

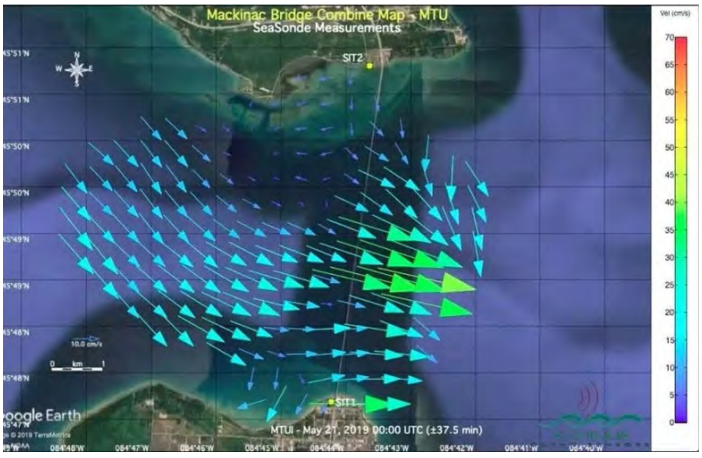
High-frequency radar antenna located at Bridgeview Park in St. Ignace, Michigan, overlooking the Straits of Mackinac.

Improving safety in the Straits of Mackinac with high-frequency radar

by TIMOTHY HAVENS

Nestled between Michigan's Upper and Lower Peninsulas, the Straits of Mackinac have long been a vital passageway for maritime traffic, connecting lakes Michigan and Huron. They serve as a crucial junction for shipping routes that link the Great Lakes to the Atlantic Ocean via the Saint Lawrence Seaway. Stunning natural beauty and regional historical significance attract countless tourists to Mackinac and Bois Blanc islands. This busy maritime corridor presents navigational challenges, including strong currents, rapidly changing weather conditions, and the narrowness of the Straits. The Straits are also home to the Mackinac Bridge—the longest suspension bridge in the Western Hemisphere—and Enbridge's Line 5 pipeline, a submerged natural gas and crude oil pipeline just west of the bridge. Coupled with this significant infrastructure, the potential risk of accidents increases. Moreover, the Straits' ecological sensitivity, due to their proximity to numerous freshwater ecosystems, adds another layer of complexity to their management. To enhance maritime safety and environmental monitoring, high-frequency radar (HFR) technology has become a game changer for this critical waterway.

Originally developed for military applications, HFR found a new and crucial role in maritime safety and environmental monitoring. HFR works by emitting radio waves that travel across the water's surface. When these radio waves encounter surface waves on the water, they are reflected back to the radar, which then analyzes the data to provide real-time information about the speed and direction of the water's surface currents. While HFRs have been in widespread use in coastal ocean regions for more than 40 years—with over 150 systems deployed on the United States coasts—the first demonstration of this technology on freshwater did not occur until 1999 in southern Lake Michigan. Following this successful test, Lorelle Meadows and Guy Meadows of Michigan Technological University performed other feasibility tests and then, in 2020, installed the first permanent system on freshwater in the Straits.



Surface currents from HF radar in the Straits of Mackinac, measured on May 21, 2019. Arrows indicate direction and speed of the surface current.

One of the primary benefits of HFR in the Straits is the invaluable, real-time, high-resolution data on surface currents it provides. Ships navigating through the Straits can adjust their routes based on the current patterns, reducing the risk of accidents caused by unexpected strong currents. This helps tankers and cargo ships, which require precise navigation to avoid collisions and grounding.

The freshwater ecosystems in and around the Straits support diverse wildlife and are vital for the region's fishing industry. HFR technology plays a crucial role in protecting these ecosystems by providing data to help monitor and mitigate environmental impacts. Researchers could use HFR data to study the dispersion of pollutants in the water. Understanding how contaminants spread can inform cleanup efforts and prevent further environmental damage. This is particularly relevant with the presence of the Enbridge Line 5 pipeline in the Straits. In the event of a leak, HFR data could help track the spill and optimize clean-up efforts to minimize the impact on the surrounding environment.

Additionally, HFR technology supports the work of the U.S. Coast Guard and other emergency responders. In the event of a maritime incident, such as a ship grounding or chemical spill, real-time data on surface currents helps responders predict the spill's movement or locate distressed vessels more quickly and accurately. This capability significantly enhances search and rescue operations and environmental response efforts.

The data generated by HFR in the Straits is invaluable for scientific research, providing insights into coastal processes, climate change, and ecosystem dynamics. It has fostered collaboration among various stakeholders, including government agencies, academic institutions, and private organizations. Researchers use HFR data to study the complex hydrodynamics of the Straits. Their findings contribute to a deeper understanding of how natural and human-induced changes affect the Great Lakes system. This research, in turn, informs policy decisions and conservation efforts aimed at preserving the health of the Great Lakes for future generations.

As technology advances, HFR's capabilities are expected to further improve. Future developments may include enhanced spatial resolution, longer range, and the integration of artificial intelligence. This could provide even more detailed and comprehensive data. Moreover, the success of HFR technology in the Straits could serve as a model for other critical freshwater systems worldwide and inspire similar initiatives in other freshwater bodies facing comparable safety and environmental challenges. Michigan Tech, in collaboration with the Great Lakes Observing System, will begin construction of a new HFR east of the Mackinac Bridge in 2025.



High-frequency radar antenna located outside Fort Michilimackinac in Mackinac City, Michigan.

The introduction of HFR in the Straits of Mackinac represents a significant leap forward in maritime safety and environmental stewardship. By providing publicly available real-time data on surface currents, HFR technology helps mariners navigate safely, supports efficient emergency response, and aids in the protection of sensitive ecosystems. As we look to the future, continued investment in and development of this technology will ensure that the Straits of Mackinac remain a safe and vibrant passageway, balancing the needs of commerce, recreation, and environmental conservation.

More information on the Straits HF radar, including real-time data, can be found online.

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