FRESH EYES ON ICE

Assessment of the River Ice Information Needs of Alaskans

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Prepared by:

GOLDSTREAM group, inc.

PO Box 83418
Fairbanks, Alaska 99708
907.452.4365
www.goldstreamgroup.com

Contributing Authors
Kelly Kealy
Jen Danielson
Dr. Delia Allen

Layout and Design
Doreen Deaton

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Prepared for:

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A collaboration among:

Principle Investigator Team:

Dr. Chris Arp (UAF Water and Environmental Research Center, WERC)
Dr. Katie Spellman (UAF International Arctic Research Center, IARC)
Dr. Dana Brown (UAF IARC)
Brooke Woods (Tanana Chiefs Conference)
Dr. Laura Oxtoby (UAF WERC)
Dr. Elena Sparrow (UAF IARC)

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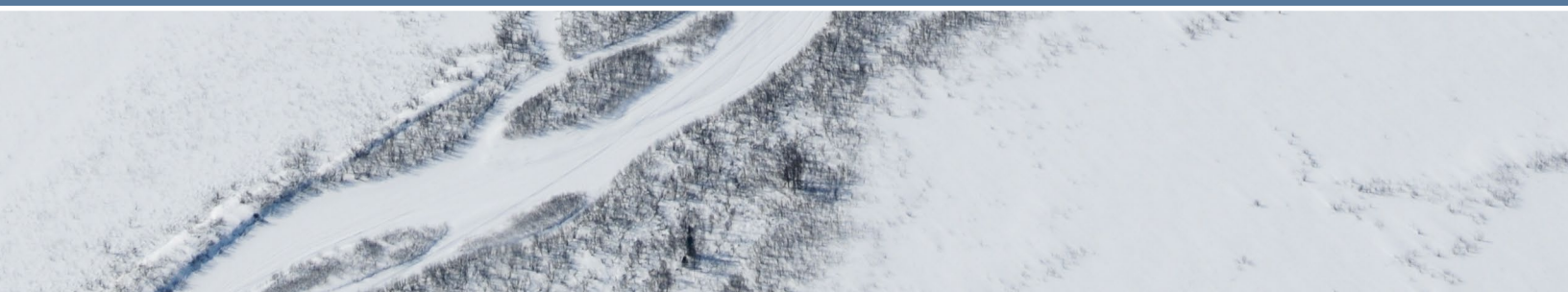
EXECUTIVE SUMMARY



Executive Summary

Warmer winters have rapidly altered freshwater ice conditions in Alaskan river basins. Changes in ice thickness and the timing of freezeup and breakup influence hydrology, ecosystems, winter travel safety, access to subsistence resources, and spring ice-jam flooding. Remote sensing enhances hydrologic research and forecasting in this vast region, but we are currently limited by the spatiotemporal extent of ground-based observations. The goal of the Fresh Eyes on Ice project is to expand the existing freshwater ice monitoring efforts within Alaska using a culturally responsive citizen science model to increase the spatial extent and frequency of observations and expand the diversity of participants across Alaska. The project included partners from University of Alaska Fairbanks (UAF), Tanana Chiefs Conference (TCC), National Weather Service Alaska Pacific River Forecast Center (NWS APRFC), and NASA GLOBE Observer (NASA GO). The first step is to conduct a front-end assessment of ice concerns, local knowledge, research priorities, data product needs, and technological access across river communities in Alaska.

This needs assessment sought to surface the needs and preferences of different users and observers in using and making ice observations, to identify any additional user groups, to articulate commonalities across different user groups, and to ultimately improve Fresh Eyes on River Ice programs by providing guidance for refining tools with the knowledge of different user groups. Organizing questions for this work were the following:

1. What do people know about river ice currently?
2. To what extent are people interested in and willing to contribute information about river ice conditions?
3. What information do people need about river ice and how are they going to use that information?
4. How do people describe different qualities of ice?
5. What are the best ways to share needed information about river ice with different audiences?
6. Who will use information about river ice conditions?
7. What supports do different audiences need to make observations and contribute that information and knowledge about ice conditions to the community?

