Ed Struzik

BREAK THE ICE

The rapid retreat of sea ice in the Arctic is opening up new opportunities for shipping companies, but can they rely on current meteorological data?

February 2018 saw nearly half of the ice cover on the Bering Sea in the Pacific Ocean disappear over a two-week period – at a time of year when it normally increases. US National Weather Service meteorologist Rick Thoman has only seen a winter meltdown like this twice before in his 30-plus year career – in 1981 and 2001. According to Thoman, there were significant differences between what happened back then and what transpired this year.

"In early February 1981, Bering Sea ice extent fell by a large amount, but it was starting from a higher extent. As a percentage of extent lost, there was a 42% decline between February 6, 1981 and February 19, 1981. This represents the greatest mid-winter loss," explains Thoman. "In mid-February 2001 ice conditions were similarly low on the Alaska side of the Bering, but there was much more ice on the Russian side."

Thoman and his Arctic weather and sea ice forecasting colleagues were not entirely surprised by this year's meltdown. The loss is part of a warming trend throughout the Arctic that has been accelerating for almost three decades.

Arctic sea ice reaches minimum levels each September. According to satellite data from NASA and the National Snow and Ice Data Center, September Arctic sea ice is now declining at a rate of 13.2% per decade, relative to the 1981 to 2010 average. Sea ice extent was around 7,000,000km^2 (2,702,715 square miles) in September 1980. This dropped to around 4,500,000km^2 (1,737,460 square miles) in September 2016. Arctic sea ice extent for February 2018 averaged 13,950,000km^2 (5,390,000 square miles). This is the lowest monthly average recorded for February.

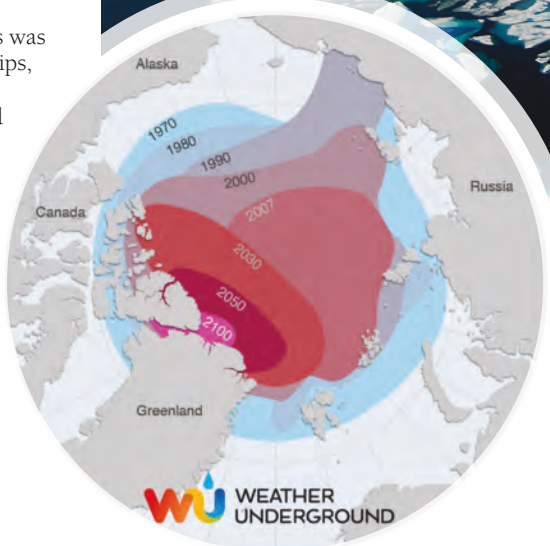
SHIPPING OPPORTUNITIES

This rapid retreat of sea ice in the Arctic is presenting shipping companies with unprecedented commercial opportunities, some of which are already being exploited. The seasonally ice-free ocean around Svalbard in Norway has been a popular tourist ship destination for more than two decades. And the number of cruise itineraries in Arctic Canada more than doubled between 2005 and 2013, albeit with only a small number of passengers on board.

In terms of large passenger cruise ships, in late 2016 Crystal Cruises' luxury cruise ship Crystal Serenity completed its first

> "You can't look at one weather forecast element in isolation and 'be safe'"
>
> **Capt. Ken Burton, veteran arctic sailor and former executive director of Vancouver Maritime Museum**

