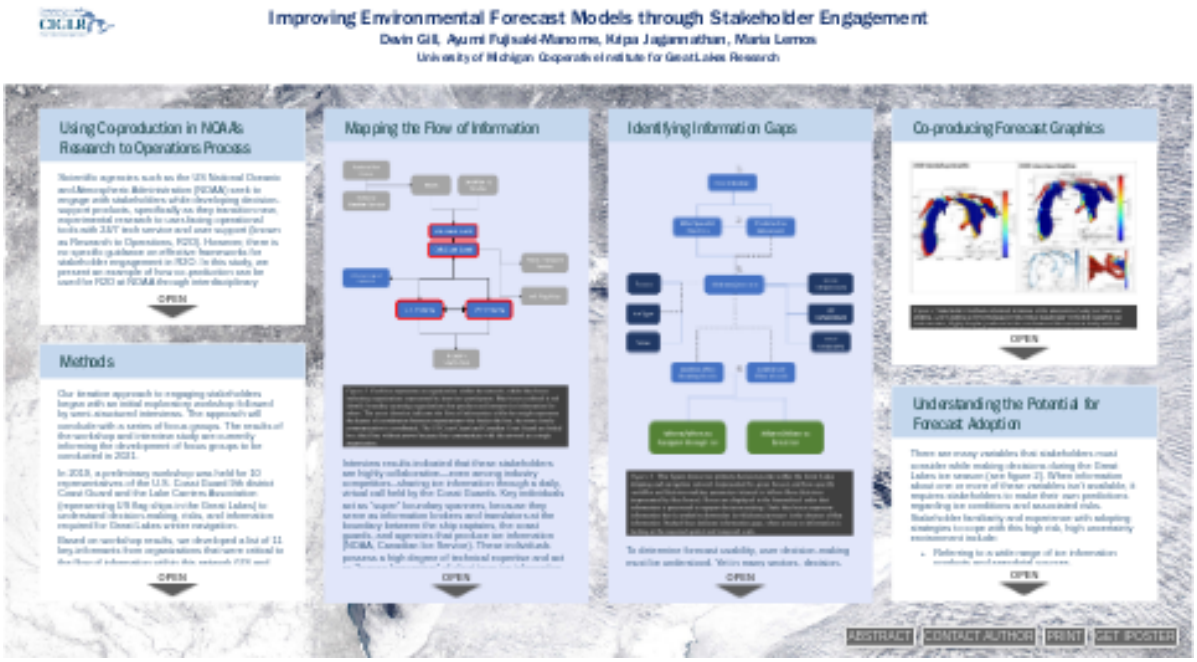
Improving Environmental Forecast Models through Stakeholder Engagement



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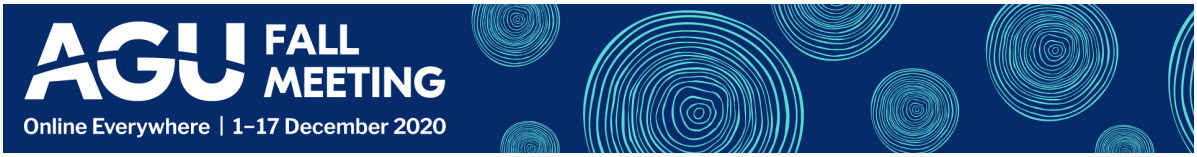

USING CO-PRODUCTION IN NOAA'S RESEARCH TO OPERATIONS PROCESS

Scientific agencies such as the US National Oceanic and Atmospheric Administration (NOAA) seek to engage with stakeholders while developing decision-support products, specifically as they transition new, experimental research to user-facing operational tools with 24/7 tech service and user support (known as Research to Operations, R2O). However, there is no specific guidance on effective frameworks for stakeholder engagement in R2O. In this study, we present an example of how co-production can be used for R2O at NOAA through interdisciplinary research and crossline office collaboration.

Three regional NOAA-funded organizations (the Cooperative Institute for Great Lakes Research, the Great Lakes Integrated Sciences and Assessments program, and the NOAA Great Lakes Environmental Research Lab) partnered to co-design a short-term Great Lakes Ice Forecast by bringing together personnel from across these organizations with expertise in social sciences, stakeholder engagement, and ice modelling. Our goal is to produce an ice forecast for the Great Lakes Operational Forecast System (GLOFS) (Anderson et al. 2018) that supports decision-making within the Great Lake Shipping and Navigation Industry. We conducted workshops and interviews with stakeholders in the Great Lakes Shipping and Navigation network who helped us achieve the following results:

- Characterize the user types and flow of ice information within the Great Lakes Shipping and Navigation network,
- Understand the informal decision-making process for Great Lakes ice navigation, and the potential value of the new NOAA forecasts,
- Examine the role that risk and uncertainty plays in shaping new forecast usability.

