Icebreaking keeps the Great Lakes open in winter

The Great Lakes are the heart of American industry, bringing jobs not only to the region but also to the nation. This vital marine transportation system is relying on icebreaking to keep the waterways open and commerce moving.
Photo: Icy Lake Michigan shoreline, Grand Haven, February 1, 2011, R. Greaves. (CC-BY-2.0)

The Great Lakes, the vast freshwater lake area on the border between Canada and the United States, provide transportation systems along a contiguous body of water that is a vital artery to the economies of both countries. From approximately mid-December to mid-April, the waters are susceptible to freezing and ice impedes navigation, requiring icebreakers to keep waterways open

The Great Lakes waterways support 1.3 million jobs and $82 billion (USD) in annual wages, according to a recent report from Michigan Sea Grant. The area has been called the growth engine of North America. The lakes hold 21% of the world's surface freshwater and serve as a source of drinking water for more than 30 million citizens in the U.S. and Canada.

The five freshwater lakes are connected by a series of rivers or locks to allow for trade throughout the whole lake region. It supports not only a critical economic highway of agriculture, industrial and manufacturing goods, but also a multi-billion dollar outdoor recreation and tourism industry

Ice coverage varies every winter

The annual ice coverage depends on the severity of the winter. Over the past 42 years, the Great Lakes annual maximum ice coverage has been as much as 94.7 percent and as little as 9.5 percent.

During a typical winter, the Great Lakes icebreaking program extends the navigation season by 4 months, ensuring the continued flow of maritime commerce.

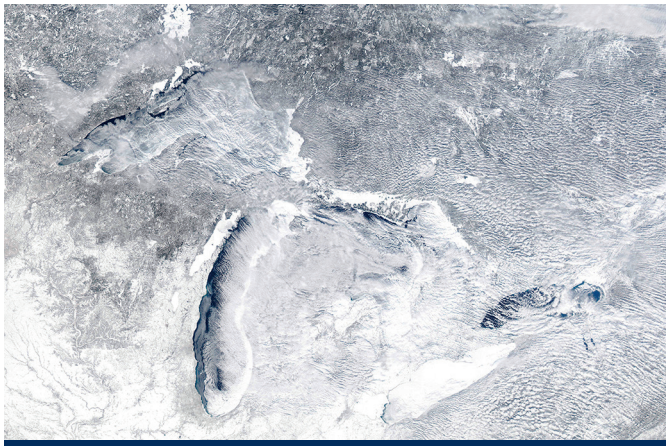

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Photo: MODIS Image of ice cover on the Great Lakes, NOAA Great Lakes CoastWatch.

Keeping routes open

The United States Coast Guard (USCG) is responsible for icebreaking operations on the Great Lakes in cooperation with the Canadian Coast Guard (CCG), keeping certain shipping routes and ports open during the parts of winter when they otherwise would be impassable by commercial vessels. It responds to vessel requests for assistance when they are disabled or are stranded in ice-covered waters. The USCG, in coordination with the U.S. Army Corps of Engineers, also breaks ice to control flooding caused by ice jams during the spring thaw.

The current USCG icebreaking fleet in the area consists of nine vessels: the heavy Great Lakes icebreaker USC-

GC *Mackinaw*, two smaller buoy tenders USCGC *Alder* and USCGC *Hollyhock*, and six Bay-class icebreaking tugboats.

The annual icebreaking operation, referred to as Operation Taconite, is the USCG's largest domestic icebreaking operation and encompasses Lake Superior, Lake Michigan, the St. Mary's River, the Straits of Mackinac and Georgian Bay.

Wide area to cover

Lake freighters, ships transporting cargo within the Great Lakes, are famously long-lived; the oldest "lakers" date back to the 1940s. Like the ships they assist, the Great Lakes icebreaking fleet also has a significantly longer lifespan, as the freshwater is much kinder to hulls compared to saline sea water.

"For example, the 2006-built USCGC *Mackinaw* replaced a 1944-built icebreaker of the same name," says Naval Architect Aaron Tam. "The 140-foot icebreaking tugboats built in the late 1970s and 1980s are expected to remain in service until the 2030s."

