civilian environmental specialist. As an environmental specialist, he has served in the Coast Guard's prevention, preparedness, and response programs, where he has managed many port emergencies and preparedness exercises. He also holds a bachelor's degree in organizational management.

LT Joshua McElhaney has served 18 years with the U.S. Coast Guard as a deck watch officer, boarding officer, small boat coxswain, command duty officer, federal on-scene coordinator representative, and SR-UAS remote pilot.

Nathan Westrich will be a senior in the undergraduate communications program at John Carroll University in University Heights, Ohio. During his six-month internship at the Coast Guard's Ninth District, he is completing his capstone project en route to earning his Bachelor of Science in communications.

Jerome A. Popiel has served 30 years with the U.S. Coast Guard as incident management and preparedness advisor, search and rescue specialist, group operations officer, public affairs officer, admiral's aide, 47' MLB program manager and shipboard engineer. He also served as assistant vice president of operations for The Great Lakes Towing Company.

The Pilot Light of North American Manufacturing

Great Lakes' locks, rocks, and docks

by Jim Weakley
President
Lake Carriers' Association

The Great Lakes-St. Lawrence Seaway System is the largest interconnected freshwater navigation system in the world, stretching 2,340 miles from the Atlantic Ocean to the heartland of the United States and Canada. Home to more than 107 million people, the Lakes are surrounded by eight U.S. states and two Canadian provinces, making the region an economic powerhouse serving North America.

The Great Lakes-St. Lawrence Seaway marine transportation system is complex, with 17 locks that raise and lower vessels more than 590 feet from Lake Superior to the Atlantic Ocean. The system serves more than 100 individual ports and supports 237,868 jobs resulting in $35 billion in economic activity. More than 160 million metric tons of cargo move throughout the system annually including iron ore, limestone, steel, coal, grain, and large project cargo, like wind turbine blades. On average, Great Lakes-St. Lawrence Seaway shipping is 14 percent more fuel efficient than rail and nearly 600 percent more efficient than trucking, resulting in 19 percent fewer carbon emissions than rail, and 533 percent less than trucks.

The largest vessels plying the Great Lakes are more than 1,000-feet long, with a beam of 105 feet, and can carry 70,000 tons of bulk cargo per trip. Uniquely, they have the ability to self-unload with a conveyer belt system and a boom that reaches up to 280 feet, allowing the discharge of cargo at virtually any dock in eight hours or less. All the "footers" are "Jones Act" qualified vessels, meaning they are U.S.-flagged, U.S.-owned, U.S.-built, and crewed by U.S. sailors; all important security considerations.

A System of Efficiency

Commercial shipping on the Great Lakes has been an economic driver for more than two centuries. Initially, commodities like lumber and grain were shipped across the region to build cities like Chicago, Detroit, Cleveland, and Buffalo. With the onset of the industrial revolution, steel manufacturing took center stage as massive steel mills were built in the southern Great Lakes states and fed with iron ore from the iron ranges in Minnesota and northern Michigan. The only means to move massive amounts of raw material efficiently was through commercial shipping. Navigation infrastructure became critical to maintaining the constant flow of materials from Lake Superior's ports and Michigan's limestone quarries to the manufacturing facilities in the southern Lakes' ports, where a robust workforce existed. Key pieces of infrastructure, the large navigational locks in Sault Ste. Marie (the Soo), Michigan, allowed vessels to bypass the

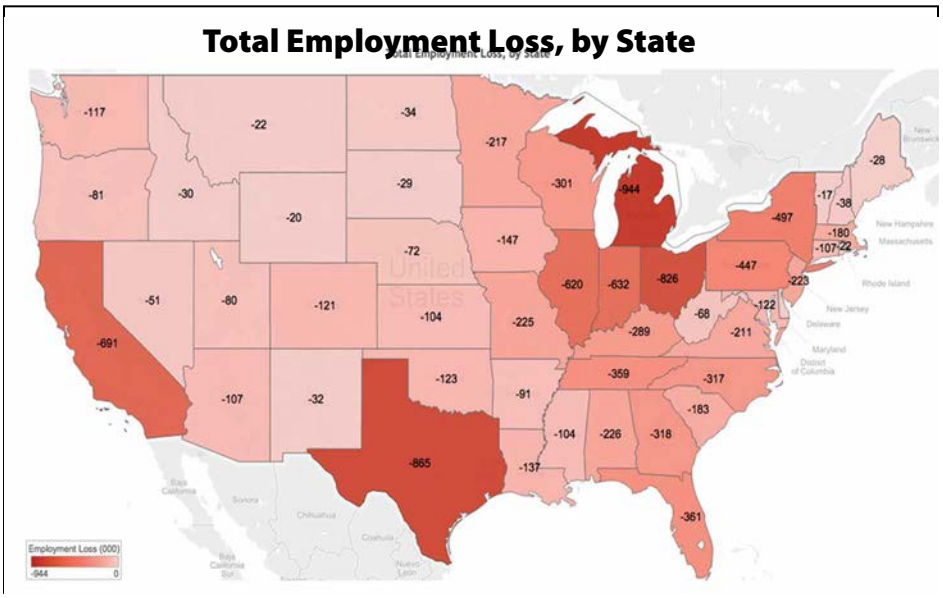
A Great Lakes freighter uses a self-unloading system at a Great Lakes port. The largest vessels plying the Great Lakes have the ability to self-unload with a conveyer belt system and a boom reaching up to 280 feet. This allows the discharge of cargo at virtually any dock in eight hours or less. Photo courtesy of Interlake Steamship Company

rapids created by the 21-foot drop from Lake Superior to the lower lakes. The locks were so important that 10,000 U.S. Army soldiers were stationed in the Soo during World War II to protect them and the ability of the United States to continue to make steel for the war effort.

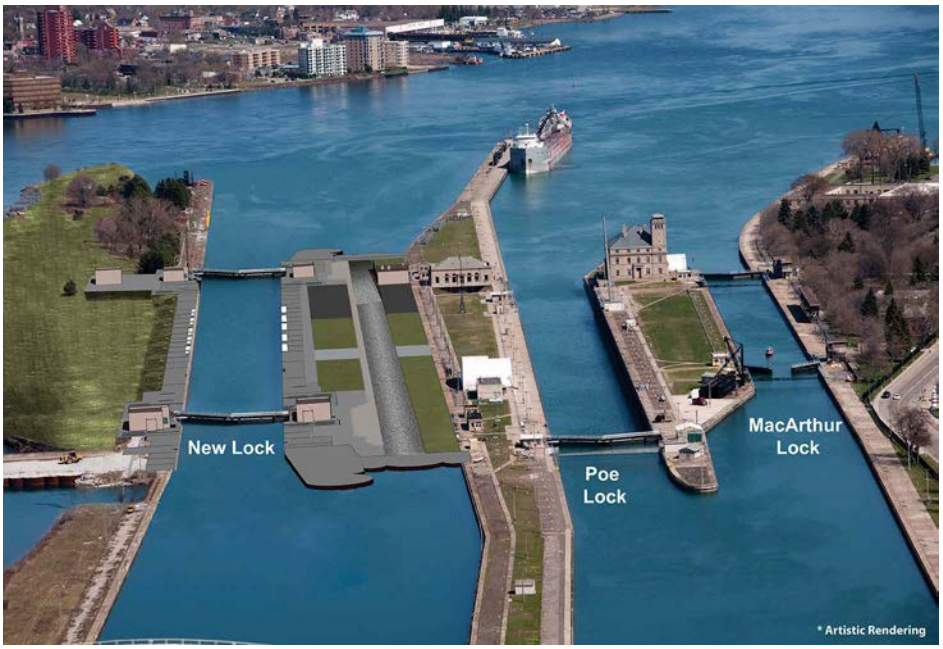
As commercial shipping sought to be more efficient, the ships became larger, carrying more in fewer trips. In 1968, the largest lock at the Soo, the Poe Lock, was constructed to accommodate the new 1,000-foot vessels. Today, more than 70 percent of the vessel traffic, carrying 57 million tons of cargo annually, is restricted to the use of the larger Poe Lock. The problem is the Poe Lock is now 54-years old. Based on a 2015 Department of Homeland Security Report, a closure of the lock would be catastrophic for the nation.

"Approximately 75 percent of the U.S. integrated steel production would cease within 2–6 weeks after the closure of the Poe Lock. Approximately 80 percent of iron ore mining operations, and nearly 100 percent of the North American appliances, automobile, construction equipment, farm equipment, mining equipment, and railcar production would shut down. The shutdowns in production of these products would begin slowly and then increase quickly as the stress grows in the iron mining—integrated steel production—manufacturing supply chains. Almost 11 million people in the United States, and potentially millions more in Canada and Mexico, would become unemployed due to the production stoppage, and the economy would enter a severe recession." [1]

Congress authorized a second Poe-sized lock in 1986, but it failed to get significant appropriations until 2017. Due to increased Congressional and Executive Branch pressure, as of 2022, a total of $1.371 billion has been allocated to complete construction of the second large lock, expected to be finished by 2028.



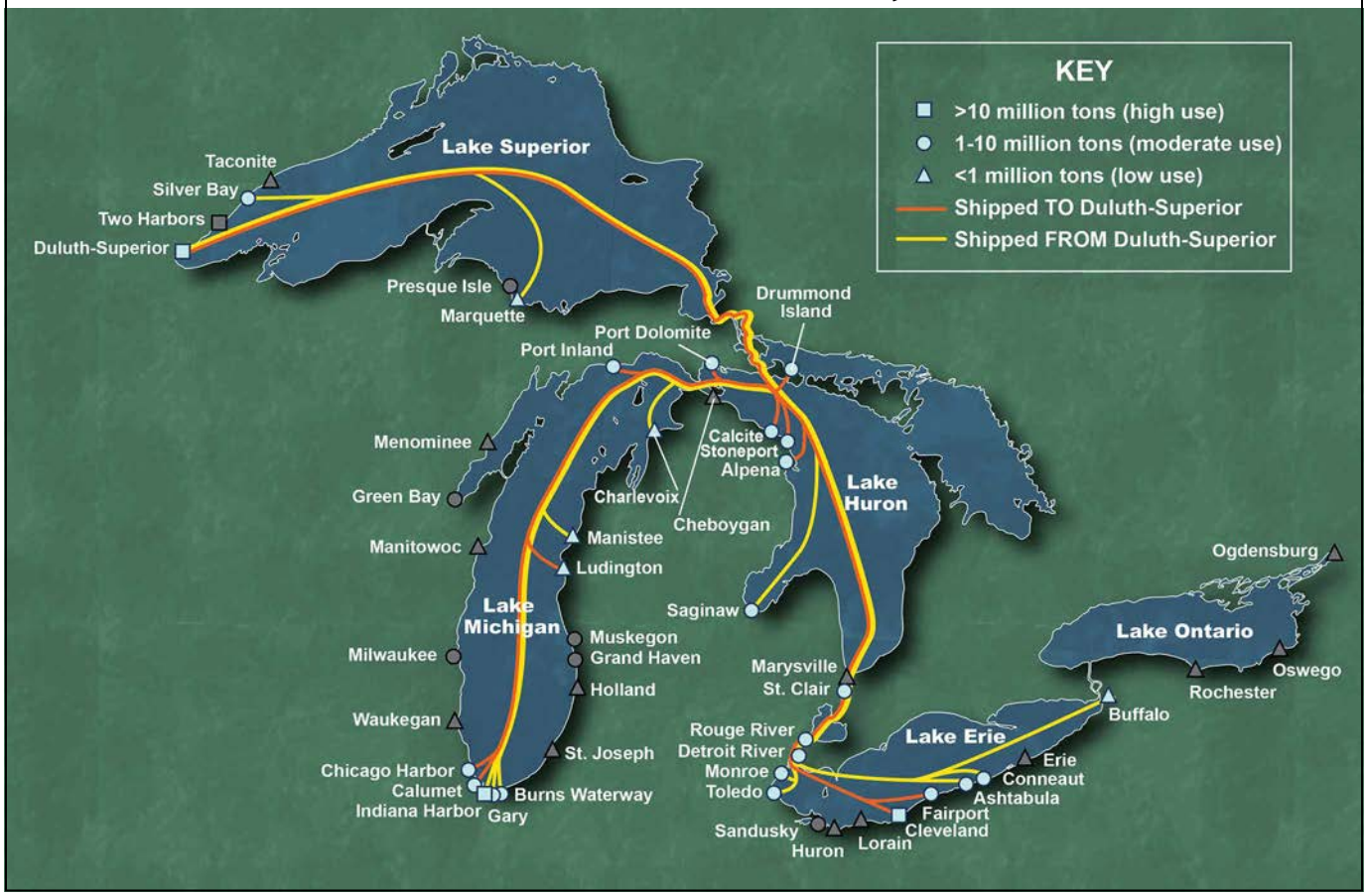
The economic impacts of a Soo Lock closure would ripple throughout the nation. Department of Homeland Security Report



Considering the importance of the Soo Locks in Sault Ste. Marie, Michigan, and the age of the Poe Lock, a new lock was authorized in 1986, receiving significant appropriations in 2017. The new lock is shown in this rendering. Image courtesy of the U.S. Army Corp of Engineers

Maintaining and updating the Poe and the 800-foot-long MacArthur locks requires ongoing funding. Just this year, the replacement of an original lock dewatering pump, dating to the early 1900s and used to completely drain the Poe Lock so the Army Corps can conduct annual maintenance, was funded. Keeping the current Poe Lock operational until the new lock is constructed is a matter of national economic security, and rehabilitation of the lock going forward is vital to ensuring resiliency of the Great Lakes Navigation System.

Great Lakes Interconnectivity



U.S. Army Corps of Engineers

Similar to the Poe Lock in the Soo, the system of locks in the St. Lawrence Seaway and the Welland Canal are critical to imports and exports, allowing movement between the Great Lakes and the Atlantic. These movements depend on the system of eight Canadian locks connecting Lake Erie to Lake Ontario in the Welland Canal, which bypasses Niagara Falls, and the seven U.S. and Canadian locks in the St. Lawrence Seaway. Vessels making transits from Europe or Asia plan trips months in advance and a failure at any one of these locks would impact cargo movements downstream causing supply chain disruptions on a global scale.

A Connected System

The supply chain on the Great Lakes has moved closer to "just in time" delivery to reduce stockpiling of costly raw materials, though this model remains constrained by the annual Soo Lock closure from January 15 to March 25. Mills need stockpiles to sustain production through the winter, and starved facilities need resupplying as soon as winter, and icebreaking resources, allow. Many facilities can only receive supplies by vessel since other sufficient transportation is unavailable for the movement of bulk material.

The mines in the northern Lakes produce raw materials on demand at the manufacturing facility and the cargo is shipped when the need is signaled. Along the same lines, factories only produce based on the demands of the consumer.

The automotive industry is a perfect example of how the interconnected system works in the Great Lakes region. When cars are in demand, steel manufacturers react with increased requests for raw materials, which drives the need for increased shipping. Hence, mine production in the north ramps up. The impacts of COVID-19 in 2020 provided a textbook illustration of this process. As the demand for automobiles dropped, the steel manufacturers curtailed operations, which slowed mine production and shipping.

Each port in the Great Lakes System can have trickle-down impacts to the entire system. For example, operational disruptions in the twin ports of Duluth/Superior, one of the largest for iron ore loadings, would impact receipt of the raw materials needed for continued operations in the southern Lakes. That would cascade into mining operations and, ultimately, reduce shipping,

translating to loss of jobs and economic productivity.