METHODS

Our iterative approach to engaging stakeholders began with an initial exploratory workshop followed by semi-structured interviews. The approach will conclude with a series of focus groups. The results of the workshop and interview study are currently informing the development of focus groups to be conducted in 2021.

In 2019, a preliminary workshop was held for 10 representatives of the U.S. Coast Guard 9th district Coast Guard and the Lake Carriers Association (representing US flag ships in the Great Lakes) to understand decision-making, risks, and information required for Great Lakes winter navigation.

Based on workshop results, we developed a list of 11 key-informants from organizations that were critical to the flow of information within this network (US and Canadian Coast Guards, US and Canadian Shipping Companies, and the US Army Corps of Engineers), and who were perceived by their peers as being exceptionally knowledgeable about Great Lakes ice navigation. We conducted virtual semi-structured interviews to better understand:

- Use of ice information,
- Usefulness of the available Great Lakes ice information products,
- Feedback on an early Great Lakes short-term ice forecast prototype.

MAPPING THE FLOW OF INFORMATION

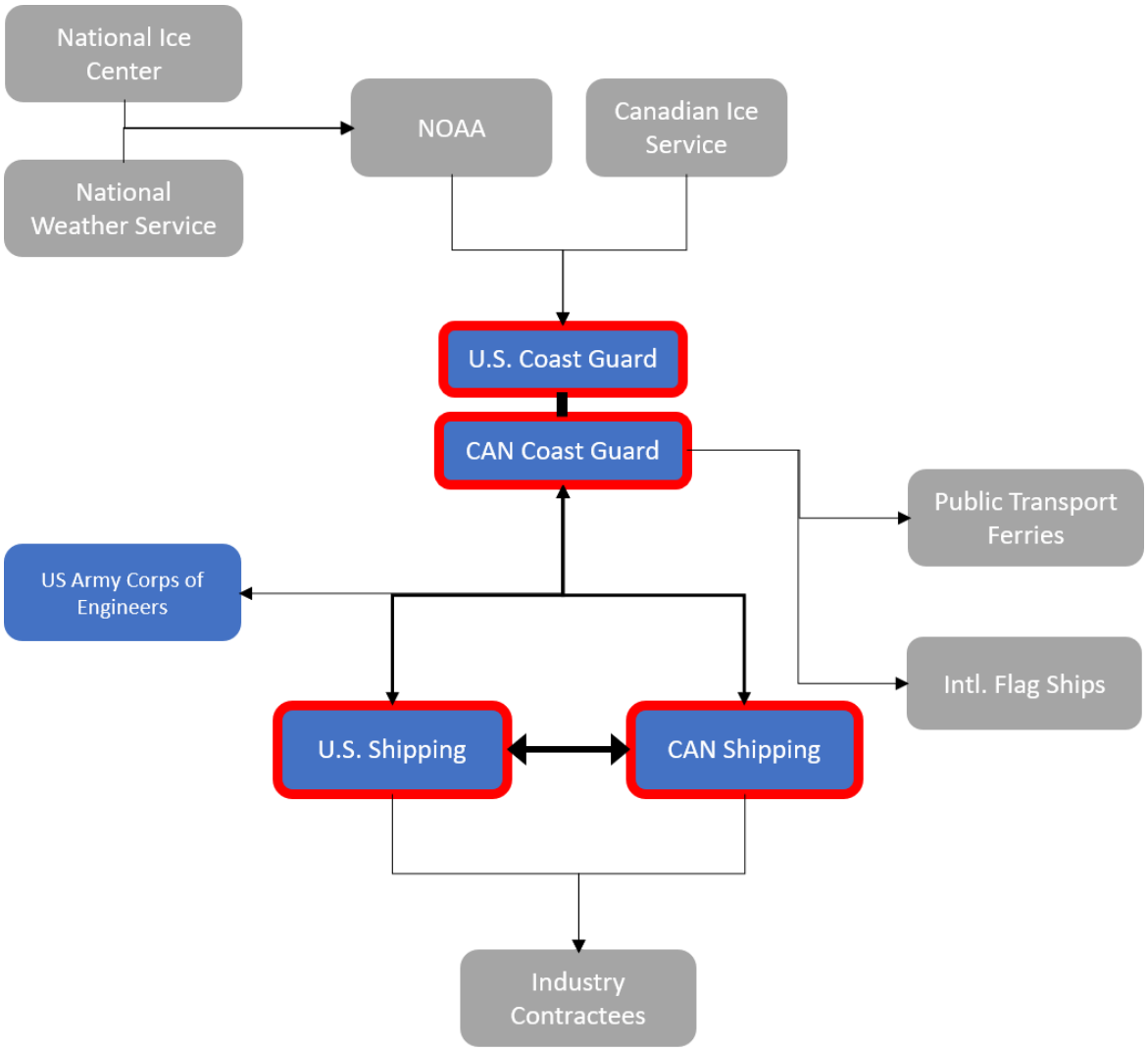

Figure 2. Each box represents an organization within the network, which blue boxes indicating organizations represented by interview participants. Blue boxes outlined in red identify boundary spanning organizations that produce and interpret ice information for others. The arrow direction indicates the flow of information, while the weight represents the degree of coordination between organizations--the thicker the line, the more closely communication is coordinated. The US Coast Guard and Canadian Coast Guard are linked by a thick line without arrows because they communicate with the network as a single organization.

Interview results indicated that these stakeholders are highly collaborative—even among industry competitors--sharing ice information through a daily, virtual call held by the Coast Guards. Key individuals act as “super” boundary spanners, because they serve as information brokers and translators at the boundary between the ship captains, the coast guards, and agencies that produce ice information (NOAA, Canadian Ice Service). These individuals possess a high degree of technical expertise and act as “human forecasters” of short-term ice information, using their knowledge and experience to interpret existing, fragmented information for themselves and others.