Methods

A survey was co-designed by project partners (including the University of Alaska Fairbanks and Tanana Chiefs Conference) and the project evaluation team, then piloted, refined

further, and then disseminated. Dissemination occurred via the Fresh Eyes on Ice Facebook page; the Tanana Chiefs Conference social media channels, the Fresh Eyes on Ice web site; through email lists of recreation, science, tribal, and other relevant associations; through virtual workshop events; and through personal contacts in research, subsistence, and winter recreation spaces. Entry into a raffle for one of two $250 prizes was offered upon completion of the survey. Responses were cleaned for spam responses, resulting in a total of 100 valid responses. Respondents were also offered the opportunity to indicate interest in a follow-up interview; 10 respondents were interviewed and provided $25 incentive once completed (two declined the incentive).

Findings

Findings were categorized into three main areas: characterizing ***users*** of river ice data, characterizing uses of river ice data, and feedback on methods of using or sharing river ice data. A summary of major findings follows.

Locations of Survey Respondents:

- **Altogether, Interior respondents, whether rural or urban, represented 51.0% of respondents.** A total of 24.0% of respondents lived in urban locations like Fairbanks, and 27.0% lived in rural Interior locations.
- A total of 20.0% of respondents were from urban Southcentral Alaska.
- The total count of rural Alaska-based respondents was 44.0%.

Affiliations:

- A total of 13.0% of respondents indicated that they resided in urban locations (whether Interior or Southcentral) and performed periodic field work in remote rural locations.
- **The total Indigenous-affiliated response rate was 27.2%, or nearly a third of survey responses.**[1]
- The most prevalent response type indicated tribal council affiliation (19.2%), followed by university affiliation (18.2%), then by K-12 school system affiliation (17.2%) and federal agency (17.2). State agencies and private businesses were represented by 8.1% of responses and 5.1% of responses, respectively.

Relationship with Ice:

- A total of 40.0% of all respondents noted they engage in river ice travel. A total

[1]This response rate is similar to rates at which Alaskan respondents to 2020 Census identified as Alaska Native, American Indian, or part AN/AI: 21.9%. https://www.census.gov/library/stories/state-by-state/alaska-population-change-between-census-decade.html

of 38.0% noted they recreate on ice, followed closely by subsistence (34.0%) and research (30.0%). 18% reported education-related ice interaction.
- Participants are very willing to share and use information about river ice conditions (more than 4 out of a 5-point agreement scale, where 5 is “strongly agree” 3 is neutral). They are less likely to feel like they know where to efficiently find or share river ice information (from 3 to 3.5 out of 5).

Uses of River Ice Data:

- For both professional and personal use, the clear top river ice knowledge needs were thickness of the ice (53.9% of survey responses) and whether it is safe to travel (48.3% of responses).
- Total survey respondents who indicated needing river ice information for either safety or travel was 52 – or 59.1% of responses. Other prevalent themes were subsistence and accessing resources (12.5%), gaining specific types of data knowledge for use in specific data application contexts (including assisting institutions such as tribes) (11.4%), and long-term monitoring and understanding (10.2%).
- From day to day or week to week, respondents were most likely to indicate needing to know information about whether or not the ice was thick enough or of good enough quality to travel on safely, whether for work, subsistence, or travel (21.6%). From year to year or decade to decade, respondents most wanted information about changes to freezeup or breakup timing (25.7%).
- The need for local, current information about ice conditions – particularly ice thickness – is considered, across all user groups who responded to the survey, to be a top need. Local observers are critical to local safety, as well as to the efficacy of larger data sets used by scientists and state and federal entities.