Keeping ships moving on the Great Lakes all year is one of the Coast Guard's most important missions. They also help free vessels that do become beset, like these two stranded in eastern Lake Superior in March 2022. Photo courtesy of the Lake Carriers' Association

Icebreaking

If the Soo Locks are the beating heart of the Great Lakes Navigation System, U.S. Coast Guard's nine icebreakers keep the blood flowing during the winter months. The U.S. Coast Guard partners with the Canadian Coast Guard which contributes two to the cause. Through attrition and retirements, the combined total of the coast guards' icebreakers and ice-capable ships dropped from 20 to 11 over the past 25 years. The Canadian Coast Guard ships have had recent engineering challenges affecting their availability, and the U.S. Coast Guard's 40-year-old icebreaking tugs still have mechanical and propulsion issues despite a recent service-life extension. Although authorized a second one by Congress, the U.S. Coast Guard continues to rely on one "heavy" icebreaker, and its loss during the icebreaking season would be devastating to the agency's capabilities.

Until recently, the U.S. Coast Guard's icebreaking performance metrics were exclusively focused on four small, connecting waterways and did not capture the impacts to vessels beset, delayed, or slowed by ice in the open Lakes, bays, or harbors. Although the Coast Guard now internally tracks closures and restrictions in additional waterways, it only reports to Congress performance in the four connecting waterways. Additionally, there are no measures that capture the effects of ice dam-induced coastal flooding.

Lake Michigan alone has 1,640 miles of shoreline, which is equivalent to the distance from Maine to Miami. Given the vast distances between ports and the need to deliver multiple cargoes on time, maintaining an adequate amount of reliable icebreaking resources is critical to the economic well-being of the industries that rely on an efficient supply chain. This is especially important for companies that must stock up for the winter when the Lakes' locks close for two months and are wanting for materials when ships start moving again in the spring.

Ice-related delays to the movement of these cargo-carrying vessels, or their inability to complete a voyage due to damage from ice, can impact the region's economic activity, including the loss of revenue and jobs. A more comprehensive set of metrics that capture these transportation and economic impacts across the entire system is needed to accurately assess and inform both Coast Guards as they plan for the acquisition of icebreaking resources for the future. Ideally, this will result in the right mix of heavy, medium, and light icebreakers, and ice-capable buoy tenders that can support the needs of commerce throughout the whole Great Lakes marine transportation system.

A Resilient and Dependable System

The Great Lakes-St. Lawrence Seaway System is the key to economic growth and stability for all of North America, whether it is raw materials shipped within the lakes, or imports and exports leaving the heartland. As global supply chains continue to face challenges getting goods to consumers, the Great Lakes-St. Lawrence Seaway System stands poised to provide a permanent relief valve for congested coastal ports.

This waterborne commerce depends on continuous dredging, reliable icebreaking during the winter months, and infrastructure maintenance and improvements for navigation. With national infrastructure projects taking shape, the raw materials and manufacturing capability contained in the Great Lakes region is the cornerstone of future success. The vessels that move goods efficiently throughout the system are the glue holding together one of the most productive areas of the country. The Great Lakes-St. Lawrence Seaway System is the pilot light of North American manufacturing.

About the author:

Jim Weakley became President of the Lake Carriers' Association in January 2003. He retired from the Coast Guard Reserve where his duties included vessel and facility inspections, pollution response, maritime security, intelligence, emergency response, and search and rescue. A 1984 graduate of the U.S. Coast Guard Academy, Mr. Weakley earned a Master of Business Administration degree from Case Western Reserve University.

Endnote:

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The Icebreaking Mission on the Great Lakes

Ensuring navigability and safety with an aging fleet

by Brian Smicklas
Waterways Management Specialist
Ninth District
U.S. Coast Guard

The Great Lakes contain more than 21 percent of the world's fresh water supply and support $3.1 trillion in gross domestic product.[1] So, when ice hinders navigation, goods, services, and safety, the U.S. Coast Guard, in partnership with the Canadian Coast Guard, takes action. Taking action throughout 94,000 square miles of lakes containing 6 quadrillion gallons of fresh water requires a significant number of operational assets, a strategic understanding of Great Lakes icebreaking, and excellent bilateral coordination with the Canadian Coast Guard (CCG).

The Coast Guard began facilitating navigation and safety through Great Lakes icebreaking in the 1930s with the 165-foot Escanaba-class cutters, followed by the more capable Raritan- and Balsam-class cutters.[2] The current fleet consists of nine vessels, including six 140-foot purpose-built icebreaking tugs, two 225-foot buoy tenders with icebreaking capabilities, and one 240-foot medium-heavy icebreaker with buoy tending capabilities. In concert with the Coast Guard team, the Canadians have two medium-heavy icebreakers on the Great Lakes and can surge additional icebreakers into the St. Lawrence River or the Lakes during especially challenging ice seasons. The combined operational strength of Great Lakes icebreaking assets is, almost without exception, able to reasonably accommodate the icebreaking and waterways management needs of the Great Lakes and remains essential to the effectiveness of the Great Lakes Marine Transportation System (MTS).

Great Lakes Icebreaking Mission Priorities

To achieve the coordination necessary to meet operational icebreaking objectives, the Coast Guard has divided the Great Lakes into two operational domains overseen by Coast Guard Sectors Sault Ste. Marie and Detroit, Michigan. Respectively, Operation Taconite covers the northern and western Great Lakes, and Operation Coal Shovel maintains responsibility for the southern and eastern Great Lakes. These operations follow the Ninth Coast Guard District's guidance to conduct

USCG Cutter Homeports

Coast Guard Graphic

Ninth District Cutters and their Homeports	
USCGC **BISCAYNE BAY** *St. Ignace, Michigan*	USCGC **MACKINAW** *Cheboygan, Michigan*
USCGC **BRISTOL BAY** *Detroit, Michigan*	USCGC **MOBILE BAY** *Sturgeon Bay, Wisconsin*
USCGC **BUCKTHORN** *Sault Sainte Marie, Michigan*	USCGC **MORRO BAY** *Cleveland, Ohio*
USCGC **HOLLYHOCK** *Port Huron, Michigan*	USCGC **NEAH BAY** *Cleveland, Ohio*
USCGC **KATMAI BAY** *Sault Sainte Marie, Michigan*	USCGC **SPAR** *Duluth, Minnesota*

Coast Guard Cutters *Katmai Bay* and *Biscayne Bay*, two of six 140-foot icebreaking tugs, break ice in the St. Marys River. Coast Guard photo

icebreaking using four service priorities:

- search and rescue (SAR)
- urgent response to vessels beset in ice
- exigent community service
- facilitate navigation

Search and Rescue

During the winter, the Coast Guard principally relies upon helicopters based out of Detroit and Traverse City, Michigan, to provide an effective, rapid search and rescue capability. However, there are occasions when only an icebreaking vessel can effect the rescue. On February 7, 2022, Sector Sault Ste. Marie received a report of a 41-year-old with life threatening blood sepsis on Mackinac Island, Michigan. In this event, the only asset that could successfully transport the patient from the island to higher-level medical care on Michigan's mainland was the CGC *Katmai Bay*, a 140-foot icebreaker.[3] Icebreakers can also be called to assist recreational ice fishermen when conditions push the ice they are fishing on away from shore, as was the case for CGC *Mackinaw*, which was on scene to assist in the rescue of 14 ice fishermen off the coast of Green Bay, Wisconsin, in 2021.[4]

Urgent Response to Vessels

At times, vessels attempting to transit the Great Lakes during ice season become stuck, or beset, in ice. The Coast Guard will respond to vessels in urgent situations that, if left unassisted, have a high probability of deteriorating into a hazardous situation. Scenarios include responding to an ice-bound vessel in danger of drifting, grounding, or becoming trapped in an ice field and at risk of suffering a hull breach or being forced into shoal water. In these instances, icebreaking assets perform the harrowing task of approaching and operating close enough to a vessel to break the ice around it in an effort to free it.

On January 2, 2018, Coast Guard Cutters *Neah Bay* and *Morro Bay*, homeported in Cleveland, responded to four large bulk carriers stuck in ice, taking days to free the vessels and their crews.[5] While responding to a beset vessel could be considered routine for a Great Lakes icebreaker, from a shiphandling perspective, the risk of injury or collision is anything but routine. Unfortunately, all Great Lakes icebreakers know of collisions occasionally occurring between ice breakers and the vessels they are assisting. Communication and adherence to icebreaking doctrine reduces the risk, but due to the inherent dangers and fatigue associated with icebreaking, Coast Guard vessels rarely break ice at night.

Exigent Community Service

While not directly considered SAR, icebreakers are also responsible of conducting "exigent community service," when conditions dictate. Examples include opening

channels to icebound communities in need of food, heating oil, or road salt. When ice forms and subsequently breaks up at key locations and on rivers flowing into the Lakes, ice jams can form, potentially backing up rivers and flooding the surrounding areas. Preemptively employing a Coast Guard and/or Canadian icebreaking asset prior to the onset of flooding conditions can prevent damage to private property and natural resources, as well as reduce the risk to the lives of the public in the affected areas.

This scenario unfolded on February 22, 2010, when Army Corps of Engineer-monitored water levels exhibited an alarming difference between Lake Huron, the St. Clair River, and Lake St. Clair. When winds pushed ice accumulation into the southern shore of Lake Huron and temperatures prevent it from becoming firmly affixed, or "fast," along the shoreline, ice flows accumulate and form ice jams and ice dams throughout the waterway. These begin to hinder the natural flow of the St. Clair River, which has a historical propensity to flood the region.[6] The Army Corps of Engineers, which has statutory responsibility to mitigate flood risk, requested the deployment of Coast Guard icebreaking assets for assistance. The U.S. Coast Guard cutters *Neah Bay*, *Mobile Bay*, and *Mackinaw*, along with the Canadian Coast Guard ship *Samuel Risley*, spent more than three days breaking up ice jams and successfully preventing flooding along both sides of the St. Clair River. This action prevented a great loss of property and likely saved lives.

Facilitation of Navigation

When not tasked with the higher priority icebreaking services, icebreakers remain constantly employed with the task of facilitating navigation; primarily by establishing, and maintaining, tracklines through the ice. Icebreakers are able to develop a stable trackline through the ice when it remains "fast," or in-place. These tracklines, formed from persistent transits through ice-covered waterways during the coldest months of winter, provide a path for commercial traffic throughout the winter navigation season and are often visible from Earth-orbiting satellites.

Coast Guard Cutter *Katmai Bay* and *Neah Bay* provide an icebreaking escort to the M/V *Harvest Spirit*. Coast Guard photo

At the operational level, the geographic allocation of icebreaking assets throughout the Great Lakes requires constant attention and a thorough understanding of commercial needs, weather conditions, and icebreaker availability. Operational commanders within Coal Shovel and Taconite remain in constant communication with the Coast Guard's Ninth District and their Canadian counterparts. As a result, the Coast Guard and the CCG have enjoyed an effective and efficient team approach to Great Lakes icebreaking for decades. The combined strategic, operational, and tactical efforts of the U.S. and Canadian coast guards determine the best asset for the effort based on a complex set of variables including, but not limited to, vessel availability, ice thickness, water depth, proximity, and flood threat.

Coast Guard Cutter *Morro Bay* and Coast Guard Cutter *Neah Bay* providing icebreaking services on Lake Erie during the winter 2022 navigation season. Coast Guard photo

The decision to send a particular asset to a specific location or mission is balanced by many competing demands. Vessels must be prepared to:

- prevent flooding of the St. Clair River by completing multiple transits to induce ice movement
- maintain ice tracklines in the Straits of Mackinac between Michigan's upper and lower peninsulas
- assist beset vessels in the vicinity of Pelee Passage in western Lake Erie
- break up large fragmented ice flows throughout the St. Marys waterway

Coast Guard Cutter *Katmai Bay* breaks ice close to a commercial vessel while providing a direct icebreaking assist in the Straits of Mackinac. Coast Guard photo

The coordination required for these missions often requires a daily conference call for all waterway users, hosted by the Coast Guard's Ninth District. These calls outline current and forecasted ice and weather conditions, verify the status of icebreaking missions based on current and forecasted ice conditions, provide updates to icebreakers' current and future locations, and address Great Lakes icebreaking concerns.

The cooperation and coordination between the CCG and the Coast Guard is exceptional, however, important differences exist. Unlike the U.S. Coast Guard icebreaking fleet, which is an armed service with an active-duty workforce, the CCG is a civilian organization operating under the Canadian Department of Fisheries and Oceans. The CCG also charges service fees for providing

icebreaking services to vessels entering or leaving a Canadian port. These fees vary based on tonnage, flag state, and other factors. The fee-based system normally dedicates icebreaking efforts to the vessel, whereas the U.S. icebreaking efforts are typically focused on breaking ice in waterways connecting the Great Lakes.

The U.S. Coast Guard is bound to the four service priorities, yet also refines the facilitation of navigation priority into tiered waterways throughout the Great Lakes in order to best allocate resources to maximize maritime mobility. For example, Tier One waterways are the most important as they connect the major bodies of waters of the Great Lakes-St. Lawrence Seaway System, while Tiers Two, Three, and Four rate lower priorities, down to commercial piers and facilities (Tier Four).

Despite the differences between the Canadian and U.S. icebreaking operations, the strategic bilateral approach to icebreaking on the Great Lakes places the best assets in the best positions to enhance the entire Great Lakes MTS.

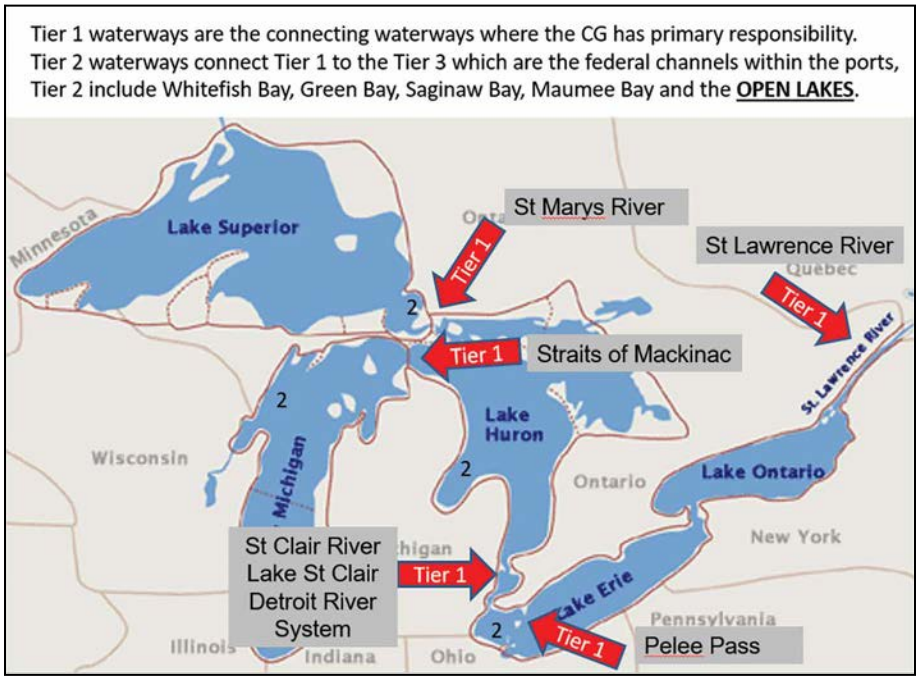
Icebreaking Challenges

Maintaining operational capability for the icebreaking vessels tasked with breaking hard ice up to 3-feet thick is costly, time consuming, and increasingly difficult given the age of most icebreaking assets. Of the nine icebreaking cutters homeported throughout the Great Lakes; only the *Mackinaw* was constructed within the past 25 years. The remainder of the fleet is decades older and requires significant maintenance and support to remain fully operational.