Despite its long experience of difficult winters, the USCG fleet still faces challenges during its operational season in this extensive area covering 1500 miles of open lake, connecting waterways and rivers. Therefore, the winter navigation system is currently being reviewed in order to increase icebreaking capacity and support the 90 million tons of cargo shipped annually on the Great Lakes. One new heavy Great Lakes icebreaker is planned for now, as well as a revision of other capacities.

Expert in icebreaking

The Finnish company Aker Arctic Technology participated in the design of the Coast Guard's newest Great Lakes icebreaker USCGC *Mackinaw*, delivered in 2006. Since then, technological advancements and environmental issues have grown apace. As an established expert in providing advanced icebreaking technology, Aker Arctic offers the Coast Guard a fast track solution to fulfilling its need for increased modern icebreaking capacity where environment considerations are also to the fore.

Finland is located by the Baltic Sea, an area with many similarities to the Great Lakes area. The efficient winter navigation system in place includes icebreakers of various sizes, many of them designed by Aker Arctic, keeping ports open and assisting vessels during the winter season December to May. The most recent one is the first LNG-fuelled, agile icebreaker *Polaris* delivered in 2016.

Always tailored to needs

"We have a fifty-year-long history of designing icebreakers, all of which are tailored to a specific purpose and area," says sales manager Jukka Salminen.

Photo courtesy of USCG.

USCGC Mackinaw

Aker Arctic Technology Inc together with Kvaerner Masa-Marine (today Vard Marine) developed the concept for the current Great Lakes heavy icebreaker, USCGC *Mackinaw*, together with the United States Coast Guard. The vessel was delivered in 2006 and features twin Azipod propulsion with a double-acting hull capable of breaking ice in both ahead and astern directions.

Length: 73 m | Beam: 17.8 m | Draught: 4.9 m

Polaris – the first LNG-fuelled icebreaker

The Finnish icebreaker *Polaris* was delivered in 2016 and designed for icebreaking and assisting commercial vessels in the Baltic Sea ports. To combat climate change and pollution, she was the first icebreaker in the world to use LNG as fuel and does not discharge any waste or grey water into the sea, not even shower water.

Everything is transported to the shore every ten days when she is on duty. Polaris has an advanced oil spill response system and features a triple azimuth propulsion solution. The captain has praised her agility and says dislodging vessels stuck in ice is fast and efficient. Her turning ratio is 1, meaning she can make a circle her own length.

Length: 110 m | Beam: 24 m | Draught: 8/9 m

"Highly innovative concepts such as the oblique icebreaker concept, where the icebreaker can break ice forwards and sideways when a larger channel is needed, and the technically advanced port icebreaker *Ob*, delivered last year for harbour assistance in the Arctic, are other medium-sized signature concepts we have designed recently."

Aker Arctic not only designs icebreakers, but also supports the shipyards constructing them in all matters regarding ice strengthening and icebreaking when needed. The in-house ice model testing laboratory is used to verify designs and icebreaking capability before construction begins.

Technology has advanced

The heavy Great Lakes icebreaker USCGC *Mackinaw* still has a life-span of 30 years. While the old concept could easily be duplicated, technology has evolved in 15 years and there are many new features a modern icebreaker should encompass today.

"In an environmentally critical area such as the Great Lakes, alternative fuels could be considered in addition to hybrid solutions and battery packs allowing zero emissions in ports, for instance," Salminen adds.

Aker Arctic is presently developing next-generation icebreakers for Sweden and Finland. In addition to striving for unprecedented overall energy efficiency using the latest available technologies and being ready for fossil-free operation by 2030, the new icebreakers will be designed to escort larger merchant ships than their predecessors. Many of the recent learnings and developments could be applicable in the new Great Lakes icebreaker.

A recent article in the National Geographic magazine cited pollution and climate change as great risks for the lakes area. Compared to other means of transportation, shipping is an efficient and sustainable method. It is the most economical way to transport and has the lowest emissions per tonne. With modern technology, impacts on the environment can be lowered even further.