Feedback on Methods of Using and Sharing Data about Ice:

- From a list of 13 common tools for using or sharing ice observation data, and a rating scale of never (1) to frequently (4), respondents indicated most frequently using resources such as talking in person (3.1), Facebook (2.8), calling or texting on

their phone (2.5), the National Weather Service River Forecast Center website (2.5), "Other" (2.4), Fresh Eyes on Ice Photo Observer website (2.1), and social media other than Facebook (2.0). Of the 14 "other" responses that were provided, seven – 50% – cited either leveraging relationships with specific individuals or entities making local observations, or using already-existing community-based monitoring tools that are driven by individual observations. In interviews, several respondents noted that for this scale, they were sometimes conflating talking in person, communicating via phone, or messaging on social media. In other words, communication of local observations between trusted individuals – whether via the internet, phone, or face to face – was the main way individuals used or shared information about river ice conditions.

- Of those survey respondents who had ever seen the GLOBE Observer Land Cover app, 55.0% of respondents noted they would consider using this smartphone-based app in the future specifically because of its ease of use and ability to operate offline.
- For broader use by non-local entities OR other local entities at other locations, observation data needs to be collected using some form of protocol, or include photos, or be otherwise required to have some standard across the data set. Those respondents who worked with specific tools such as GIS or other tools internal to their institution had specific requests for file types or other requirements.

Most Valuable Aspects of Current Tools:

- A third of respondents (32.1%) noted that what gives value to the tools they use is the fact that they are locally grounded and provide a first-hand understanding of river ice that informs daily ice-related choices.
- Nearly 25% of survey responses noted they most valued knowing that the data they are using is current.
- About 11% of responses noted that they most valued the tools they used because they fulfilled a specific data need (discrete from timeliness of data). These data needs varied, and included satellite imagery (against which ground photography can be checked to validate the satellite data), photos taken from one location over time, ice thickness, breakup timing year over year, and breakup conditions in a format that is compatible with other tools to compare data sets.
- Nearly 10% of survey respondents noted that they most valued how easy the tools were to use. Most responses of this type underscored that the tools were easy to use because they were already part of respondents' lives, such as social media, television, and school projects.

Tools Improvement:

- Tied for most common response themes related to ideas for improvement were suggestions related to physical tools and other data collection hardware (13.5%), and suggestions for output and reporting improvements (13.5%). Along with suggestions for standardizing data (9.6%), a total of 12 tool refinement suggestions (23.0%) were related to output refinements.
- Several survey responses and interviewees noted that, across several different tools, photo uploading was an area that needed improvement. Relatedly, several responses pointed to photos as a possible solution to creating consistency across ice condition observations statewide. This finding suggests that protocols related to taking photos, as well as improved photo uploading for those with poor internet or minimal access to smartphones, should be considered moving forward with any refinement to current ice data sharing tools available to Alaskans.
- Some participants expressed a sense of

wanting to improve information-sharing within their own contexts, or wanting to increase awareness across institutions and communities about the available resources. Participants noted that tools are less useful for crowd-sourced data if they are not used by enough people.

Conclusion and Recommendations

It is clear that ice thickness measurements and current geotagged and non-subjective ice condition information was of interest and currently mostly missing from what rural, recreational, and scientific/statewide context users felt they had easy access to. However, interviews and open-response survey items showed that existing tools do provide some of what is needed already. Existing data-aggregating resources such as Weather Service/River Watch tools, the LEO Network, GLOBE Observer resources, and the Fresh Eyes on Ice website are already valued by participants; almost no respondents had ever heard of the SIKU app, but features of that tool overlap features of the aforementioned tools and this Indigenous-created app currently used mostly in Canada may be worth exploring as a potential tool for locally-derived river ice observations in the Alaskan context. When asked to check all items they would want in an app from a predetermined set of items, respondents were most likely to want the ability to see or share data about one location over time (76.1%), then the ability to upload or see pictures (75%). In interviews and in open-ended items, respondents highlighted the usefulness of photos as a way to eliminate subjectivity, as well as validate satellite data. Whether existing tools are enhanced or adapted, or a new tool is created, it is clear that an easy-to-use tool that includes photos and descriptions of local observations, and which also provides guidance for data collection, is desired across the clear majority of participants. Such a tool has the potential to strengthen the power of already-useful local observations of river ice conditions by enhancing its usability in larger state-wide data analysis that informs decisions related to Alaskan transportation infrastructure, drinking water systems, ecological stewardship, and other funding decisions.