While there has been Congressional interest and legislation towards acquiring additional icebreaking capability, the current fleet of aging cutters continues to suffer from routine and non-routine engineering casualties. Due to the difficulty of dry-docking and maintaining vessels during severe winters and the need to keep assets operational for icebreaking duty, major maintenance and repairs are usually planned between April and November. While the summer maintenance periods are optimal, the challenge of maintaining a global Coast Guard fleet can, and does, frequently override regional maintenance priorities, requiring the withdrawal of cutters during the winter.

Adding to the complexity of ship maintenance, many of the largest bulk carriers traversing the Great Lakes during the winter were constructed in the 1970s

Icebreaking Waterways



Taken from the stern of Coast Guard Cutter *Morro Bay*, Coast Guard Cutter *Neah Bay* escorts a commercial vessel on Lake Erie during the 2022 Great Lakes winter navigation season. Coast Guard photo

and sometimes require more icebreaking support compared to their newer, more capable counterparts. Regardless of current capability or command, icebreaking assets must adhere to time-tested Great Lakes icebreaking doctrine to reduce the likelihood of costly shipping delays, material shortages, and threats to life and property from ice-related flooding.

The Coast Guard has constructed, operated, and maintained a team of highly capable icebreaking assets since December 31, 1936, when President Franklin Roosevelt signed Executive Order 7521 directing the Coast Guard to:

> *… assist in keeping open to navigation by means of icebreaking operations … channels and harbors within the reasonable demands of commerce.*[7]

Moreover, these teams of operators, maintainers, and tactical decision-makers' primary focus is on ensuring the Great Lakes MTS remains navigable despite arduous winter conditions and providing exceptional icebreaking services, all while saving lives and property, and safeguarding the region's economic productivity. These primary missions are performed each and every year to an exacting standard of excellence.

The CGC *Mackinaw* is seen hove to near Mackinac Island, Michigan. Coast Guard photo by LCDR Eric Quigley

About the author:

U.S. Coast Guard CDR Brian Smicklas retired from active duty in 2021. While on active duty, he served on six cutters including WHECs, WMECs, WLBs, and WPBs and completed various staff tours including Ninth and Seventh District Prevention and Waterways, Coast Guard Headquarters Office of Defense Operations, and as a Coast Guard liaison officer in Havana, Cuba.

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Lakers and the Art of Vintage Vessel Maintenance

Fire prevention on the Great Lakes

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The U.S. Laker fleet serves more than 100 commercial ports, their connecting rivers, locks, channels, and the St. Lawrence Seaway. They transport more than 20 million metric tons of vital bulk cargoes, supporting 147,464 American jobs with a $35 billion impact to our nation's economy.[1]

Vintage Vessels and Winter Work

There are 51 U.S. freight vessels known as "Lakers" because they operate only on the Great Lakes. Of these vessels, approximately 10 percent were built within the last 30 years, but the majority were built between 1940 and 1980, averaging 52 years of operation. The oldest operational freight vessel on the Great Lakes was built in 1906, and there are several Lakers still operating with steam propulsion and riveted construction, a throwback to a bygone era.

The fresh water of the Great Lakes significantly extends the operational lifespan of these vessels as long as maintenance is prioritized. Due to the icing conditions on the Great Lakes and the type of cargo transported, a majority of the Lakers moor at berth for approximately three months in the winter for steel repair, maintenance, and inspections. In most cases, once a Laker has been winterized the crew departs for the season, leaving a shipkeeper to monitor for emergencies. Throughout the freezing winter months, shipwrights work during the day welding and maintaining the ships before departing for the night. During a typical year it is common for them to replace 1,200 metric tons of steel and conduct more than $64 million in repairs.

Winter maintenance occurs throughout the Great Lakes, with the majority of the Lakers laying up in Toledo, Ohio, and Sturgeon Bay, Wisconsin. Due to the

In February 2019, during winter layup in Toledo, Ohio, the *St. Clair* experienced a fire that rendered the ship a total constructive loss. Ice-clogged dockside hydrants and a frozen Lake Erie hampered fire suppression efforts. Coast Guard photo

A drone provides a bird's eye view of the CSX Docks, in Toledo, Ohio, during winter layup. The Great Lakes winter season provides dedicated training opportunities for journeyman marine inspectors, but can also pose safety challenges. Coast Guard photo

uniqueness of the Great Lakes operating seasons, the Coast Guard hosts a once-a-year training opportunity called "Spring Breakout Training," allowing apprentice or journeyman marine inspectors from around the country to gain significant U.S.-flagged, deep-draft vessel experience in a short period of time. This allows upwards of 25 trainees from around the country to spend a focused three weeks working on hull and machinery inspector qualifications while the Lakers undergo repairs and maintenance.

While this winter maintenance period offers certain opportunities, it also presents challenges. With so many Lakers wintering in Toledo and Sturgeon Bay, they moor in close proximity to one another, and at times abreast of each other, making access difficult for emergency responders. The freezing conditions often limit access to lake water used to combat marine fires while creating slippery conditions that test local firefighters, whose experience fighting shipboard fires is minimal. Aboard the Lakers, many of the firefighting safety systems are disabled for servicing, and only minimal heating equipment remains operational to prevent pipes and machinery from freezing. While winter maintenance is critical to the longevity of the Lakers, hazards can quickly develop onboard if risk factors and conditions are not taken into consideration.

MV *St. Clair:* Toledo, Ohio

On a snowy, subzero night in February 2019, 14 Lakers at berth in western Lake Erie were lightly iced in. Welding and maintenance had been completed for the day and shipwrights had departed for the night. But trouble was smoldering below deck on one Laker. The shipkeeper for the Laker *St. Clair* was away from the ship and evening rounds had not been completed when smoke was reported coming from the aft deck by an adjacent Laker's shipkeeper. The *St. Clair*'s shipkeeper arrived at the ship to find a stack of pallets on fire in the engine room. The intense heat and smoke prevented any attempt to release the engine room CO_2 system and the shipkeeper was forced to abandon ship. It would be nearly 45 minutes until first responders arrived on scene

to attempt boundary cooling along the outside of the vessel, but their access to water was hampered by ice-clogged dockside hydrants. After breaking through lake ice to draw water for firefighting, first responders began combating the fire only to find that the water spray was freezing onto surfaces and creating serious slip hazards. The fire in the engine room burned so hot that the reinforced-rubber cargo conveyor belt running beneath the cargo holds ignited, creating a tire fire-like inferno that sent flames up the cargo riser, searing the front of the vessel's accommodation spaces and wheelhouse. The inferno would blaze for 36 hours resulting in the total constructive loss of the vessel.

Following investigations of the fire onboard the *St. Clair*, the Coast Guard leveraged its recommendations, and those of the National Transportation Safety Board, to develop a detailed marine safety information bulletin (MSIB). The 2019 bulletin consolidated best practices from local fire departments and the maritime industry. It recommended that vessel owners and operators should:

- conduct a risk assessment in order to develop mitigation strategies
- develop winter layup safety plans
- post status boards and fire control plans outside winterized Lakers
- conduct periodic inspections
- conduct training with local fire departments and other emergency responders

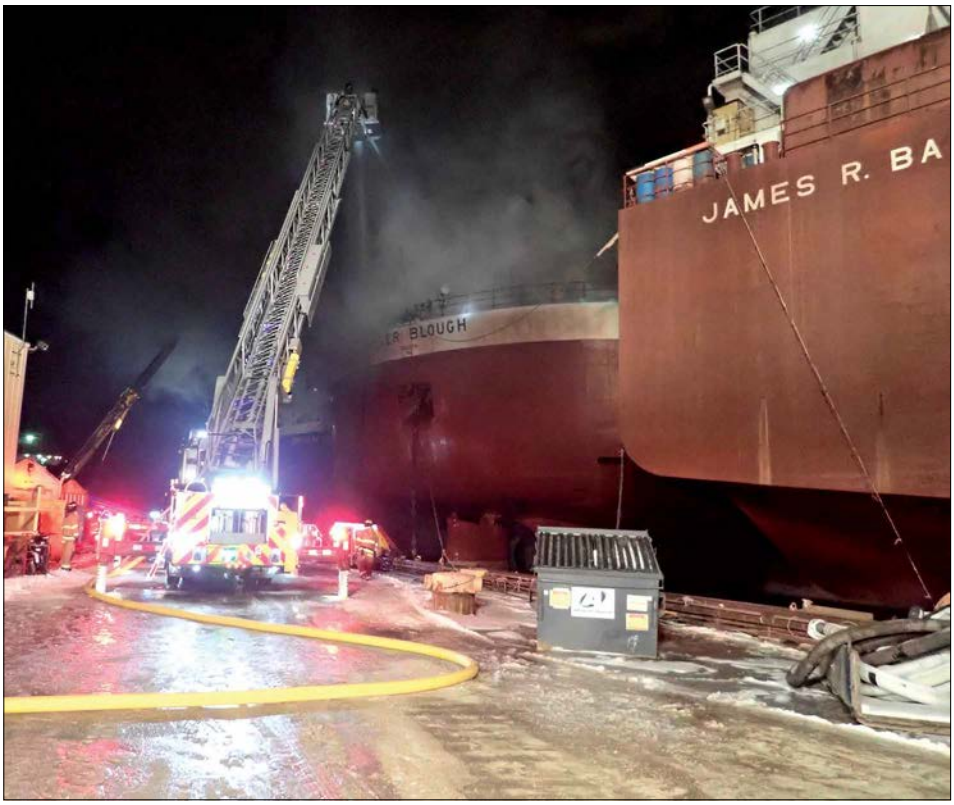
The guidance in the MSIB was largely embraced by industry, but not entirely.

MV *Roger Blough*: Sturgeon Bay, Wisconsin

Nearly two years after the *St. Clair* fire, tragedy struck the Great Lakes fleet again. This time the vessel *Roger Blough* caught fire while moored in Sturgeon Bay. While the shipkeeper was asleep on board, the furnace installed in the engine room to keep pipes and sea chests from freezing caught fire. The fire spread to the vessel's cargo unloading system that runs throughout the cargo spaces, ignited the port rubber conveyor belt, and progressed aft, transferring across to the starboard belt. The shipkeeper, waking up to alarms and thick, black smoke, quickly made his way off the ship to notify emergency responders. The Sturgeon Bay Fire Department was the first on scene, and nine additional fire departments assisted. When the fire was finally extinguished, it had burned for approximately 14 hours. More than 100 Wisconsin firefighters had assisted in combating the shipboard fire with the use of more than 1.4 million gallons of water. Luckily, no one was hurt, but the vessel was later deemed a total loss. During the fire investigation, it was determined that the vessel operator had not provided a winter layup safety plan or incorporated the recommendations from the 2019 guidance.

Prevention Through Inspection

The fire on the *Roger Blough* prompted the creation of a Coast Guard workgroup to explore authorities to further prevent fires on Lakers during winter layup. The workgroup released a second bulletin in December 2021, prior to the winter season, introducing the framework for a Coast Guard "winter layup survey" aimed at further understanding and mitigating fire hazards on the Great Lakes for 2022. This development provided the necessary guidance and structure for industry to identify hazardous conditions created by winter layup and to collaborate with Coast Guard marine inspectors and local fire departments to aid in mitigating risk.



Meant to keep pipes and sea chests from freezing, furnaces aboard the *Roger Blough* caught fire in February 2021 while the ship was in winter layup in Sturgeon Bay, Wisconsin. The vessel was a total loss after the fire burned for 14 hours. Coast Guard photo

Marine inspectors on board a Laker participate in "Spring Breakout Training," in March 2022. The Lakers' winter layup season offers journeyman marine inspectors a chance to work on hull and machinery inspector qualifications on U.S.-flagged, deep-draft vessels. Coast Guard photo

During winter maintenance, Coast Guard marine inspectors frequently visit Lakers to observe repairs and ensure compliance with regulatory requirements in accordance with the vessel's certificate of inspection. The winter layup survey allows marine inspectors to leverage additional Coast Guard authority to proactively discuss and identify safety, security, and pollution hazards that could present a risk to the port or other nearby Lakers. Proactive and frequent engagement with owners and operators is critical to raising awareness and addressing potential hazards that may arise during challenging winter maintenance conditions. The survey consists of the owner/operator providing their Laker's emergency procedures and contacts, updated fire control plans, as well as a list of the vessel's equipment operating status to the Coast Guard in advance of winterization. This information is discussed with the assigned marine inspector who conducts a walk-through of the Laker to validate the information and determine whether any unidentified hazards exist once the vessel is moored. The intent of the survey is to foster proactive risk management and maintain better awareness of rapidly changing conditions. Regular communication with maritime industry and collaboration with port partners is essential for its success.

In the 2022 winter layup season, all of the owners and operators of the Lakers fleet submitted plans and emergency procedures and conducted winter layup survey walk-throughs, often with local fire departments in attendance. Local fire departments are encouraged to participate in vessel walk-throughs to identify hazards or barriers to an effective response. The efforts of the workgroup continue by incorporating lessons learned from National Transportation Safety Board and Coast Guard investigations to improve the winter layup surveys. Additionally, further communication and collaboration with the Occupational Safety and Health Administration will help reduce the risk of fires and ensure safety and health standards for shipyard employment are maintained for workers, mariners, and Coast Guard marine inspectors.

Planning for Response

Dwight D. Eisenhower once stated that "plans are nothing, planning is everything." Since 1992 there have been

15 fires onboard vessels berthed in the Great Lakes for the winter, with two major fires occurring in the last three years. Major marine firefighting incidents like these require the coordinated efforts of federal, state, and local resources to provide an aggressive and capable response. Over the past several years, the Ninth District's response to multiple major vessel fires has stretched response resources to their limits.

In order to address the many complex issues related to major vessel fires during winter work, the Coast Guard, along with local and state partners, has developed the Great Lakes Marine Firefighting Task Force (MFFTF). The purpose of this task force is to provide strategic-level guidance to the Captain of the Port and shoreside fire agencies, and to facilitate coordinated responses to dockside vessel fires occurring throughout the Great Lakes. Another major effort within the MFFTF is to outline local, state, and federal authorities and responsibilities to enhance local contingency plans and optimize the division of effort. An example of this is the clarification of requirements for vessels to maintain their Vessel Response Plan (VRP) while in winter layup. Maintaining a VRP also includes having salvage and marine firefighting service providers, by contract or other approved means, listed in their plans per Title 33, Code of Federal Regulations, § 155.4010 (Subpart I—Salvage and Marine Firefighting).

In the wake of the COVID-19 global pandemic and the *Roger Blough* fire, Marine Safety Unit Toledo is charting a way forward with the Western Lake Erie Marine Firefighting Workgroup. This assembly of vessel operators, waterfront facilities, and local fire departments will augment and update the Northwest Ohio and Southeast Michigan Area Contingency Plan. Running in parallel with the MFFTF, this workgroup will focus on mitigating marine fires through developing tactical and operational capabilities. For Lakers at berth during the winter in the Toledo area, the update to the Salvage and Marine Firefighting (SMFF) plan specific to winter work will provide greater coordination between operators and first responders by clarifying role and resource capabilities.