IDENTIFYING INFORMATION GAPS

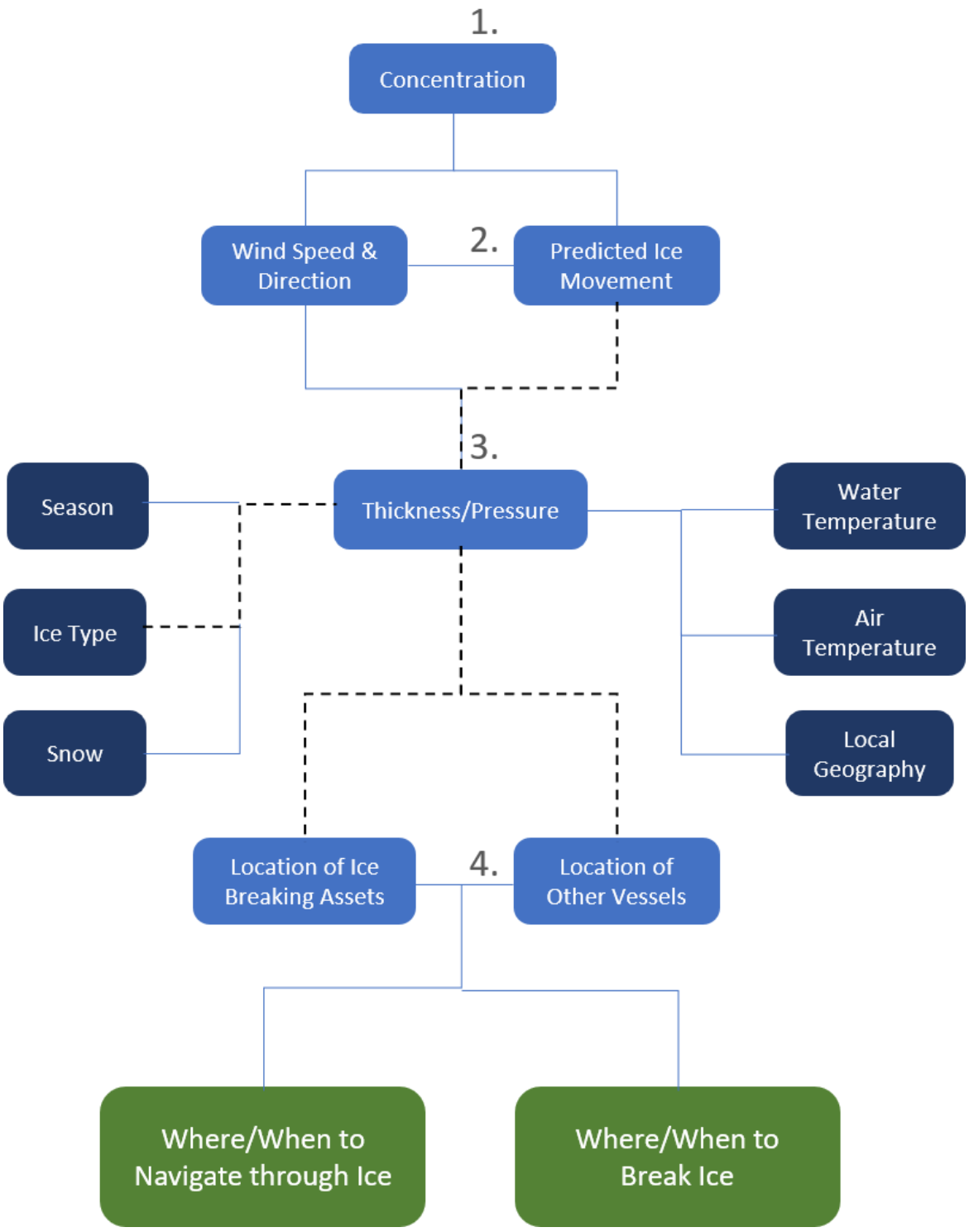

Figure 3. This figure shows two primary decision points within the Great Lakes shipping and navigation network (represented by green boxes), and how specific variables and decision-making parameters interact to inform those decisions (represented by blue boxes). Boxes are displayed in the hierarchical order that information is processed to support decision-making. Dark blue boxes represent information that is needed to determine ice thickness/pressure in the absence of that information. Dashed lines indicate information gaps, when access to information is lacking at the required spatial and temporal scale.

To determine forecast usability, user decision-making must be understood. Yet in many sectors, decision-making processes are "invisible" and not well articulated. Our interviews--particularly with boundary spanners--enabled us to identify key decisions facing the network and elicit the informal, largely hidden decision-making process.

Two key decision-points govern winter ice navigation: where/when to navigate through the ice, and where/when to break the ice. Winter navigation decisions are made by ship captains and operations managers at commercial shipping companies. Ice breaking decisions are made by the US and Canadian Coast Guards based on the needs of the industry. To make these decisions, stakeholders need to know ice concentration, predicted movement, and thickness. Yet, this information is largely inaccessible, causing stakeholders to seek additional variables (wind, temperature, etc.) to inform their own predictions based on experience and the advice of boundary spanners. This short-term Great Lakes Ice Forecast will reduce the uncertainty associated with existing methods of decision-making by providing predictions for ice thickness and movement with a higher degree of computational power.