Human observations form an important part of predicting Arctic ice conditions



Map illustrating the past, present and future changes of Arctic ice levels

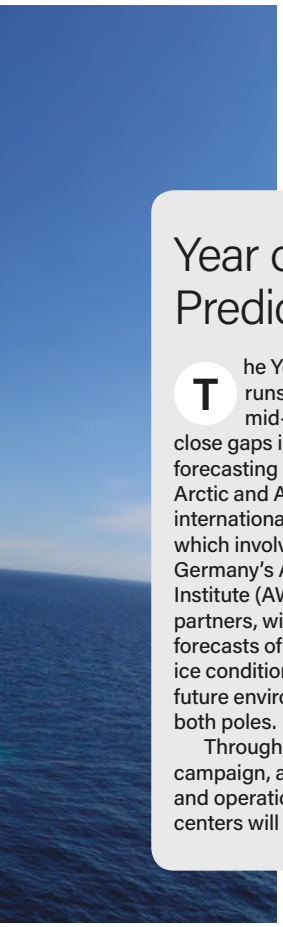
transit through the Northwest Passage. The voyage was the first of its kind made by a large luxury cruise ship, which had 1,000 guests and 600 crew members on board.

The changing sea ice conditions, however, have also made it more difficult to rely on traditional knowledge and climatological technology to predict day-to-day and seasonal environmental variability in the region. According to the WMO, which is one of the organizations involved in the Year of Polar Prediction (see box on page 27), the Arctic and Antarctic are the world's most poorly observed regions when it comes to meteorology.

For cargo and tanker ships, which could save up to 10 days' travel time sailing through the Arctic rather than through other routes such as the Panama Canal, the risks of crossing the Arctic remain high. This is evident when you look at the number of ships traveling through the Northwest Passage. According to Fisheries and Oceans Canada, in 2017, only one cargo ship, one tanker, and one tug sailed through the Northwest Passage. The number of partial transits was higher, but not by much – six cargo ships, two tankers and one tug. In 2015, just 10 ships (excluding adventurers) sailed along the Northwest Passage. By way of comparison, 12,383 vessels passed through the Panama Canal that year, according to the Panama Canal Authority (ACP).

ARCTIC WEATHER PREDICTION

Predicting weather in the Arctic remains a challenge in spite of ever-improving data provided by weather satellites, data models, observations from human observers

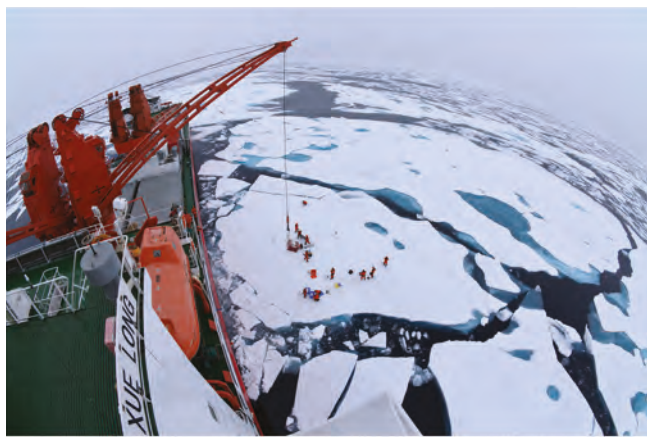


Year of Polar Prediction

The Year of Polar Prediction runs from mid-2017 to mid-2019 and aims to close gaps in polar forecasting capacity in the Arctic and Antarctic. The international campaign, which involves the WMO, Germany's Alfred Wegener Institute (AWI) and other partners, will lead to better forecasts of weather and sea ice conditions, to improve future environmental safety at both poles.

Throughout the two-year campaign, a network of scientists and operational forecasting centers will jointly undertake intensive observation and modeling activities. During special observing periods, the number of routine observations, for example through weather balloon launches from meteorological stations and buoy deployments from research vessels, will be enhanced; coordinated aircraft campaigns and satellite missions will be carried out; and new automatic weather stations will be installed at different polar locations.

There will be a special focus on sea ice forecasting capabilities. On shorter time scales, sea ice information includes information on zones of strong ice convergence – this is important for safe shipping. On monthly to seasonal time scales, the focus will include the prediction of sea ice conditions in the Northern Sea Route and in the Southern Ocean around Antarctica. All observational data will be shared via the WMO Information System – allowing operational forecasting centers around the world to receive the data in real time, to feed their forecasts.