In Sturgeon Bay, the local fire department and the Coast Guard have collaborated to increase marine firefighting training and to identify response equipment staging locations for ready deployment. In the event of a major vessel fire, initial response time can be reduced by planning ahead, collaborating on tactics, and reinforcing mutual aid agreements to meet tactical needs, as well as facilitating familiarization and training.

In April 2022, the MFFTF held an inaugural seminar in Sturgeon Bay with a combination of local fire chiefs, state fire marshals, SMFF service providers, and the Coast Guard. This seminar allowed shoreside fire department leaders to discuss complex fire problem-solving, fire command issues, interagency responsibilities, mutual aid, strategic command, strategies, tactics, and pre-fire information gathering. The MFFTF will ensure consistency and coordination between the Coast Guard, local fire departments, vessel and facility owners and operators, mutual aid groups, and other interested organizations in developing port-specific information. The Ninth District developed an SMFF annex as part of the Great Lakes Area Contingency Plan template and will leverage the MFFTF to recommend further improvements to SMFF contingency plans and training to address shipboard fire challenges.

Conclusion

By preventing marine fires through inspections, and planning ahead for a more capable response, the Coast Guard and its partners are reducing the hazards to vessels and port facilities and protecting the marine transportation system. To prevent catastrophic fires that can impact vessels and port facilities, a culture of safety must be systematically built and fostered at all levels of the entire marine transportation system. Regulatory requirements and policy are just one small piece of a complex safety ecosystem, which requires regular nurturing of working relationships and communications between stakeholders as well as continuous training and improvement of plans, policies, and procedures. Lastly, every organization needs to increase employee awareness of hazardous conditions and instill confidence that the organization will resolve identified issues through established risk management processes. Risk management is a continuous active process, and safety is everyone's responsibility.

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Marine Transportation System Cybersecurity

Risk mitigation and incident response

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Imagine the following scenario: Threat actors from around the world, including state-sponsored hackers, gain access to tens of thousands of government and private organizations' computer systems in the United States and allied countries. Highly sophisticated attacks from hostile nation states, deploying groundbreaking "zero-day" exploits, merge with a barrage of for-profit ransomware and criminal activity that leaves organizations reeling. Massive amounts of intellectual property and intelligence are harvested by attackers, all while unprecedented digital extortion of ransoms enriches a complex, cooperative, criminal underground that, in a surreal twist, features Ransomware-as-a-Service.[1] This service comes complete with help desks to assist in paying ransoms, press releases, and quite probably a friendly relationship with local governments.[2] Amid this backdrop, war breaks out and the president of the United States warns that more cyberattacks are coming.[3]

Now, imagine that a hostile world power, preparing and testing capabilities for years, decides to launch a massive first-strike cyberattack against critical U.S. infrastructure to inflict maximum, lasting damage while obscuring their own identity.

Within the marine transportation system (MTS), one of the attack vectors includes the "hijacking" of vessel controls. Taking advantage of vessel system automations and connectivity, these hypothetical attackers target critical functions including propulsion and steering. Precise timing of the attack coupled with deceitful instrument readings impedes crew efforts to avert damage. Similarly, shoreside maritime facilities' systems might be targeted.

> How can we identify, protect, detect, respond, and recover from cyberattacks impacting the MTS?

Applying the National Institute of Standards and Technology (NIST) Framework for Improving Critical Infrastructure Cybersecurity,[4] how can we identify, protect, detect, respond, and recover from cyberattacks impacting the MTS? The following is an analysis of how the NIST Framework works for the Great Lakes MTS.

Identify

The first step in the NIST Framework is to develop an organizational understanding to manage cybersecurity risk to systems, people, assets, data, and capabilities. In response to recent threats, the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) launched a "Shields Up" campaign.[5] Among other recommendations, it advises the following for corporate leaders and CEOs:

> *Plan for the Worst; while the U.S. government does not have credible information regarding specific threats to the U.S. homeland, organizations should plan for a worst-case scenario.*

In the maritime arena, hijacking of control systems would appear to be the worst case. After the attacks of September 11, 2001, the Coast Guard expended considerable resources, including creation of the subsequently renamed "Sea Marshal" program, to mitigate the risk of physical attackers hijacking and seriously damaging ships or other maritime infrastructure.

Is it possible to hijack a vessel's control systems? Dr. Gary Kessler, retired professor of cybersecurity and active Coast Guard Auxiliarist, was asked if the scenario of a successful, pre-planned, nation-state, attribution-obscured hijacking of vessel control systems is realistic. His response was "ABSOLUTELY plausible and feasible," leaving no room for interpretation.

Dr. Kessler's response correlates with aspects of joint alerts[6] issued by the FBI, CISA, and other agencies. This includes a CISA-issued alert from April 2022 that stated, "certain advanced persistent threat actors have exhibited the capability to gain full system access to multiple

industrial control system/supervisory control and data acquisition (SCADA) devices."

A previous alert stated that Russian Federal Security Service officers had "conducted a multistage campaign in which they gained remote access to U.S. and international Energy Sector networks." Additionally, it stated that Russian cyber actors have "gained access to and leveraged … malware to manipulate a foreign oil refinery's Industrial Control System controllers." Prior to that, an alert regarding satellite communications stated that the FBI and CISA are aware of possible threats of intrusion into satellite communication networks that "could create risk in SATCOM network providers' customer environments."

In July 2021, SkyNews published an article[7] on apparently leaked Iranian cyber files. This indicated an interest in satellite communications as a potential pathway to exploit shipboard ballast water systems, assumedly for capsizing or otherwise damaging the vessel. LT Kevin Kuhn wrote an insightful article for *Proceedings* in 2017, highlighting cyber vulnerabilities in the MTS,[8] as did Dr. Kessler in 2019.[9] Together, with other alerts and indicators, it would appear there is a likelihood of nation-state level interest in diverse capability, including maritime, coupled with the technological potential for such an attack.

Dr. Kessler recently returned from the 2022 "Hack the Port" event where he was a principal consultant regarding this kind of scenario. He offered the following insight into how vulnerable vessels can be:

"While we were demonstrating attacks on ship systems assuming a connection to the bus [local data network], there are a variety of ways to the bus. For example, I bribe a crew member to attach a Raspberry Pi [a credit card sized computer] to the ship's CANbus [control network]. That is more easily accomplished than you might imagine. Attacking via the VSAT [satellite communications] is very feasible as so many ships have at least one point where the Operational Technology network and ship's business network attach to common points."

Continued exploration raises the question of what targets adversaries are likely to pick. A nation-state level threat actor, with time to plan and the potential for physical access to targeted systems, might seek to develop this capability on many different platforms. A fleet of vessels with similar design, operation, and level of automation might be one example.

The Stuxnet worm that attacked Iranian uranium enrichment centrifuges in 2010 was intricately designed to recognize and attack specific types of controllers.[10] Once inside a targeted system, the worm then caused the centrifuges to operate in a self-destructive way while sending spoofed normal readings to equipment operators.

In the vessel remote hijacking scenario, destruction of shipboard equipment would not necessarily be an end goal. Instead, an opportunistic sudden-onset attack when one of the compromised vessels is at the right location at the right time would seem to pose the greatest risk. Aforementioned, the adversary might use the ship's position broadcast on AIS to help time the attack. Due to uncertainty of which specific vessels might be compromised, protective countermeasures would need a multipronged approach, consisting of implementing cybersecurity precautions spanning whole classes of vessels and precautions for vessels sailing near critical infrastructure.

Protect

The second step of the NIST Framework is to develop and implement appropriate safeguards to ensure delivery of critical services. Effective protection in today's cyber landscape requires more than the installation of antivirus software, though that is one place to start. Done correctly, protection entails a wide range of considerations in continuous adaptation for "defense in depth." One example of this is the Coast Guard's protective efforts in the MTS cyber arena.

The Coast Guard Cyber Strategic Outlook[11] published in August 2021, is organized into three primary lines of effort. One is to "Protect the Marine Transportation System" using the Coast Guard's "same broad authorities and unique capabilities" and "apply the same proven risk management framework to the prevention and mitigation of cyber risks to the Marine Transportation System." Existing Coast Guard operational structures, authorities, and responsibilities readily translate into the MTS cyber arena. The Cyber Strategic Outlook makes several references to the Coast Guard Captain of the Port (COTP) as a central player in implementation of the strategy. The history of the COTP dates back to World War I in response to an attack on our homeland by German saboteurs.[12] These authorities are central to safety, security, and environmental protection of the MTS in response to attacks by determined adversaries.

Coast Guard sector commanders serve as the regional COTP and are designated other responsibilities, including those of a Federal Maritime Security Coordinator (FMSC). Title 46 of the U.S. Code (USC) section 70103[13] includes the requirement that the FMSC develop an Area Maritime Transportation Security Plan "for detecting, responding to, and recovering from cybersecurity risks that may cause transportation security incidents." Per the Coast Guard Headquarters Domestic Ports Division webpage,[14] Regional Area Maritime Security Committees (AMSC) were developed under the Maritime Transportation Security Act (MTSA) of 2002 to, "provide a link for contingency planning, development,

Two vessels and their barges prepare to pass through the Soo Locks en route to Lake Superior on March 24, 2021. Located in Sault Ste. Marie, Michigan, and operated by the Army Corps of Engineers, the Soo Lock help ensure safe, economical transportation of raw materials and other goods between Lake Superior and industrial hubs along the lower Great Lakes. Coast Guard photo by Chief Petty Officer John Masson

LT j.g. Brock Hashimoto, a lead marine inspector from Coast Guard Sector Delaware Bay, in Philadelphia, inspects the Hong Kong-flagged bulk carrier *Jin Hao* in July 2014 at the Balzano Marine Terminal in Camden, New Jersey. The Coast Guard regularly inspects domestic and foreign vessels to facilitate secure maritime trade. Coast Guard photo by Petty Officer 2nd Class Cynthia Oldham

review, and update of Area Maritime Security Plans, and to enhance communication between port stakeholders within federal, state and local agencies, and industry to address maritime security issues." As described in the Cyber Strategic Outlook, the COTP/FMSC in coordination with AMSCs and other committees is now central in protection of MTS port regions from cyber threats.

Title 46 USC 70103 also assigns responsibility for commercial vessels and facilities regulated under the MTSA to include cybersecurity risk mitigations in vessel and facility security plans. Throughout fiscal year 2022, the Coast Guard worked with regulated industry to facilitate compliance with MTSA cybersecurity requirements. Foreign vessels trading in U.S. ports are subject to International Maritime Organization requirements that include addressing cybersecurity in vessel safety management systems. Between vessel and facility security plans and safety management systems, cybersecurity risk mitigation is now engrained as a part of MTS operations.

Detect

The third step of the NIST Framework is to develop and implement appropriate activities to identify the occurrence of a cybersecurity event. Detection is particularly challenging as tactics are continually evolving to hide attackers' presence. The dazzling array of recent successful attacks demonstrates an unsettling reality for defenders of valuable data—malicious actors might already be inside their systems.

Proactively monitoring for anomalies is critical, as is a robust implementation of protective measures like segmenting network access, encryption, and resilient backups. Security Operation Centers are offered as a service that does 24/7 monitoring, intrusion detection, log review, and correlation. Unfortunately, it appears best to assume that it is more a matter of *when*, rather than *if*, a breach will happen.

Skilled Mariners

The alertness of skilled operators has long been recognized as vital to MTS safety and security. For example, the 1972 Convention on the International Regulations for Preventing Collisions at Sea[15] is deeply inculcated in professional mariner culture, including Rule 5 which calls for maintaining a proper lookout "by all available means appropriate in the prevailing circumstances." Operator monitoring of all available indicators and alertness to anomalies could make a critical difference in preventing a major transportation security incident within the MTS.

A Joint Cybersecurity Advisory details a February 2021 incident where "unidentified cyber actors obtained

unauthorized access to the SCADA system at a U.S. drinking water treatment facility. The unidentified actors used the SCADA system's software to increase the amount of sodium hydroxide, also known as lye, a caustic chemical, as part of the water treatment process. Water treatment plant personnel immediately noticed the change and corrected the issue before the SCADA system's software detected the manipulation and alerted them. As a result, the treatment process remained unaffected and continued operating as normal." Though not specifically maritime, this incident is relatable to how experienced operators similarly safeguard the MTS.

Members of the unified response for the Deepwater Horizon oil spill listen to an update from the command members at the unified command center in Houma, Louisiana, on April 25, 2010. The command included representatives of the Coast Guard, BP, the Marine Spill Response Corporation, National Response Corporation, National Oceanic and Atmospheric Administration, and the Louisiana Department of Fish and Wildlife along with local, state and federal agencies. Coast Guard photo by Petty Officer 3rd Class Stephen Lehmann

Information Sharing

Information sharing is vital to collectively enhancing protection of the MTS from cyber threats. Some information sharing is already required for different industry segments, including MTSA regulated vessels and facilities which are required to report cyber-related breaches of security and suspicious activity. Broader voluntary information sharing through regional committees like AMSCs is highly encouraged, as is the use of the reporting options like clicking the "report" button at the upper right of any CISA.gov webpage. MTS information sharing and analysis centers and organizations provide additional sources of MTS specific cyber threat mitigation information.

The Cyber Incident Reporting for Critical Infrastructure Act was signed into law in March 2022.[16] Associated implementation regulations are under development with opportunity for public comment. All these efforts tie together into a cooperative, interconnected web that is one of our best defenses against complex, ever-evolving adversaries.

Respond

The fourth step of the NIST Framework is to develop and implement appropriate activities to take action regarding a detected cybersecurity incident. As previously discussed, AMSCs develop area maritime security plans for security risks. Similarly, area committees develop area contingency plans for response to environmental emergencies that might result from a cyber incident, and other organizations, like harbor safety committees, may also generate relevant risk mitigation and response planning.

Considering existing, robust regional incident response planning, it is reasonable to ask a couple of questions. If a vessel is on the rocks leaking oil, wouldn't existing plans be sufficient? For purposes of the response, does it matter if cyber was a factor in how it got there? On one hand, many aspects of a response would remain the same, like those laid out in the Coast Guard Incident Management Handbook (IMH). However, there would also be some important differences in how a regional MTS cyberattack might present itself and how the response might differ from a traditional response.

One of the challenges of planning for and exercising capability to respond to a cyber incident in the MTS is that it may not initially manifest as a cyber-related incident. The IMH includes sample objectives for different incident types, like oil spills or MTS recovery, but understandably, investigation of an incident's causal factors is not listed as a time-critical initial objective. However, from the COTP or unified command perspective, early identification of a cyber-nexus is vital in order to initiate safeguards for other vessels that may be transiting near critical infrastructure or navigation chokepoints. It also may be important for possible evidence retention purposes.

Specific to Coast Guard resources, early technical consultation with regional MTS cyber specialists or the national level Maritime Cyber Readiness Branch may be helpful in analyzing potential cyber-related data points that emerge. Coast Guard Cyber Protection Teams could be rapidly mobilized for direct on-scene analysis of cyber data-points and development of defensive strategies if a broader attack is suspected. The Coast Guard Incident Management Handbook mobile app includes a technical specialist job aid which indicates that under the Incident Command System, "personnel with specialized skill can be assigned anywhere in the response organization."

The Intelligence/Investigation section has largely

been the traditional locus of all cyber aspects of response exercises. However, in the event of a worst-case scenario like a sophisticated remote vessel hijacking, seamless integration of a cyber specialist into several aspects of the response may be necessary.