CO-PRODUCING FORECAST GRAPHICS

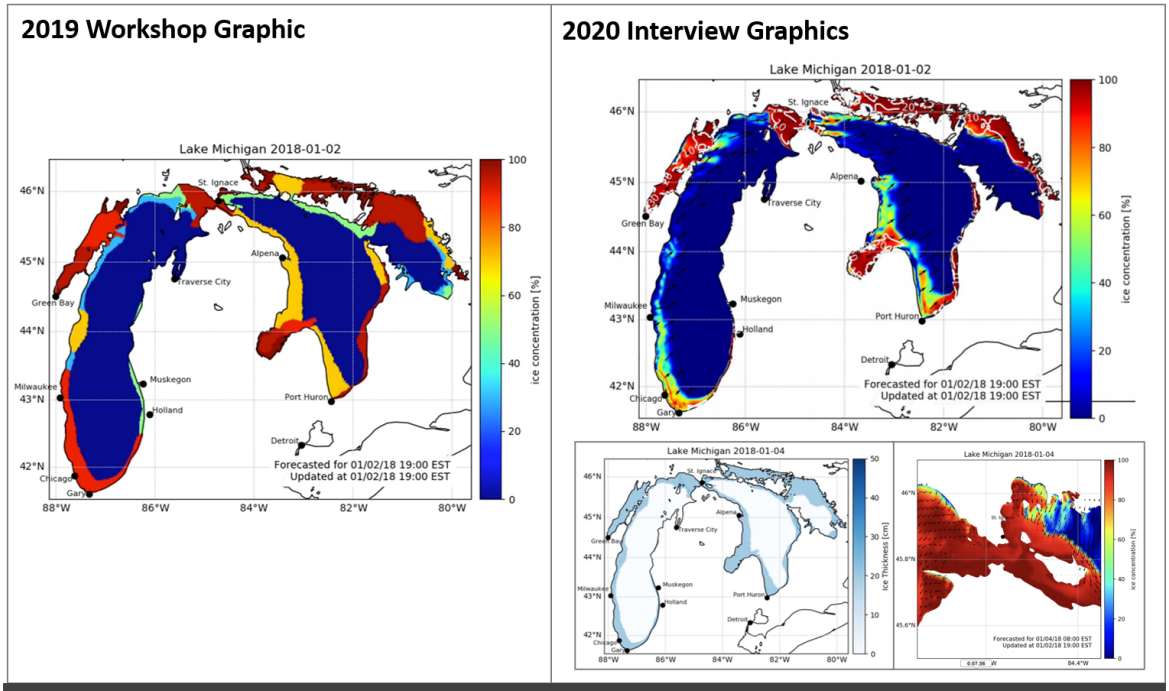

Figure 1. Stakeholder feedback informed iterations of the short-term (5-day) ice forecast graphic. *Left)* Graphic as first produced for the initial stakeholder workshop featuring ice concentration, *Right)* Graphic produced at the conclusion of the interview study with the addition of ice thickness, wind direction and speed, and ice velocity. Higher resolution views were also created for areas that are particularly challenging to navigate during icy conditions.

Great Lakes stakeholders need timely, accurate, and usable ice information to support winter transportation and navigation. When ice information is actionable, it can reduce safety risks for mariners and their vessels. For many years, this industry has largely relied on real-time ice observations and historic trends to make decisions. Scientists at CIGLR and NOAA GLERL are developing a short-term (5-day) Great Lakes ice forecast to address information gaps and better support decision-making while navigating the Great Lakes during the winter season.

Scientists at CIGLR and NOAA GLERL recently developed a coupled lake hydrodynamic-ice system--the Great Lakes Operational Forecast System (GLOFS)--to provide improved short-term forecasts of winter conditions. GLOFS models are currently transitioning from research to operations at NOAA National Ocean Service Center for Operational Oceanographic Products and Services to provide the first-ever short-term ice forecast guidance.

UNDERSTANDING THE POTENTIAL FOR FORECAST ADOPTION

There are many variables that stakeholders must consider while making decisions during the Great Lakes ice season (see figure 2). When information about one or more of these variables isn't available, it requires stakeholders to make their own predictions regarding ice conditions and associated risks. Stakeholder familiarity and experience with adopting strategies to cope with this high risk, high uncertainty environment include:

- Referring to a wide range of ice information products and anecdotal sources,
- Relying on a cooperative communication network, and
- Seeking the expertise of "super" boundary spanners who interpret ice information and assess risk.

To further support decision-making, project participants explicitly asked for future access to our short-term Great Lakes ice forecast at the conclusion of the interview study, suggesting that quick adoption of the forecast is likely.

> *At present, we're applying experience and guessing at what is gonna happen. With your predictive model…even if it's 30% accurate…that's going to improve our ability to provide tactical support and improve the safety of these waterways….Instead of waiting until we have problems, we could prevent problems from developing.* –Anonymous Interview Participant