Heavy ice conditions can still be experienced in the summer months

Arctic expedition to examine changing ice conditions in shipping lanes

and automated weather stations. Local weather can be profoundly influenced by valleys, hills, glaciers and the presence of open water. Knowledge of local conditions is therefore still critical, according to Capt. Ken Burton, a veteran Arctic sailor, and former executive director of the Vancouver Maritime Museum. He was on board the Crystal Serenity in 2016 as the ship's historian. "You can't look at one weather forecast element in isolation and 'be safe'," he says. "You might think the wind direction will be fine, only later to realize that it has pushed a large ice floe and trapped you in a bay. Better forecast does not necessarily make for a safer passage. A sound understanding of what the forecast is actually telling you and what local conditions lie ahead is still very important.

"The weather systems in the North, particularly in the Gulf of Alaska and Beaufort Sea, move very quickly," he continues. "You need to be on your toes. Whenever I have traveled through, regardless of the weather forecast, I have kept a close eye on a standard barometer. Some areas, such as those around Devon Island and Greenland, have large areas of land covered in ice. This tends to mitigate the weather along the coast and certainly inland. That is one reason why it tends to be sunny in Greenland. The ice cap produces its own high-pressure weather and makes for a sunny experience in Greenland and a predominantly low pressure system over Baffin Bay."

SEA ICE FORECASTS

Predicting ice conditions in the Arctic is an even more daunting challenge. As fast as the Arctic Ocean is warming, there still are, and will continue to be, summers with occasional heavy ice conditions. Canadian scientist David Barber experienced this in 2017 when he was supposed to be on board the CCGS Amundsen with 40 other scientists to study sea ice and climate change in the region. The sea ice research team's expedition had to be canceled because there was too much ice flowing south from Greenland's melting sea ice and glaciers.

There is a reason why neither Barber nor anyone else saw this coming until just 10 days before the expedition's launch. Currently, ship captains rely on ice forecasts from modern sea ice analysis centers such as the US National Weather Service's Alaska Sea Ice Program, the National Ice Center and the

Devon Island's Northwest Passage

CCGS Louis S St-Laurent, a Canadian Coast Guard heavy Arctic icebreaker

When will Arctic shipping lanes open?

Three routes through the Arctic are being watched closely by shipping companies.

The Northwest Passage: The Canadian Arctic Archipelago shields sea ice in this passage from the summer break-up and the melting effects of wind and powerful currents, making it the most challenging route in Arctic Canada for shipping companies. The route through the Northwest Passage is also shallow and poorly charted.

The Transpolar Route: From a geopolitical point of view, this stretch may be may be the one to watch. It offers the shortest route between the Atlantic and Pacific oceans, directly across the North Pole. In 2012, the Chinese icebreaker Snow Dragon successfully sailed this route across the central Arctic Ocean.

The Northern Sea Route: This runs along Russia's northern Asian coast. It lies between Novaya Zemlya in the west and the Bering Strait in the east, and stretches northward to the boundary of Russia's exclusive economic zone. It tends to be the most ice-free route.

Few researchers have pulled together the scientific evidence and climate modeling to determine where, and when, shipping companies could exploit the region on a large scale. Geographers Scott Stephenson of the University of Connecticut and Laurence C Smith of the University of California, Los Angeles, used 10 climate models – known to reasonably predict Arctic sea ice and weather in broad ranges – to assess shipping routes during two time periods, from 2011 to 2035, and from 2036 to 2060. It was clear from the results of the study that the Northern Sea Route will become accessible much sooner than the Northwest Passage. The authors were, however, surprised to find that a couple of the models illustrated very clearly that the Northwest Passage would be accessible.

Canadian Ice Service. These agencies use data from a variety of satellite sensors to estimate the concentration, age, and movement of ice.