Recover

The final step of the NIST Framework is to develop and implement appropriate activities to maintain plans for resilience and to restore any capabilities or services that were impaired due to a cybersecurity incident. The recent damage organizations have suffered shows recovery should not be an afterthought in the planning process. It may not be a question of whether a recovery plan will ever be enacted, but more a question of when, and how well it will go.

NIST Special Publication 800-184 Guide for Cybersecurity Event Recovery[17] states that, with the increase in cybersecurity events, resilience can be improved by ensuring risk management processes "include comprehensive recovery planning." Identifying and prioritizing organizational resources helps guide effective plans and realistic test scenarios. This preparation enables rapid recovery when incidents occur and helps minimize the impact on the organization and its constituents.

For organizations just stepping into the recovery arena, the CISA Shields Up guidance includes recovery fundamentals, as do other resources, like the CISA Cyber Essentials Starter Kit. Actual testing of recovery plans is, of course, highly recommended, as is continuous adaptation, including recognizing that ransomware operators will likely also target backup systems.

Conclusion

The prospect of a worst-case cyber incident in the MTS is highly alarming, and technically plausible. Cross-walking between cyber technical concepts that may seem intimidating at first and "real-world" MTS operations is a challenge, but structurally the MTS community is highly adaptive and may find that cybersecurity can be readily incorporated into the MTS culture.

As part of the Department of Homeland Security, with strong ties to the Department of Defense, close connections to the maritime industry, and a web of port partners, the Coast Guard is well-suited to answer this challenge. Being *Semper Paratus* in the cyber age is a new challenge, but draws on a proud tradition including the first COTPs answering the call during World War I.

For more information

The Coast Guard *Incident Management Handbook* can be found at www.atlanticarea.uscg.mil/Portals/7/Ninth%20District/Documents/USCG_IMH_2014_COMDTPUB_P3120.17B.pdf?ver=2017-06-14-122531-930

The mobile app can be found by searching MIMH in app stores. Both are free of charge.

More information on CISA Shields Up can be found at www.cisa.gov/shields-up

About the author:

Patrick Nelson has served in his current position for more than a year, and has 30 years of active duty service with the Coast Guard, primarily in prevention and technical assignments. He holds a Bachelor and Master of Science in electrical engineering, with a focus on energy systems and electrical power.

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The St. Lawrence Seaway's Voyage Information System

The next step in vessel traffic management

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Advancements in navigation technology and the need for greater certainty in transportation supply chains are revolutionizing vessel traffic management. In the St. Lawrence Seaway, an initiative is underway to modernize the Seaway's vessel Traffic Management System (TMS) by developing a new Voyage Information System (VIS) to better manage vessel transits through the international waterway. The two entities responsible for overseeing the Seaway—the Canadian St. Lawrence Seaway Management Corporation (SLSMC) and the U.S. Great Lakes St. Lawrence Seaway Development Corporation (GLS)—see the VIS not only improving vessel traffic management, but also transforming vessel voyage planning in the Seaway and beyond.

The St. Lawrence Seaway, an international waterway that sustains nearly 238,000 jobs and $35 billion in transportation-related business revenue, has been jointly managed by Canada and the United States since it opened to deep-draft navigation in 1959. It is composed of 15 locks—13 Canadian and two American—between Montreal, Quebec, and Lake Erie. On average, there are approximately 4,000 vessel transits a year, consisting primarily of international and Canadian-flagged vessels. A vessel transiting the full length of the Seaway crosses the international border 27 times as it traverses the St. Lawrence River, Lake Ontario, the Welland Canal, and part of Lake Erie. Due to this unique geography, the GLS and the SLSMC collaborate on all operational aspects of managing the Seaway, including joint management of a binational TMS that encompasses the Seaway's four vessel traffic sectors.

A vessel transiting the full length of the Seaway crosses the international border 27 times as it traverses the St. Lawrence River, Lake Ontario, the Welland Canal, and part of Lake Erie.

The Seaway corporations have previously introduced new navigation technologies like the Automatic Identification System (AIS) in 2002 and the Draft Information System (DIS) in 2009. In both cases, the Seaway was the first inland waterway in the world to adopt these technologies, which dramatically increased safety and efficiency, leading to their adoption on other inland waterways.

In 2017, the Seaway corporations collaborated with the U.S. Department of Transportation's Volpe National Transportation Systems Center to develop a concept of operations for a new vessel management tool, dubbed Seaway Time of Arrival, or SeaTA, to improve the accuracies of estimated times of arrival (ETAs) for vessels.[1] SeaTA was designed to leverage the current Seaway TMS platform to provide travel-time estimates between the current locations of vessels transiting the St. Lawrence Seaway and key waypoints along their routes. The SeaTA concept has led to the current initiative to develop a Seaway VIS that can provide more accurate—and predictive—ETAs.

Vessels transit the locks in the St. Lawrence Seaway's Welland Canal. Photo courtesy of the St. Lawrence Seaway Management Corporation

This has the potential to dramatically improve the safety and efficiency of vessel voyage planning for the Seaway's traffic controllers, as well as for operators, agents, pilots, terminals, stevedores, and ports. The Seaway VIS can provide greater transparency and certainty to the Great Lakes Seaway waterborne supply chain. While a new, and possibly revolutionary, navigation tool, the VIS will rely on and integrate with the Seaway's well-established and dependable TMS technology. Therefore, to understand the Seaway VIS, one must first understand the Seaway's TMS.

The Seaway's Current Traffic Management System

Personnel operating from vessel traffic control centers located at Canada's St. Lambert Lock, the United States' Eisenhower Lock, and Canada's Welland Canal control vessel traffic through the St. Lawrence Seaway. The TMS provides and receives navigation information needed by traffic controllers and ships to transit the Seaway. The Seaway corporations share the system to provide ships with a seamless transit through Canadian and U.S. waters. The TMS is used to establish a transit plan for each vessel transiting the Seaway. The plan is automatically populated with static information about the vessel, like type, size, and owner, from the TMS database, while controllers enter specific transit-related information like draft, cargo, and pilot requirements. Currently, some information used by vessel traffic control personnel is still transmitted via VHF radio and entered manually into the TMS system.

In 2002, the Seaway Corporations made a significant improvement to navigation safety and efficiency by bringing the AIS online and fully integrating it with the Seaway's TMS. A team that included the GLS, the SLSMC, various marine transportation interests, and technical assistance from the U.S. Volpe Transportation Systems Center completed the project.

Using GPS technology, any vessel equipped with an AIS transponder transmits its position to the Seaway corporations as well as to other ships on the waterway equipped with AIS. The AIS broadcasts voyage-related information, including ship location, speed, course, heading, rate of turn, and ETAs. Additionally, static information, including ship name, Maritime Mobile Service Identity, type, size, draft, and destination, is entered manually by the vessel and broadcasted via AIS.

Seaway traffic controllers use the information they receive through AIS to help control the traffic. Using TMS and AIS benefits the Seaway Corporations and vessel operators by reducing vessel delays, improving scheduling of lockages, pilots, and vessel tie-ups, and allowing faster response times in the event of an accident or incident. They also provide the ability to monitor all vessels' speeds to ensure compliance with Seaway speed limits, as well as for enhanced monitoring of vessels for safety and security purposes.

Complementing the standard vessel information provided through AIS, additional useful data is broadcast to vessel operators over AIS or TMS, including wind speed and direction, water levels and outflows, ice conditions, lock availability, bridge status, and pertinent safety-related messages. The information provided by these systems enhances the ability of each ship captain and pilot to navigate the Seaway safely and efficiently.

Additionally, TMS generates several reports tracking information like transits, delays, enhanced seaway inspections, Canadian Seaway tolls, and incidents.

The Seaway's traffic controllers work from information displayed on an overview and monitors at their workstations. The overview shows information for all of the vessels within Seaway control sectors, including vessel position, direction of travel, length, beam, draft, cargo, speed, pilot requirements, order of turn, any vessel-specific instructions, and the ETA for the next call-in point. Currently, ETAs are based on standard transit times for upbound and downbound transits that were developed based on historical data. For most of the navigation season, order of turn at each lock in the Seaway is determined on a first-come, first-served basis. Lock operators use information from TMS to determine where to position the ship in the lock as well as the best position to attach the Hands-Free Mooring (HFM) units to the vessel.

> The Marine Connectivity Platform will be designed to allow for the secure and reliable exchange of data and information within the maritime sector.

As the VIS is developed, the TMS will be modernized in several significant ways. First, information entry will be automated and a platform for efficient information exchange with ships transiting the Seaway will be provided. Second, as better quality and more accurate information is shared between the Seaway corporations and their users/stakeholders, more accurate ETAs will allow vessel operators to use this information to save fuel, reduce greenhouse gas emissions, and reduce staffing needs. The hope of the Seaway corporations is to build a system where information that will improve the safety and efficiency of a ship's voyage through the Great Lakes Seaway System can be shared for the entire voyage.

Voyage Information System Development

The Seaway VIS is based on the principle that the safety and efficiency of a Seaway transit can be enhanced by having additional information regarding the entirety of a vessel's voyage, from its origin to its destination. Knowing where a vessel intends to go, and where it must stop along that voyage, will allow Seaway traffic controllers and stakeholders to better plan and manage each transit segment.

During the initial phases of the VIS development, the Seaway corporations plan to:

- improve transit planning through historical transit data analysis
- incorporate the improved ETA data in the Seaway's TMS
- develop the Seaway Marine Connectivity Platform
- demonstrate how the improved ETAs can improve operations at the Seaway's locks and bridges

The current estimated vessel travel time between waypoints in the Seaway is based on a few standard criteria. By expanding this model to include more vessel characteristics, like hull configuration, load condition/draft, river flows, and time of year/weather to determine an average speed, the predicted ETA accuracy will improve. This will be achieved by applying advanced analytics to historical transit data from previous years.

As part of the VIS development process, the Seaway corporations intend to measure the accuracy of ETAs for vessel transits. Ultimately, the VIS will develop accurate predictions over a period of several days. The further into the future one goes, however, the more challenging it becomes to maintain accuracy. Therefore, it will be essential to continuously measure the accuracy of predicted ETAs against the actual transit times of vessels. This will be an iterative, learning process, but a necessary one to provide accurate, reliable data to Seaway users as they plan their voyages. These enhanced predictions will be available through existing tools—the joint Seaway website, greatlakes-seaway.com, or AIS messages—and a future electronic data exchange platform and portals.

A Great Lakes St. Lawrence Seaway Development Corporation vessel traffic controller monitors seaway vessel traffic from the control center in Massena, New York. Photo courtesy of the Great Lakes St. Lawrence Seaway Development Corporation

To accomplish this, ship operators will be required to share the vessel's voyage plan with the Seaway corporations prior to the vessel's departure from a port or entry into the Seaway. The Seaway VIS will be developed to provide confidential and secure data exchange to protect potentially sensitive commercial information, and cybersecurity risk management will be a prime objective in the system's design and implementation.

The Seaway corporations plan to create a Marine Connectivity Platform to connect the VIS with Seaway partners, such as the Canadian and U.S. Coast Guards, pilotage and port authorities, and vessel and fleet operators while allowing for a secure data exchange. A different platform for information-sharing services that will include vehicles using the Canadian Seaway's lift bridges and pleasure craft transiting the locks will be available to the general public. The development of these services will be patterned after the River Information Services framework, as defined by the World Association for Waterborne Transport Infrastructure River Information Services Guidelines.

To prevent redundant data entry in multiple systems, the VIS will be designed to integrate and be interoperable with other existing systems including those being developed in the intelligent transportation system domain. The integration or interoperability with the National Maritime Single Window initiatives, port management or port community systems, and Vessel Traffic Maritime Information Systems (VT-MIS) is an example of this. Progressively, all data exchange with external parties will occur through the Marine Connectivity Platform.

For Seaway users, there are numerous anticipated benefits, including the reduction of vessel delays due to lockage availability or improved scheduling of needed services like pilotage. Additionally, the VIS will allow the Seaway corporations to deploy their personnel and resources more efficiently, while also allowing the Canadian Seaway to improve the dispatch of tasks within its remote operations center. Vessels that are not able to use the Seaway's HFM technology could more efficiently schedule conventional mooring services. Finally, having a more accurate understanding of vessel ETAs will allow the Seaway corporations to optimize infrastructure maintenance.

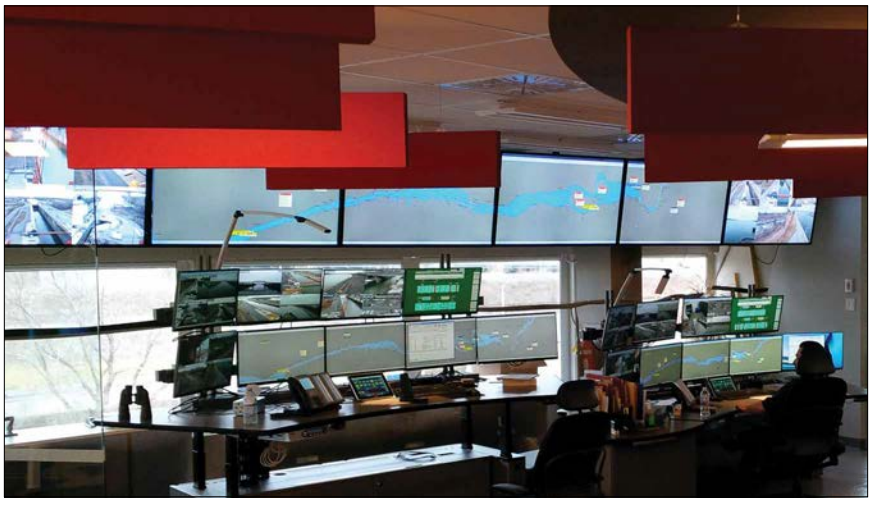
The first phase of VIS is also an opportunity to continue the development of the Seaway's Electronic Navigation portfolio. Through this initiative, more information about the status of locks and bridges will be made available to mariners through the Marine Connectivity Platform, AIS, and other communication channels.

For the early phases of the VIS project, real-time data such as water levels, flows, and the status of movable bridges and locks will be communicated to the vessels. As the project progresses, experience will be gained on how to effectively share information in a number of areas, including fog and ice delays, pilot and anchorage availability, speed restriction zones, buoy outages, and virtual buoys, among others. The requirement for VHF communications at call-in points can be made more efficient by exchanging information electronically.

Although the geographic and infrastructure configuration of the Seaway's traffic control sectors are different, the fundamental navigation requirements for each region are the same. The Seaway VIS will have identical capabilities and services for all sectors, even though some of the system's features may be more useful in certain sectors than in others.