Glen Haven Beach ice caves.
Photo: US National Park Service (CC-BY-2.0)

Economic gains from icebreaking

According to a study commissioned by the Lake Carrier's Association, businesses that depend upon the Great Lakes maritime industry lost over USD 1 billion in revenues during the 2018-2019 ice-season because of delays in icebreaking. These economic losses resulted in the loss of over 5000 jobs throughout the Great Lakes region.

"Looking at the trade results, there is a clear correlation between difficult winters and the amount of cargo traded. In a year with a difficult winter, like 2019 that shipped 84 million tons, there was a reduction of about 5.5% in the year's total potentially traded cargo," adds Tam.

In the case of the recent 2018/19 season, over 4 million tons of iron and almost 900 thousand tons of coal was unable to be traded due to the difficult winter. The industry cited delays from icebreaking assistance and convoy formations, as well as ice damage to vessels and inadequate broken ice tracks.

"The benefit to the economy of an improved winter navigation system is obvious, the sooner the better," Salminen underlines.

Baltika – the world's first sideways-moving icebreaker

The oblique icebreaker *Baltika* was designed to operate in the Baltic Sea, especially for assisting large vessels in icy harbours, but has since shown that she can break ice successfully also in the Arctic. Her asymmetric hull form means she can break ice conventionally moving forwards, but when a wider channel is needed, she can turn up to 85° sideways to break ice. The angle is not pre-set and can be selected according to needs. Rubble clearing, manoeuvring and ice management performance is also excellent, and she is equipped with an oil spill response system. Compared to conventional icebreakers, Baltika can carry out the same operations with only half the propulsion power, thus saving fuel and reducing emissions.

Length: 76.4 m | Beam: 20.5 m | Draught: 6.3 m

Photo: Dmitri Lobusov

Ob – the most advanced port icebreaker in the world

Our newest port icebreaker design, *Ob*, was designed for assisting very large LNG carriers in the Arctic harbour of Sabetta. She can break 1.5-metre-thick level ice in both ahead and astern directions and the quad-screw propulsion configuration provides superior manoeuvrability and control when operating in close proximity to vessels. She is powered by the world's most efficient four-stroke diesel engine and features a DC grid to further improve efficiency and reduce fuel consumption.

Length: 89.2 m | Beam: 21.9 m | Draught: 6.5/7.5 m

Shallow icebreaking tug Mangystau

The Mangystau series of five shallow icebreaking tugs was designed in 2009 – 2010. Since delivery, the tugs have been working at the Kashagan oil field supporting the oil drilling platforms in the north Caspian Sea. The tugs are used for towing and pushing barges as well as ice management operations in astern working mode in ice rubbles reaching the sea floor.

Length: 66 m | Beam: 16.4 m | Draught: 3 m

Photo: Ilari Rainio/ Finnish Transport Infrastructure Agency

Innovative self-propelled detachable icebreaking bow

A totally new concept of a detachable icebreaking bow, which is self-propelled and connected to a tugboat during the winter season, has been taken into use in Lake Saimaa, Finland's largest freshwater lake, and the Saimaa Canal. The lake has a number of industries located on its wide shores and the canal connects the lake district with the Gulf of Finland. It is a vital transport channel for exports and imports of goods. The detachable bow brings more efficient icebreaking and ice management operations to the area. The concept was developed by ILS Oy for the Finnish Transport Infrastructure Agency. Aker Arctic designed and delivered the two shaft lines and propellers for the bow, two bronze propellers for the tug and the Ice Load Monitoring System, which can be supervised remotely, as well as performing the ice model tests to verify the design before construction.

Length: 25.3 m | Beam: 12.6 m

Aker Arctic Technology

Shipyards in Finland have built the majority of the world's icebreakers during the past 70 years. This development has created long term know-how and a successful industry around icebreaking ships.

In 2005, the development and design activities were separated from the yards to the newly established company Aker Arctic Technology. On-going projects and ship design engineers were transferred to their own facility in Vuosaari, Helsinki. Since then, numerous new icebreakers and icebreaking ships have been developed, designed and built by various shipyards.

Aker Arctic Technology is today known all over the world for its innovative, high quality solutions in icebreaking and ice management. All designs are verified with model tests before construction, with most undergoing full-scale tests after delivery.