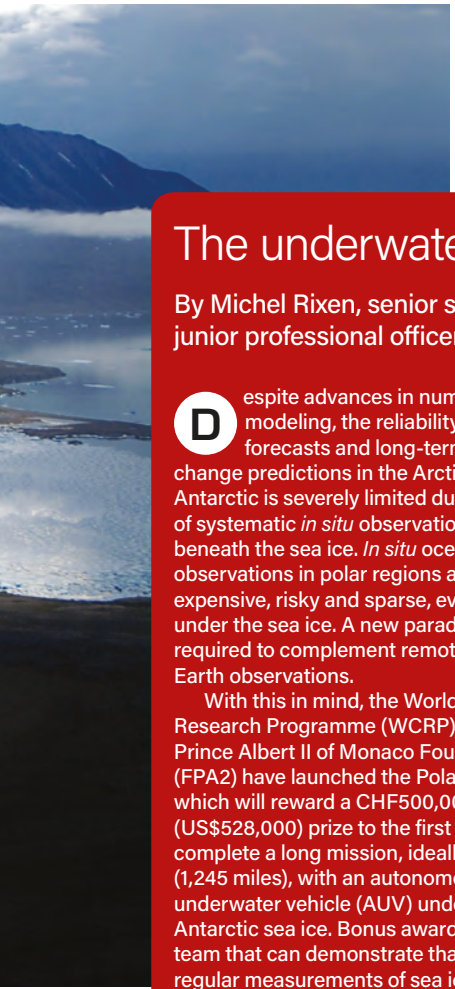
While polar orbiting satellites provide visual coverage for the entire arctic, they transmit the data only a few times a day. Cloud cover can also contaminate the visuals. Geostationary satellites provide data more frequently, but because they are parked over the equator, the Earth's curvature constrains coverage beyond 60° north for some, and 75° north for others. Much of the Northwest Passage lies between 73° and 75° north.

"Sea ice predictions from forecasters tend to be pretty reliable, but only within a 200km [125-mile] range, and only when the forecast is made in July and onward into the short summer season," says Nathanael Melia, a research scientist from Reading University. According to a study that he and his colleagues published in July 2017, called *Towards seasonal Arctic shipping route predictions*, the summer ice and open water forecasts are not much better than guesswork when they are made eight months in advance of the summer season.

This comes as no surprise to Ron Kwok, senior research scientist at NASA's Jet Propulsion Laboratory, California Institute of Technology. His research interests include the mass and energy balance of the Arctic and Southern Ocean ice cover and the role of the sea ice in global climate. "It's really difficult to improve beyond the current measure of less than nine days. And prediction of sea ice is even more difficult because we don't know the initial ice conditions, such as thickness, snow cover, etc, to start with."

"The Canadian Ice Service tries to compensate by incorporating some intellectual guesswork into its seasonal ice models," says Scott Weese, a senior forecaster with the agency. Typically, it does this by looking at analogous sea ice conditions that have occurred in the past. It then incorporates this data into its models to predict what might happen in the future. The agency's Montreal office is also experimenting with a new prediction model that incorporates weather patterns and ocean circulation data with sea ice conditions.

Weese is hopeful that the launch of the Canadian Space Agency's RADARSAT Constellation satellite system later this year will help improve the forecasts. It's an integrated three-satellite system that will



The underwater Polar challenge

By Michel Rixen, senior scientific officer, and Matthias Tuma, junior professional officer, World Climate Research Programme

Despite advances in numerical modeling, the reliability of weather forecasts and long-term climate change predictions in the Arctic and Antarctic is severely limited due to the lack of systematic *in situ* observations of and beneath the sea ice. *In situ* ocean observations in polar regions are inherently expensive, risky and sparse, even more so under the sea ice. A new paradigm is required to complement remotely sensed Earth observations.