Beyond The Seaway

While the initial goal of the VIS project is to improve Seaway transits, the potential applications are significant. In developing the system, the Seaway corporations want to ensure the modernized Seaway TMS can align with efforts by other stakeholders to improve vessel traffic management throughout the Great Lakes-St. Lawrence River Seaway System. The successful history of the Seaway's development and implementation of AIS in 2002 provides a potential road map for how the Great Lakes region's stakeholders could leverage the information provided by a Seaway VIS to improve their operations. The Seaway corporations were the first entities to implement AIS in the Seaway portion of the Great Lakes-St. Lawrence River Seaway System, which



A St. Lawrence Seaway Management Corporation vessel traffic controller monitors vessel traffic from the control center in Montreal, Quebec. Photo courtesy of the St. Lawrence Seaway Management Corporation

The New Seaway Traffic Management System Graphic Display

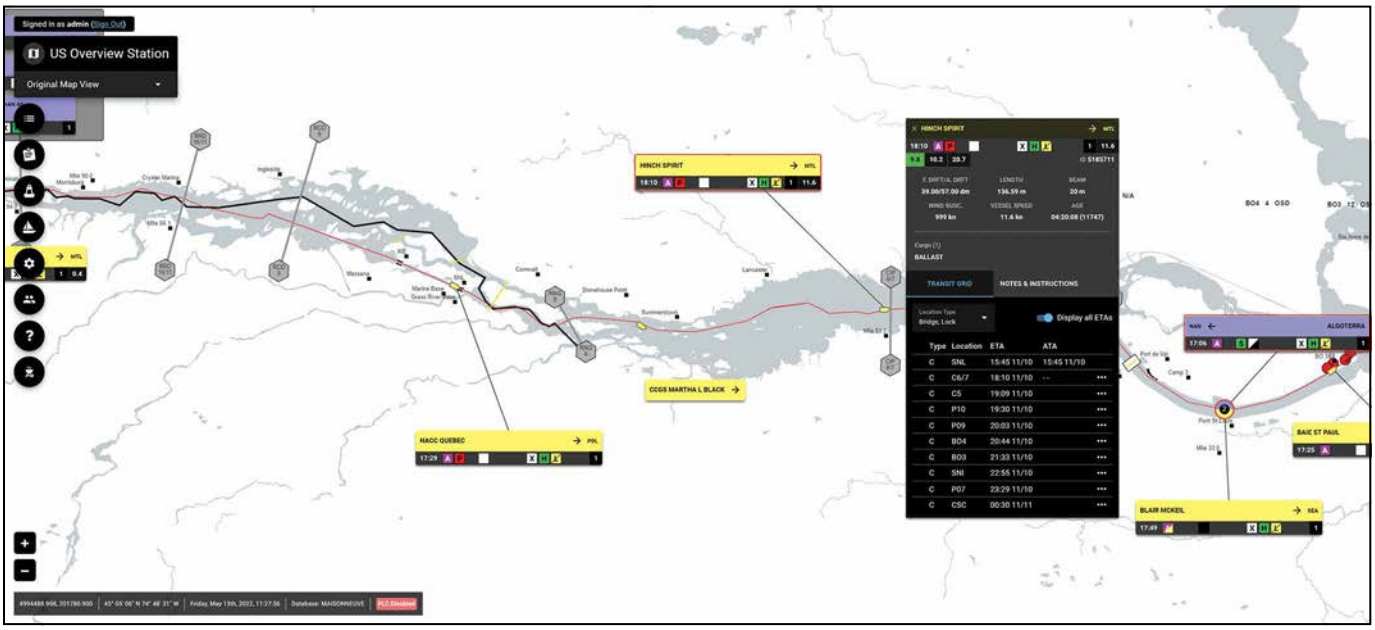


Image courtesy of St. Lawrence Seaway Management Corporation

demonstrated the benefits of the technology, allowing the U.S. and Canadian Coast Guards to extend it to the other geographic regions of the System. Having AIS throughout the Great Lakes-St. Lawrence River Seaway System has been a boon for navigation safety and efficiency.

Implementing a VIS in the Seaway will produce initial benefits for the Seaway corporations and the stakeholders who transit it. But, ultimately, a voyage management tool—or tools—that can cover the entire region will produce the most significant benefits for all of the System's stakeholders. The Seaway corporations hope to be a catalyst in encouraging that long-term development, just as they were for AIS.

The VIS will provide a means of analyzing the data collected from Seaway transits over the last 20 years. By using advance analytics like machine learning/artificial intelligence and modeling, the VIS will be able to integrate live data and new information from partners to provide optimized ETAs and other traffic-related information on a continuous basis.

Conclusion

The Seaway corporations have embarked on an effort to develop a new navigation and algorithmic tool that improves the accuracy of vessel ETAs and enhances overall system efficiency and scheduling decisions. Enhancing the current TMS to make it more accurate and predictive will not only improve the ETA for vessels at the Seaway's locks, but, ultimately, everywhere throughout the Seaway. The goal is to create a more comprehensive TMS that can enable enhanced voyage planning from origin, transit through the Great Lakes, and to destination. The VIS would have the ability to gather and process data that could provide recommendations for real-time course or speed changes to safely facilitate maximum operational efficiency. This includes scheduling vessel inspections, bridge closures, pilotage services, and dock usage at ports, as well as lockages, while respecting the interests of individual vessels.

Bringing this technology to the Seaway will help chart the future of reliable, safe, and efficient navigation across the entire Great Lakes-St. Lawrence River Seaway System.

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Endnote:

1. "Concept of Operations: SeaTA, Enhanced Travel Time Estimates and Traffic Management Practices for the Saint Lawrence Seaway," Volpe Transportation Systems Center for the U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology, Intelligent Transportation Systems Joint Program Office (2017).

Internal Waterway Navigability Determinations and the U.S. Coast Guard

How internal waterways become subjected to Coast Guard jurisdiction

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The views expressed are those of the authors and do not reflect the official policy or position of the U.S. Coast Guard, Department of Homeland Security, or the U.S. Government.

Is a waterway navigable? The best answer relies upon the well-worn rejoinder to every question ever tendered at law schools: It depends. Whether a waterway is navigable, and thus subject to U.S. Coast Guard jurisdiction, depends upon four sources of law governing the internal waters of the United States. These are the regulatory definition of navigable waters,[1] the Clean Water Act,[2] the Rivers and Harbors Act,[3] and decisions by courts of law, commonly called case law.

Regulatory Definition of Waterways

Navigable waterways are generally defined as internal waters that form "in their ordinary condition, by themselves, or by uniting with other waters, a continued highway over which commerce is or may be carried on with other States or foreign countries in the customary modes in which such commerce is conducted by water."[4] Courts, the Coast Guard, the United States Army Corp of Engineers (USACE), and Congress may designate and de-designate bodies of water, including lakes and rivers, as navigable waters subject to U.S. jurisdiction.

Unless otherwise specified by Congress, the Code of Federal Regulation (CFR) delineates three methods, by which the Coast Guard has jurisdiction over navigable waters. Territorial seas, or bodies of water extending 12 nautical miles from land and into the oceans, are just one type of body of water over which the Coast Guard always has jurisdiction.[5] Additionally, internal waters

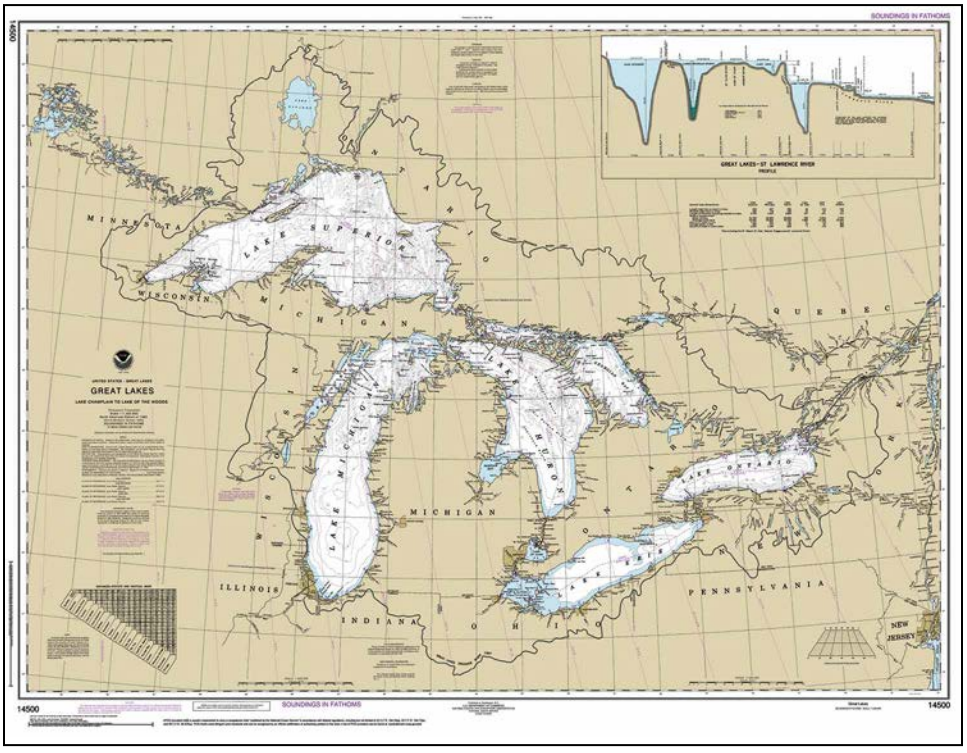
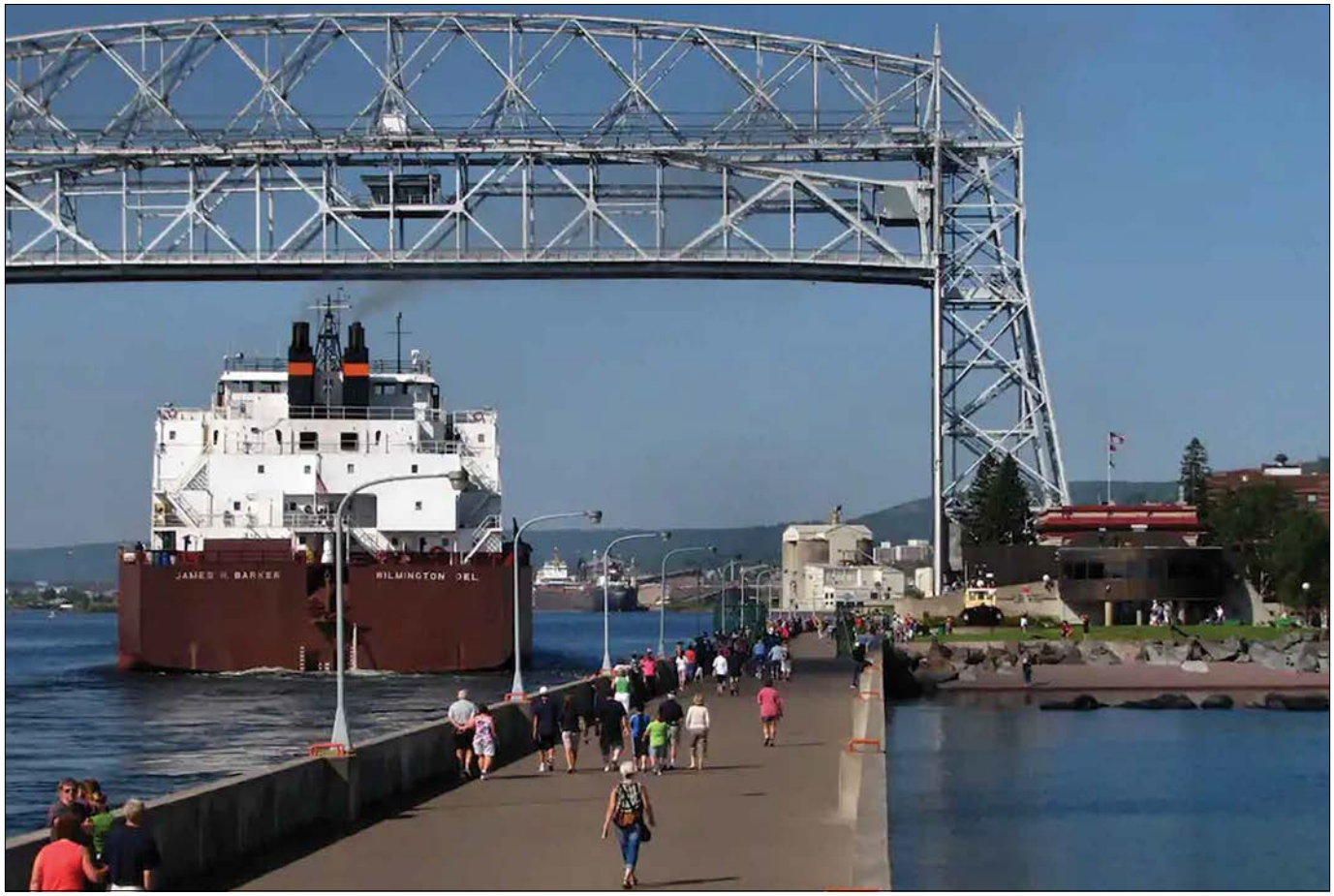


Chart courtesy of the National Oceanic and Atmospheric Administration



The *James R. Barker*, a 1,000-foot bulk carrier, arrives in Duluth, Minnesota. Photo courtesy of the U.S. Army Corps of Engineers

of the United States that are subject to tidal influence are also generally under Coast Guard jurisdiction.

Internal waters not subject to tidal influence can be subject to Coast Guard jurisdiction, but only if certain parameters are met.[6,7] These waters are defined as those that are or have been used, or are susceptible for use, by themselves or in connection with other waters, as highways for substantial interstate or foreign commerce, notwithstanding natural or man-made obstructions that require portage.[8] Alternatively, non-tidally influenced waterways can be those that a governmental or nongovernmental body, having expertise in waterway improvement, determines. They must be capable of improvement at a reasonable cost to provide, by themselves or in connection with other waters, highways for substantial interstate or foreign commerce.[9] Waters that meet any of these definitions listed in the CFR, are subject to the jurisdiction of the Coast Guard.[10]

Clean Water Act

Another statutory source used in determining the navigability of a waterway is the Clean Water Act.[11] This act states that navigable waters, to include territorial seas, are the waters of the United States.[12] Furthermore, USACE regulations set forth the jurisdictional limits of authority for the Army Corps of Engineers under the Clean Water Act.

Under this act, navigable waters are defined as the territorial seas, and waters currently or previously used for, or that may be susceptible to use in interstate or foreign commerce. This includes waters which are subject to tidal ebb and flow and tributaries or such bodies of water, lakes and ponds, and dammed bodies of water containing navigable waterways.[13] This definition is synonymous with the definitions found in the CFR defining navigable waters for the purposes of the Clean Water Act and its implementing regulations.[14]

Rivers and Harbors Act

The Rivers and Harbors Act[15] further defines navigable waters of the United States. They are "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce."[16] Additionally, the Act provides that, "a determination of navigability, once made, applies laterally over the entire surface of the waterbody, and is not extinguished by later actions or events which impede or

destroy navigable capacity."[17]

Once a navigability determination has been made, no construction or excavation in navigable waters may take place without authorization from USACE.[18] This similarly impacts the ability to construct dams on navigable waterways, and implicates activities that alter the course of navigable waters.

While a conclusive determination of the navigability of a waterway can only be made by Congress or the federal courts, a determination by USACE, the Coast Guard, or other agency is accorded substantial weight by the courts.