This eagerness to adopt a new, experimental product in the face of high risk decision-making is somewhat surprising. We hypothesize that the eagerness to adopt this new forecast model can be attributed in part to the role of "super" boundary spanners in the network's decision-making framework. The ice forecast provides a more scientific analysis of current and predicted ice conditions for "super" boundary spanners, rather than relying on their skill as human forecasters. Since these individuals have long acted as trusted advisors and science translators to the industry, their enthusiasm for the new product supports community acceptance of the product. We intend to test this hypothesis as the project develops. As the Great Lakes short-term ice forecast model is transitioned to operations, this co-production approach has been invaluable to understanding user requirements for decision-support.

ABSTRACT

Environmental modelling efforts can inform decision-makers in many sectors. However, models are often created without in-depth consideration of stakeholder usability needs. To bridge the gap between environmental modeling and its use, NOAA's Great Lakes Environmental Research Laboratory (GLERL) and the University of Michigan's Cooperative Institute for Great Lakes Research (CIGLR) have developed an approach for co-designing Great Lakes environmental information products with targeted stakeholders. This approach applies social science research methodologies (including interviews, focus groups, and qualitative data analysis) to an iterative four-step process: 1) User Decision-Making and Information Needs Assessment, 2) Product Prototype Development, 3) Prototype Usability Evaluation, 4) Product Dissemination. In a case study, we used our approach to co-design a short-term Great Lakes ice forecast under NOAA's Great Lakes Operational Forecast System (GLOFS). Co-design was conducted with members of the shipping and navigation industry, and implemented with additional support from the University of Michigan's Great Lakes Integrated Sciences and Assessments (GLISA). We employed a series of stakeholder engagement activities and scenario planning exercises to map stakeholder's decisions, identify variables of interest, and clarify preferences for interpreting forecast uncertainty. Our process created an ice forecast that is informed by user needs and ready for easy application by decision-makers. Furthermore, our work provides lessons on how stakeholder-driven refinement of models and forecast products can potentially improve their usability and acceptance among the user community.