***A Not-so Ice-free Arctic Ocean: Implications for Coast Guard Operational Capabilities, Posture, and Strategic Messaging* (Polar Insights 01-24)**

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"The Arctic Ocean may see ***ice-free*** summers as soon as 2030, flooding and wildfires will increase in frequency, new economic opportunities could emerge, and geopolitical tensions may grow," National Strategy for the Arctic Region, October, 2022

Arctic sea could be ***'ice-free'*** by the 2030s, new study warns, The Hill, March 5, 2024

The Arctic may be sea ***ice-free*** in summer by the 2030s, new study warns, CNN, June 6, 2024

"Several portions of the Arctic Ocean that have historically been covered with sea ice through at least parts of the winter will become increasingly ***ice-free*** in the coming years," navy.mil, February 22, 2024

"As the number of ***ice-free*** days in the seas surrounding Alaska increases over time, so do opportunities," U.S. Climate Resilience Toolkit, Update May 10, 2024

As the above examples demonstrate, the use of the term, "ice-free", is regularly creeping into the mainstream lexicon used in conversations about the warming Arctic by both the popular media and Federal government partners. This is a mischaracterization that the Coast Guard should avoid, and when presented with the opportunity, clarify in order to educate and articulate an appropriate strategic and operational posture for the changing Arctic Ocean.

This paper provides an overview of recent scholarship to correct the discourse and inform more accurate and effective terminology to improve strategic messaging and operational assessments of the future Arctic maritime operating environment.

A recent scientific review, out of the Institute for Arctic and Alpine Research at the University of Colorado at Boulder, describes in detail the major changes observed in Artic sea ice coverage over the last 45-years and the timing and regional variability of diminishing ice anticipated in the future: [1]

- Typical sea ice area (SIA) in September, the month of minimal coverage, in the 1980's was 5.5 million km^2, more than 10X the size of California.
- Typical September SIA from 2015-2023 was 3.3. million km^2, significantly diminished from the 1980's, but still an area larger than the nation of India.
- One commonly used scientific definition of an ice-free Arctic Ocean is the point at which SIA is less than 1 million km^2, which, while just one-third of the typical SIA of the last decade, still represents an area twice the size of California, but likely to be spatially concentrated north of Greenland and the Canadian Arctic Archipelago.[2]

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[1] Jahn A, Holland M, Kay J. Projections of an ice-free Arctic Ocean. *Nature Reviews Earth and Environment*, Volume 5, 164-176 (2024)

[2] A similar definition using sea ice extent (SIE) describes ice-free as when the area of the Arctic Ocean with at least 15 percent sea ice concentration falls below 1 million km^2. The definitional difference results in SIA calculations of area being greater than SIE calculations.

- Applying this definition, the first ice-free September in the Arctic is likely to occur by 2050 (within a range of 2035-2067), but daily ice-free events in September could occur years earlier.
- Ice-free conditions are expected to occur sequentially in the European Arctic first, followed by the Pacific Arctic, then the Central Arctic Ocean if it becomes ice free at all.

This issue is more than just a matter of semantics as the state of sea ice coverage has direct impacts on Arctic communities, activities, and the maritime operating environment. The future conditions, rather than being devoid of ice or risk, are arguably even riskier, especially when considered in combination with their influence on human activities, including indigenous subsistence communities, and regional wildlife. Thus, we suggest consideration of an alternative expression of the evolving Arctic sea ice environment as follows.

There will come a date in September sometime between 2030 and 2050 where, for brief periods, there will be no or very little ice remaining throughout much of the Arctic Ocean. However, the Arctic Ocean will remain significantly ice-covered, fully or partially, for 7-9 months a year mid-century & beyond, by seasonal, thinner first-year sea ice. This first-year sea ice will likely be much more mobile/dynamic, implying continued risk to marine traffic and new challenges for local communities if appropriate mitigations are not in place.

Recent research led by Coast Guard Academy Professor, Dr. Lucy Vlietstra, underscores this point, revealing the increasing risks associated with the combination of a warming ocean, highly variable sea ice formation, and increased human activity, especially vessel operations.[3]

The increase in activity, and its risks, are real. The Arctic Ocean, for the period of 2013-2019, saw a 25% increase in ship traffic and 75% increase in distance sailed.[4] Within this period, there were 58 besetting incidents along Russia's Northern Sea Route (NSR) between 2013 and 2017, and in 2021, at least 18 ships were beset in the NSR in November alone, some frozen in for weeks and required icebreaker support to resume their voyage.