Two Lakers pass on the St. Clair River, Michigan. Just over 40 miles long, the St. Clair River connects lakes Huron and St. Clair and forms part of the international boundary between Michigan and the Canadian province of Ontario. Photo courtesy of the U.S. Army Corps of Engineers, Detroit District

Case Law to Define Waterways

The final body of law that is useful in determining the navigability of a waterway is that of the courts. There are many cases that have established a number of historical precedents in these matters, but the generally recognized test for determining navigability is called the *Daniel Ball* test, named for the 1870 *The Daniel Ball* court case.[19] This test states that when waterways form by themselves, or by bonding with other waters, and create a continued thoroughfare where trade is, or could be, conducted with other states or foreign countries in manner where trade is administered by water they are considered navigable.[20] Waters satisfying these tests are subject to the jurisdiction of the Coast Guard.[21] A later Supreme Court case, *The Montello*,[22] further clarified whether a waterway was navigable when the Court explained the standard of navigability. It is the public's use for purposes of transportation and commerce affords the "true criterion of the navigability of a river, rather than the extent and manner of that use. If it be capable in its natural state of being used for purposes of commerce, no matter in what mode the commerce may be conducted," it is navigable in fact, and becomes in law a public river or highway.[23] The Court concluded that since a waterway is navigable—it can support transportation and commerce—then it is subject to the Commerce Clause and Congress can regulate activities upon it.[24]

This was elaborated on with *United States v. Utah*, where the Supreme Court held that the most persuasive evidence is that which shows actual use of streams, especially where there's extensive and continued use for commercial purposes.[25] The Court further clarified that even with limited scope or frequency of use explained away due to exploration and settlement, the susceptibility of a waterway to be used as a highway of commerce may still be satisfactorily proven.[26]

United States v. Appalachian Electric Power Co.[27] was instrumental in crafting this body of law. Here, the Court held that a waterway need not be currently navigable, nor navigable for its entire length, provided that there is a balance between the need for improvement with the cost of doing so.[28]

The bottom line is that Congressional approval is necessary prior to the designation of a waterway as navigable. Once a navigability determination is made regarding a waterway it is not "extinguished by later actions or events which impede or destroy navigable capacity."[29] However, designating a new body of water as navigable is a very difficult process.[30]

Prior to a waterway being designated as navigable, notifications must be made to several entities, including:

- the governor of each state in which such waterway is located
- the public
- the Senate Committee on Commerce, Science, and Transportation
- the House Committee on Transportation and Infrastructure[31]

The notification must include an analysis of whether vessels operating on the waterway are subject to

inspection, licensing, or similar regulations by state or local officials. Additionally, it must include an estimate of the annual costs the Coast Guard may incur in conducting operations on the waterway.[32]

While the Coast Guard must comply with these regulations limiting its ability to make new navigability determinations, the same is not true for broadening existing determinations. There, the service can determine that an existing navigability determination applies to a connecting waterway, or another stretch of the same body of water. When the Coast Guard takes such action, industries that find themselves restricted by the imposition can choose to comply or challenge the navigability determination in court.

Once a waterway is determined to be navigable, then the Coast Guard has authority to exercise statutory jurisdiction. The Coast Guard is mandated by Congress to "enforce or assist in the enforcement of all applicable Federal laws on, under, and over the high seas and waters subject to the jurisdiction of the United States[.]"[33]

Some of these authorities are mandatory, while others are permissive in nature. For example, the Coast Guard is mandated to enforce or assist in enforcement of federal laws, administer laws, and promulgate regulations for the protection of life and property. It must develop, maintain, and operate aids to maritime navigation, icebreaking facilities, and rescue facilities for the promotion of safety, and engage in oceanographic research.[34] The Coast Guard also must enforce rules and regulations regarding anchorage grounds, as determined by the Secretary of Homeland Security.[35] Finally, The Secretary of Homeland Security is directed to evaluate and mitigate safety risks for vessel traffic service areas to improve safety and reduce the risks of oil and hazardous material discharge.[36]

However, the Coast Guard also has permissive authorities that allow it to engage in rescue and rendering aid,[37] and make inquiries, examinations, inspections,

The *Great Republic*, a bulk carrier homeported in Wilmington, Delaware, prepares to tie up below the MacArthur Lock while it waits for fog to lift in the lower St. Marys River in October 2011. Photo courtesy of the U.S. Army Corps of Engineers

searches, seizures, and arrests for violations of law.[38] The Secretary's permissive authorities include controlling the anchorage and movement of any vessel in the navigable waters of the United States to ensure the safety or security of any vessel of the armed forces in those waters.[39] They also include marking obstructions;[40] protecting the waters and resources from harm resulting from vessel or structure damage, destruction, or loss;[41] and investigating events affecting the safety or environmental quality of the ports, harbors, or United States' navigable waters.[42]

Once a waterway has been determined to be navigable, the Coast Guard is able to avail itself of a host of authorities relating to the enforcement of environmental, safety, inspection, and other authorities. A navigability determination affects every facet of a waterway and the surrounding area. Commercial and pleasure craft alike are impacted by these determinations, as is the construction of manmade structures. While the building of bridges, dams, and other structures may not seem affected by a navigability determination, where construction projects have the potential to impede the free flow of commerce on the waterway, the Coast Guard has an interest. Therefore, once a navigability determination has been made, any commercial or pleasure activity in, on, or around that waterway has the potential for regulation by Coast Guard authorities.

As first mentioned, the answer to whether a waterway is navigable is complicated. The answer truly is: It depends. The regulatory definition of navigable waters; the Clean Water Act; the Rivers and Harbors Act; and case law all help determine waterway navigability.

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LT Griffin Deitz has served in the U.S. Coast Guard for three years, spending two years as a Special Victims' Counsel, and one year as a staff attorney. Prior to joining the Coast Guard, LT Deitz worked as a deputy district attorney and as an attorney in private practice.

Endnotes:

1. 33 C.F.R. § 2.36(a) (supplementing 14 USC § 503)
2. 33 U.S.C. § 1251 *et seq*
3. 33 U.S.C. § 403
4. *The Daniel Ball*, 77 U.S. 557, 563 (1871). Once a water is determined to be navigable, that "power authorizes all appropriate legislation for the protection or advancement of either interstate or foreign commerce, and for that purpose such legislation as will insure the convenient and safe navigation of all the navigable waters of the United States, whether that legislation consists in requiring the removal of obstructions to their use, in prescribing the form and size of the vessels employed upon them, or in subjecting the vessels to inspection and license, in order to insure their proper construction and equipment." Thus, once a waterway is determined to be navigable then the United States may implement and assert all authorities to improve (USACE) and regulate/inspect/license (USCG). Congress codified the decision in The Clean WaterAct, 33 U.S.C. 1251 *et seq*
5. 33 C.F.R. 2.36(a) (2022)
6. Ibid
7. 33 C.F.R. 2.36(a)(3)(ii) (2022) is what gives the USACE authority to designate internal waters, not subject to tidal influence as navigable for the purposes of this regulation
8. 33 C.F.R. 2.38 (Waters Subject to the Jurisdiction of the U.S.; Waters over which the U.S. has Jurisdiction) implementing 14 U.S.C. 503 states "Waters subject to the jurisdiction of the United States and waters over which the United States has jurisdiction mean the following waters—(a) Navigable waters of the United States, as defined in § 2.36(a). (b) Waters, other than those under paragraph (a) of this section, that are located on lands for which the United States has acquired title or controls and—(1) Has accepted jurisdiction according to 40 U.S.C. 255; or (2) Has retained concurrent or exclusive jurisdiction from the date that the State in which the lands are located entered the Union. (c) Waters made subject to the jurisdiction of the United States by operation of the international agreements and statutes relating to the former Trust Territory of the Pacific Islands, and waters within the territories and possessions of the United States."
9. 33 C.F.R. 2.36(a)(3)(ii) (2022) is what gives the USACE authority to designate internal waters, not subject to tidal influence as navigable for the purposes of this regulation
10. 33 C.F.R. 2.38
11. 33 U.S.C. 1251 *et seq*
12. 33 U.S.C. 1362(7).
13. 33 C.F.R. § 328.3(a)
14. 40 C.F.R. 120.2 (2020) is the regulation implementing the Clean Water Act for the Environment Protection Agency and other federal agencies
15. 33 U.S.C. 401 *et seq*
16. 33 C.F.R. 329.4 (1986)
17. Ibid
18. 33 U.S.C. 401 and 403
19. *Lockheed Martin Corp. v. Morganti*, 412 F.3d 407, 412 (2nd Cir. 2005) (Citing *The Daniel Ball*, 77 U.S. 557(1871))
20. *The Daniel Ball*, 77 U.S. 557, 563 (1871)
21. 33 C.F.R. 2.38 (Waters Subject to the Jurisdiction of the U.S.; Waters over which the U.S. has Jurisdiction) implementing 14 U.S.C. 503 states "Waters subject to the jurisdiction of the United States and waters over which the United States has jurisdiction mean the following waters—(a) Navigable waters of the United States, as defined in § 2.36(a). (b) Waters, other than those under paragraph (a) of this section, that are located on lands for which the United States has acquired title or controls and—(1) Has accepted jurisdiction according to 40 U.S.C. 255; or (2) Has retained concurrent or exclusive jurisdiction from the date that the State in which the lands are located entered the Union. (c) Waters made subject to the jurisdiction of the United States by operation of the international agreements and statutes relating to the former Trust Territory of the Pacific Islands, and waters within the territories and possessions of the United States."
22. *The Montello*, 87 U.S. 430
23. *LeBlanc v. Cleveland*, 198 F.3d 353, 357 (2nd Cir. 1999) (Citing *The Montello*, 87 U.S. 430 (1874)
24. *The Montello*, 87 U.S. 430
25. *United States v. Utah*, 283 U.S. 64, 82 (1931)
26. Ibid
27. *United States v. Appalachian Electric Power Co.*, 311 U.S. 377 (1940)
28. Ibid
29. 33 C.F.R. 329.4 (1986)
30. 14 U.S.C. 563 (2018)
31. Ibid
32. Ibid
33. 14 U.S.C. 102
34. Ibid
35. 46 U.S.C. 70006
36. 46 U.S.C. 70001
37. 14 U.S.C. 521
38. 14 U.S.C. 522
39. 14 U.S.C. 527
40. 14 U.S.C. 545
41. 46 U.S.C. 70011
42. 46 U.S.C. 70035

Historical Snapshot

The Frozen Fury, The Big Blow

The White Hurricane of 1913 lives up to its many monikers

by Samantha L. Quigley
Executive Editor, Proceedings of the Marine Safety & Security Council
U.S. Coast Guard

No lake master can recall in all his experience a storm of such unprecedented violence with such rapid changes in the direction of the wind and its gusts of such fearful speed.

— Lake Carriers' Association, 1913

As noted throughout the articles in this issue, the Great Lakes offer spectacular beauty and recreational opportunities for every season. They are also vital to the North American economy and, thanks to the U.S. Coast Guard and its Canadian, federal, and state partners, the Great Lakes-St. Lawrence River Seaway System remains viable and maintained. Those who know the Great Lakes, however, know they can also be unpredictable and dangerous, which means the White Hurricane of 1913 should be shocking only for its unrelenting ferocity, not that it occurred.

November Gales

The Gales of November, a term said to have been coined by singer Gordon Lightfoot, are a common occurrence on the Great Lakes, with sustained winds clocking in between 40 and 54 mph. Add waves that can reach 30 feet in height on Lake Superior and it is a recipe for anything but smooth sailing. The Gales, also referred to as a November Witch, have bested many a ship, including the SS *Edmund Fitzgerald*, which sank November 10, 1975, on Lake Superior in 533 feet of water during a ferocious storm. Her entire crew of 29 was lost.

Gales are created by mid-latitude cyclones, which present on weather radar as comma-shaped cloud patterns with a "well-defined circulation," according to the National Oceanic and Atmospheric Administration. They are more frequent in colder months, but can occur from late fall to early spring, and are caused by a significant contrast in air mass temperatures.

One of the most devastating examples of a mid-latitude cyclone crossed the region in November 1913. The storm killed as many as 300 people, sank 12 ships, stranded or damaged many more, and crippled the region with two feet of lake-effect snow and ice, according to *The Farmers' Almanac*.

Technically a Hurricane

On November 7, 1913, a storm was brewing over the Great

The greatest losses occurred across southern Lake Huron with at least eight boats suffering a total lost and seven others stranded. Three ships have never been found. Coast Guard map

Lakes region, but without the technology and constant weather monitoring of today, it was unclear that it would be far worse than any in recent memory. An Alberta Clipper was pushing a cold-air mass south, while warm air from the Gulf was moving north. The result was technically a hurricane with sustained winds of 70 mph and gusts up to 90 mph causing waves as high as 35 feet on the Lakes—all anecdotal estimates. Dropping temperatures made conditions ripe for the blizzard conditions that buried the region. All said, the storm caused an estimated $5 million in lost ships and cargo alone, or around $100 million in today's dollars.

Initially, the weather forecast for November 8 called for moderate winds and occasional rain. It was later upgraded to severe, which was enough to keep ships in port, but the following day brought a lull which led forecasters to believe the storm had weakened. It also prompted shipping traffic to pick up. The storm hit a

The Final Hours of *Light Vessel 82*

by LT J.G. Daniel C. Banke
United States Coast Guard

Goodbye Nellie. Ship is breaking up fast. Williams.
—Captain Hugh Williams, November 10, 1913

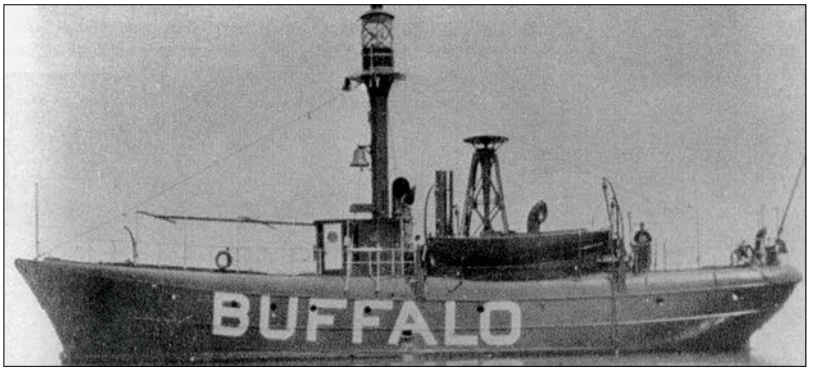
In mid-November 1913, not long after a deadly storm struck Lake Erie, a fisherman came across a wooden hatch cover that had drifted ashore near Buffalo, New York. Inscribed on the hatch was the message quoted above—the last words of a dead man.

Built in Muskegon, Michigan, in 1912, *LV-82* was the most modern lightship in the United States Lighthouse Service fleet. A 95-foot, steel-hulled vessel, it had been equipped with state-of-the-art light lenses, a modern power-plant, and the latest creature comforts. The vessel was stationed in the rocky shallows off of Canada's Point Abino on Lake Erie, 13 miles from Buffalo Harbor.

More than 100 years ago, Point Abino was a remote area and the Canadian government had little interest in financing a lighthouse there. Its shoals were of great concern to American mariners navigating the approaches to Buffalo, however, so the U.S. Lighthouse Service authorized a light vessel to mark the dangerous location.

Known as the "White Hurricane," the Great Lakes Storm of 1913 developed in Lake Superior on November 7, 1913, and wreaked havoc on the region for four days, growing to hurricane strength as it rolled east across the Lakes. By November 8, the storm was described as "severe," with white-out snow conditions whipping Lake Erie into a maelstrom of heavy seas. The following day, wave heights reached nearly 40 feet with winds up to 80 miles per hour. By the time the storm subsided, hundreds of souls were lost, 12 ships had disappeared, and many more vessels were stranded or damaged. It was the deadliest, most destructive storm in the Great Lakes' history, prompting the *Buffalo Evening News*' November 11 headline: *Scores lost in terrific gale, Buffalo Lightship goes down and crew of six are drowned!*

Earlier that morning, pieces of *LV-82* had washed ashore at the foot of Michigan Street in Buffalo. With Lake Erie's waters still roiling, Lighthouse Tender *Crocus* quickly deployed to search for the lightship, but there were no signs of it on the lake. Eventually, the ship's battered lifeboat drifted into Buffalo harbor with an oar fitted in the lifeboat's oarlock indicating that the crew attempted an escape during the storm, according to newspaper reports.