With this in mind, the World Climate Research Programme (WCRP) and the Prince Albert II of Monaco Foundation (FPA2) have launched the Polar Challenge, which will reward a CHF500,000 (US$528,000) prize to the first team to complete a long mission, ideally 2,000km (1,245 miles), with an autonomous underwater vehicle (AUV) under the Arctic or Antarctic sea ice. Bonus awards will go to the team that can demonstrate that it has taken regular measurements of sea ice thickness or draft and to those who successfully transmit their under-ice position and environmental data to operational networks.

The Polar Challenge competition was launched in early 2016 and will last until 2019 or run for another two more years, until 2021, if any of the challenges remain open. Several teams around the world have already expressed interest in competing. WCRP and FPA2 aim to promote technological innovation toward a future cost-effective, autonomous and scalable observing network for sea ice covered regions, based on a fleet of AUVs.

Different types of AUVs are already operating in ice-free zones around the world, surfacing regularly to obtain a GPS fix and to transmit near real-time environmental data. They are able to collect high-quality oceanographic observations – temperature, salinity, chlorophyll concentration, pH levels and more – at much lower cost than conventional observing systems such as ship-based measurements. Operating range, positioning and data transmission represent major challenges for AUVs under sea ice but the integration of some recent innovations, for example in power systems, navigation and communication techniques, could expand the range of their application.

If successful, the initial proof of concept could be scaled up into a game-changing ocean monitoring network for the poles with wide-ranging benefits for climate research and services, as well as for other sectors, such as environmental protection, weather forecast, tourism, safety, security, transport, energy, insurance, biodiversity and fisheries. Ultimately, this initiative can have a tremendous impact on shaping future weather and climate research in the polar regions. New collocated multidisciplinary data sets of sea ice and under-ice properties at unprecedented temporal and spatial resolution far into unexplored territories could revolutionize our knowledge of climate change in those regions, for example, in heat fluxes and storage, fresh water exchanges, carbon sequestration and ocean acidification.

provide all-weather day and night data in more robust forms.

There are other initiatives in play to improve sea ice forecasts. Government and university scientists associated with SEARCH, the Study of Environmental Arctic Change, are trying to improve understanding and prediction of sea ice change by working with the Inuit who are ground- or ice-truthing satellite data. Some of the scientists are also developing new computer models that will hopefully improve weekly and monthly forecasts.

THE FUTURE OF ARCTIC SHIPPING

As sea ice continues to retreat and as tourism demands grow, the need for more reliable prediction systems in the Arctic is likely to grow. In a paper called *Sea ice decline and 21st century trans-Arctic shipping routes*, published in 2016, Melia and his colleagues predicted that Arctic sea ice traffic will double by mid-century. Several countries are already preparing for this future.

Russia has created a single enterprise to oversee its expanding activities in the Arctic. The country is building new facilities, such as the liquid natural gas port at Sabetta along the Yarmal Peninsula. In December 2017, a ship from the port carried the first shipment of Russian liquefied natural gas to the UK. Elsewhere in the world, the US state of Maine has plans to turn Portland into a gateway to the Arctic, and Iceland is working on a feasibility study for a deep water port at Finnafjörður.

Another country that is showing great interest in the Arctic is China. "China's interest in the Arctic is no longer a secret," comments Rob Huebert, a senior research fellow with the Centre for Military and Strategic Studies at the University of Calgary in Canada.

He expects a rush to exploit Arctic shipping routes coming sooner rather than later. Huebert appreciates the fact that most western-based shipping companies are pessimistic about the short-term opportunities of exploiting Arctic sea routes. It's China that has him intrigued.

Huebert was taken aback by the so-called *Polar Silk Road* policy statement that the country released in January 2018. It outlines plans for China to build more ice-capable vessels so that Arctic sea routes can be exploited for research, shipping and resource development. "China does not issue white papers like this unless it is very serious," says Huebert. "In fact it doesn't do white papers and make them public at all. The fact that it did so in this case suggests that it is very serious. All I can say is that we need to be better prepared than we are now in dealing with future shipping activity in the Arctic." ∎