One goal of Vlietstra and Hinrich's research was to visualize where vessels are operating in or near the Marginal Ice Zone (MIZ), defined as seas experiencing 10-80% surface ice concentration, for the purpose of determining: 1) if ships are spending more time in the MIZ, 2) where ships are encountering the MIZ, 3) and if those locations are consistent over space and time, as this information can guide emergency planning and preparedness in the short term and inform priorities for sustainable Arctic shipping development in the long term.

This research found that there is a slight positive trend in MIZ coverage from 2012-2023, but with significant variability year-to-year. While the vast majority of ship hours in the Arctic Ocean were observed to be in open water, there was an overall positive trend in ship hours along the outer ice edge, the boundary between open water and the MIZ. One observed feature of diminishing overall sea ice coverage is greater MIZ coverage, so while the potential for ships to experience pack ice is diminishing, the potential for ships operating in a less predictable Arctic Ocean ice environment is

[3] Vlietstra L, Hinrichs K, Proximity of Commercial Maritime Traffic to the Arctic Marginal Ice Zone, 2012-2023, presented at Arctic Frontiers, Tromso, Norway, January 2024.
[4] Shipping data is from the Arctic Council Working Group on the Protection of the Arctic Marine Environment (PAME)

increasing. In combination, these observations may indicate increased potential for operational mistakes or risks for future Arctic Ocean shipping.

A second study by Vlietstra et al focused on polar class (PC) ship accessibility in the North Bering Sea and Arctic Ocean region north of the Bering Strait from 2012-2022.[5] This study considered accessibility for three levels of ice-capability, PC3 (most capable), PC5, and PC7 (least capable). PC1 and 2 were excluded as they are likely unhindered in the Arctic sea ice environment.[6]

This research employed a model to convert sea ice conditions into a measure of accessibility for the three PC levels and found, on average, more area was accessible to each successive PC class, with PC7 gaining the most (21%), but with significant seasonal variability. June was especially restrictive to PC7 ships, but in contrast, the area accessible to PC3 ships was relatively uniform across the four months. The area accessible to all three classes in November was similar. Accessibility declined for all three classes in November and was only slightly positive in September.

In aggregate, these findings indicate a trend toward an earlier Arctic navigation season, but sustained risks to freeze-in toward the season's closing.

If ice conditions observed are indicative of future conditions, PC ship accessibility to established trade routes through Arctic seas north of the Bering Strait may not be too different for PC3 and PC5 ships. In this case, commercial operators may benefit from prioritizing new construction of PC5 ships over that of PC3 icebreakers, possibly incentivizing a tradeoff of capability for reduced costs in future Arctic shipping.

While declines in sea-ice coverage in the Arctic Ocean may create opportunities for polar marine traffic in general, this research shows that the Arctic environment remains highly unpredictable on smaller (regional and local) spatial scales. Real possibilities exist for planning miscalculations.

The cumulative conclusion is that communities, emergency responders, regulators, and the maritime industry may have trouble adapting to high levels of environmental variability observed and anticipated in the changing Arctic Ocean.

In summary, ice-free is anything but risk-free in the Arctic marine environment, and the greatest risks are likely to be seen in those highly variable marginal areas of ice concentration, so, a need for ice capability will remain, but to what degree to maximize operational effectiveness efficiently? What additional measures, e.g. regulations, or operational capabilities and postures, beyond surface assets, may contribute to an appropriate degree of Arctic operational readiness? What are the implications of Arctic sea ice patterns for where strategic ports are situated in the region? These and other questions are integral to CASP's study and analytical agenda and may be the focus of future "Polar Insights".

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[5] Vlietstra L, Hinrichs K, Bernstein R, Darden A, Martino M, Polar class ship accessibility to Arctic seas north of the Bering Strait in a decade of variable sea-ice conditions, *Frontiers in Marine Science*, Volume 10 (2023)
[6] Ships with a PC rating are built to safely navigate a defined range of ice conditions, which determines their assigned rating (PC1–PC7) within the Unified Requirements for PC Ships (International Association of Classification Societies, 2016). The polar classes serve as an effective proxy for most ice strengthened ships (PC6–PC7), ice-capable ships (PC4–PC5), and icebreakers (PC1–PC3).

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