Above, the newly-built *Light Vessel 82* is seen on station after its assignment to the rocky shallows at Point Abino. Coast Guard photo

No whistles, flares, or any other signs of distress were observed from the direction of the vessel, but experts surmised that *LV-82* went down on November 10, when the storm reached its zenith. A year later, the body of Chief Engineer Charles Butler

crescendo on November 9, turning deadly, before abruptly dying out when it made landfall over Ontario, Canada.

A November 27, 2021, article from *The Farmers' Almanac* marking the storm's 100th anniversary reported that forecasters misread the storm. In 1913, weather data was reported just twice a day. This created a false sense of security for mariners who got underway November 8 when forecasters, noticing what was just a lull in the storm, reported it had weakened. This error in forecasting led to the devastating day for mariners on four of the five Great Lakes.

While the storm had long-lasting impacts on the entire Great Lakes region, there were benefits. For instance, the storm fundamentally influenced modern weather forecasting. It also produced numerous accounts of heroism one of which, authored by now-LT Daniel Banke, is featured below.

floated to the surface, but none of the other crew members were ever found. *LV-96* took over the Point Abino station in 1914. Divers located the *LV-82* wreckage in 63 feet of water two miles off station later that year.

After several failed attempts to salvage the lightship, it was raised to the surface September 16, 1915, and brought back to Buffalo where it was refurbished and reassigned. *LV-82* continued to serve the Lighthouse Service until decommissioned in the mid-1930s, though it is unclear what happened to it after its career ended.

U.S. Coast Guard *LV-82*, stationed in Buffalo, sank during the fierce storm in November 1913; all six members of the crew were lost. In 1914 the wreck was found nearly 2 miles from its station, sitting on the bottom of Lake Erie in water 63 feet deep. Coast Guard photo

In 1918, the construction of a lighthouse on Point Abino eliminated the need for a lightship.

In its January–February 1975 issue, *Telescope Magazine* reported that, when asked on November 10, 1913, whether *LV-82*'s captain, Hugh Williams, could have raised anchor and sought shelter from the storm, his wife, Ann Marie Williams, replied definitively. "Certainly not! Captain Williams and his crew were guardians and they would remain at their station until blown away or ordered to move. I know this because I know the caliber of my husband and the men who served him on the lightship," she said.

In 2012, a group of Canadian citizens and members of the U.S. Lightship Sailors Association cooperated to erect a memorial to *LV-82*'s lost crew. Photo courtesy of U.S. Lightship Sailors Association

In 2012, a group of Canadian citizens and the Lightship Sailor's Association cooperated to erect a marker on Point Abino memorializing *LV-82*'s lost crew. This monument, and a marker on the grounds of the Coast Guard's Sector Buffalo base, are all that recognizes the sacrifices of *LV-82*'s crew.

More than 100 years ago, the men of *LV-82* served in harm's way to ensure the safety of mariners navigating the Great Lakes during the treacherous winter months. They are among the many heroic members of the long blue line long forgotten by the mariners they vowed to protect and serve. Please pause to remember these brave men:

- Hugh M. Williams, Captain, of Manistee, Michigan
- Charles W. Butler, Chief Engineer, of Buffalo, New York
- Andrew Leahy, Mate, of Elyria, Ohio
- Cornelius Leahy, Assistant Engineer, of Elyria, Ohio
- William Jensen, Seaman, of Muskegon, Michigan
- Peter Mackey, Cook, of Buffalo, New York

Chemical of the Quarter
Understanding Offshore Bulk Liquid

by LT Ethan Beard,
Hazardous Materials Division
U.S. Coast Guard Office of Design and Engineering Standards

Offshore Contaminated Bulk Liquid on Offshore Supply Vessels

Offshore Supply Vessels (OSVs) conduct multiple missions in support of the offshore oil and gas industry, carrying supplies, personnel, and equipment to aid in exploration or exploitation of mineral or energy resources as defined in 46 CFR 125.160. One of the OSV fleet's major missions is to transport proprietary liquid mixtures to wellheads for various operations and, subsequently, carry the contaminated byproducts back to shore. This is known as a backload, and each mixture has a slightly different chemical composition. Many mixtures include spent acids, corrosion inhibitors, and various polymer gel mixtures, in addition to produced water and crude oil. In the United States, 46 CFR 125.120(a) specifies that any OSV desiring to carry products outside the regulations must receive approval from the Coast Guard's Hazardous Materials Division of the Office of Design and Engineering Standards

As part of developing a code for carriage of chemicals onboard OSVs, or the OSV Chemical Code (Code), the International Maritime Organization (IMO) developed an alternate method of classifying backload liquids, with a generic description of 'Offshore Contaminated Bulk Liquid.' This allows a vessel captain to conduct a self-classification of the backload product and assign carriage requirements. This vastly streamlined approach sacrifices some accuracy in that unique requirements are not developed for each operation based on the characteristics of the base liquid. The Coast Guard's backload classifications must be completed within 30 days, while the IMO approach could provide carriage requirements within hours. Since this type of classification is necessarily more general, the resulting carriage requirements in the Code are conservative.

To complete the classification via the alternate IMO method, the Code requires the party desiring shipment to provide the vessel captain with a list of properties for the mixture. The captain then assesses the hazards associated with the product based on flashpoint, pH, lower explosive limit, hydrogen sulfide level, etc., and determines whether the offshore contaminated bulk liquid presents only pollution hazards, or both pollution and safety hazards. Once the classification is complete, the captain carries the mixture in accordance with the appropriate entry in the Code. Although this is an appealing method of classification, there are still challenges when applying it to domestic operations.

First, most backloads will be classified as presenting safety hazards due to flashpoint, and the carriage requirements for this product exceed the design of most current OSVs. The United States would have to alter the requirements for domestic operations to suit current vessels, or restrict the use of this method to new OSVs that meet appropriate design standards. Second, the classification process needs to be transparent and auditable. The Coast Guard will need to have a way to ensure classifications are correctly conducted at sea, and mixtures are carried appropriately. Finally, the domestic regulatory framework surrounding OSVs is complicated, especially in regards to chemical carriage. The United States has not yet adopted the Code, and domestic OSVs are voluntarily operating under the previous chemical carriage regime set by IMO Resolution A.673.

Despite these challenges, self-classification could be a potential benefit to both the Coast Guard and industry partners. If implemented correctly, vessels' baseline safety standards would be increased and roadblocks to backload operations would be decreased. Additionally, companies would have the added benefit of not having to go through an approval process to conduct their operations. Though there are still several unresolved questions surrounding implementation, this classification method is worth pursuing for the potential increases in classification efficiency.

About the author:
LT Ethan Beard is a staff engineer in the Hazardous Materials Division of the Office of Design and Engineering Standards. He graduated from the U.S. Coast Guard Academy in 2015 with a B.S. in naval architecture/marine engineering, and holds an M.S. in chemical engineering from Stanford University.

References:

Code of Federal Regulations, Part 46: Shipping, Subchapter L: Offshore Supply Vessels

IMO Resolution A.1122(30), Code for the Transport and Handling of Hazardous and Noxious Liquid Substances in Bulk on Offshore Support Vessels (OSV Chemical Code)

IMO Resolution A.673(16), Guidelines for the Transport and Handling of Limited Amounts of Hazardous and Noxious Liquid Substances in Bulk on Offshore Support Vessels

Nautical Engineering Queries

Questions

Prepared by NMC Engineering Examination Team

1. What is the function of a shading coil as used in an AC magnetic controller?

A. Reduce chatter and noise in the contactor
B. Prevent flux buildup in the operating coil
C. Eliminate arcing when the contacts close
D. Energize the operating coil and 'pull in' the contacts

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2. The ratio of output response to a specified change in the input is known as _____ .

A. Primary feedback
B. Deviation
C. Sensitivity
D. Dead band

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3. When a vessel is inclined, the tendency for it to return to its original position is caused by the _____ .

A. Movement of the center of gravity
B. Movement of the center of buoyancy toward the low side of the vessel
C. Upward movement of the center of flotation
D. Increased free surface in the buoyant wedge

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4. The average exhaust temperature of a two-stroke/cycle diesel engine with a turbine-driven supercharger is lower than a similar four-stroke/cycle diesel engine at equal loads because _____ .

A. Two-stroke/cycle diesel engines have a higher M.E.P. than four-stroke/cycle diesel engines
B. Four-stroke/cycle diesel engine exhaust is cooled by scavenging air
C. Two-stroke/cycle diesel engines have a lower M.E.P. than four-stroke/cycle diesel engines
D. The opening of the two-stroke/cycle diesel exhaust ports or valves occurs much later than in four-stroke/cycle diesel engines

Engineering Answers

1. A. Reduce chatter and noise in the contactor — **Correct answer.** The shading coil behaves as the short-circuited secondary of a transformer whose primary is the operating coil. In accordance with Lenz's law, the shading coil causes the flux in the shaded part of the pole face to lag behind the flux in the nonshaded part. This prevent the flux in the armature from falling to zero and thus reduce armature chatter.

B. Prevent flux buildup in the operating coil — Incorrect answer

C. Eliminate arcing when the contacts close — Incorrect answer

D. Energize the operating coil and 'pull in' the contacts — Incorrect answer

Reference: Operating, Testing, and Preventive Maintenance of Electrical Power Apparatus, *Hubert, page 463*

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2. A. Primary feedback — Incorrect Answer

B. Deviation — Incorrect answer

C. Sensitivity — **Correct answer.** "Sensitivity is the ration of output response to a specified change in the input. This term can be applied to any element in the control loop. For a measuring instrument the input is the measured variable; for an automatic controller it is the controlled variable."

D. Dead band — Incorrect answer

Reference: Handbook of Instrumentation and Controls, *Kallen, page 2–12*

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3. A. Movement of the center of gravity — Incorrect Answer

B. Movement of the center of buoyancy toward the low side of the vessel — **Correct Answer.** "When a vessel is in still water and no external force in inclining her, G and B are the same vertical line and no couple is formed. But as soon as the vessel inclines, B moves toward the low side of the vessel, and a righting tendency is created."

C. Upward movement of the center of flotation — Incorrect answer

D. Increased free surface in the buoyant wedge — Incorrect answer

Reference: Stability and Trim for the Ship's Officer, *3rd Ed., George, pages 8 and 9*

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4. A. Two-stroke/cycle diesel engines have a higher M.E.P. than four-stroke/cycle diesel engines — Incorrect answer

B. Four-stroke/cycle diesel engine exhaust is cooled by scavenging air — Incorrect answer

C. Two-stroke/cycle diesel engines have a lower M.E.P. than four-stroke/cycle diesel engines — **Correct answer.** "… the exhaust temperatures of two-stroke engines are considerably lower than the corresponding temperatures of four-stroke engines. This is due, first, to the lower mean effective pressures in two-stroke engines and second, to the cooling effect of the scavenge air."

D. The opening of the two-stroke/cycle diesel exhaust ports or valves occurs much later than in four-stroke/cycle diesel engines — Incorrect answer

Reference: Diesel Engine Operation and Maintenance, *Maleev; pages 275, 276 and 282, Fig 16–17*

Nautical Deck Queries

Questions

Prepared by NMC Engineering Examination Team

1. BOTH INTERNATIONAL & INLAND: Which statement is TRUE in an overtaking situation?

A. An overtaking situation exists when one vessel is approaching another vessel from anywhere abaft the beam.
B. Any later change of bearing between the two vessels shall not make the overtaking vessel a crossing vessel.
C. It is the duty of the vessel being overtaken to get out of the way.
D. All of the above

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2. The official identification of a vessel is found in which document?

A. Certificate of Inspection
B. Certificate of Documentation
C. Load Line Certificate
D. Classification Certificate

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3. Your vessel is in distress and the order has been given to abandon ship. If you must enter the water, which of the following would aid in preventing hypothermia?

A. Once you are in the water, keep moving as much as possible to increase circulation
B. Apply as many layers of clothing as possible before donning a survival suit to preserve body heat
C. Remove as many layers of clothing as possible before donning a survival suit to help increase buoyancy
D. Consume large amounts of cold liquids to increase hydration

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4. A rotary current sets through all directions of the compass. How much time does it take to complete one of these cycles in a locale off the East coast of the U.S.?

A. 2½ hours
B. 3½ hours
C. 6¼ hours
D. 12½ hours

Deck Answers

1. A. An overtaking situation exists when one vessel is approaching another vessel from anywhere abaft the beam. — Incorrect answer

B. Any later change of bearing between the two vessels shall not make the overtaking vessel a crossing vessel. — **Correct answer.** Int'l./Inland Rule 13(d) *"Any subsequent alteration of the bearing between the two vessels shall not make the overtaking vessel a crossing vessel within the meaning of these Rules or relieve her of the duty of keeping clear of the overtaken vessel until she is finally past and clear."*

C. It is the duty of the vessel being overtaken to get out of the way. — Incorrect answer

D. All of the above — Incorrect answer

Reference: Int'l./Inland Rule 13

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2. A. Certificate of Inspection — Incorrect answer

B. Certificate of Documentation — **Correct answer.** *"The certificate of documentation shows the vessel's name, official number, dimensions, owner's name and address, nationality, and details of the mortgages."*

C. Load Line Certificate — Incorrect answer

D. Classification Certificate — Incorrect answer

Reference: Masters Handbook, *Messer, 3rd Ed., pages 156–157*

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3. A. Once you are in the water, keep moving as much as possible to increase circulation — Incorrect answer

B. Apply as many layers of clothing as possible before donning a survival suit to preserve body heat — **Correct answer.** *"IN A DISTRESS ALERT SITUATION: Put on as many layers as possible, alternating thin/close-meshed and thick/wide-meshed! The outer layer should be as watertight as possible. Fasten, close and/or button up clothing to prevent cold water flushing through the clothing."*

C. Remove as many layers of clothing as possible before donning a survival suit to help increase buoyancy — Incorrect answer

D. Consume large amounts of cold liquids to increase hydration — Incorrect answer

Reference: Pocket Guide to Cold Water Survival, *IMO, 2006 Ed., page 16*

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4. A. 2½ hours — Incorrect answer

B. 3½ hours — Incorrect answer

C. 6¼ hours — Incorrect answer

D. 12½ hours — **Correct answer.** *"Offshore, the (rotary tidal) current, not being confined to a definite channel, changes its direction continually and never comes to a slack, so that in a tidal cycle of about 12½ hours it will have set in all directions of the compass."*

Reference: Reprints of the Tide and Tidal Current Tables, Part Two, *page 193*

In the News: Great Lakes Center of Expertise Opens

Assistant Commandant for Response Policy Rear Admiral Jo-Ann Burdian, joined by, from left, Lake Superior State University President Dr. Rodney S. Handley, U.S. Senator Gary Peters, and Sault Ste. Marie Mayor Don Gerrie cut the ribbon to open the Coast Guard's new Great Lakes Oil Spill Center of Expertise on August 24, 2022. Headquartered at Lake Superior State University in Sault Ste. Marie, Michigan, with an office in Ann Arbor, the center will research freshwater oil spills and help develop effective responses. Coast Guard photo by Chief Petty Officer John Masson

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The U.S. Coast Guard Cutter *Mackinaw* (WLBB-30) delivers Christmas trees from northern Michigan to Chicago every year as a part of Chicago's Christmas Ship program. The one-of-a-kind icebreaker and its predecessor, USCGC *Mackinaw* (WAGB-83), have delivered more than 25,000 Christmas trees to Chicago families in the past 20 years. Coast Guard photo by CMDR John M. Stone