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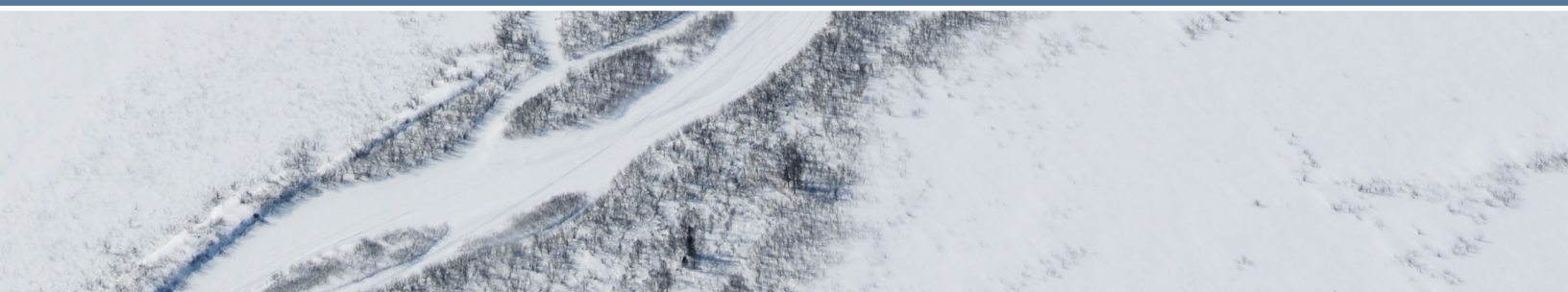

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Introduction

Warmer winters have rapidly altered freshwater ice conditions in Alaskan river basins. Changes in ice thickness and the timing of freezeup and breakup influence hydrology, ecosystems, winter travel safety, access to subsistence resources, and spring ice-jam flooding. Remote sensing enhances hydrologic research and forecasting in this vast region, but we are currently limited by the spatiotemporal extent of ground-based observations. The project goal is to expand the existing freshwater ice monitoring efforts within Alaska using a culturally responsive citizen science model to increase the spatial extent and frequency of observations and expand the diversity of participants across Alaska. The project will include partners from University of Alaska Fairbanks (UAF), Tanana Chiefs Conference (TCC), National Weather Service Alaska Pacific River Forecast Center (NWS APRFC), and NASA GLOBE Observer (NASA GO). The first step is to conduct a front-end assessment of ice concerns, local knowledge, research priorities, data product needs, and technological access across river communities in Alaska.

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7. How will the information be used by different audiences?
8. What supports do different audiences need to make observations and contribute that information and knowledge about ice conditions to the community?

Methods

This needs assessment used a descriptive research design, focused on describing the needs and preferences of different ice users and observers in using and making ice observations.[1]

Survey

A survey was co-designed with a committee consisting of the evaluator and key Fresh Eyes on Ice project collaborators from University of Alaska Fairbanks and Tanana Chiefs Conference. Included on this committee were individuals with extensive experience working in the science outreach space with diverse populations and with experience improving data collection tools with equity and accessibility in mind. To help reduce bias that may result from some of the closed-ended survey items asking about respondents' relationship to specific aspects of ice, ice data, data collection and dissemination tools, or distinct ice data user groups, the survey also began with several open-ended items asking respondents to self-define their relationship with ice and what communities or institutions they associate with (i.e., how they would self-define their user group(s)).

The survey was piloted in November 2021

[1] Patton, M. Q. (2002). Qualitative research and evaluation methods (3rd ed.). Thousand Oaks, CA: Sage.

with a group of educators enrolled in the Fresh Eyes on Ice project workshop for the 2021-2022 academic year; as a result of feedback, a few items were either reworded slightly or deleted. However, the survey remained largely the same when disseminated more broadly. The data in this report reflect both the piloting data from teachers (n=16) as well as data from the broader dissemination of the survey from December 2021 through April 30, 2022.

Due to persisting pandemic cancellations of in-person activities for many medium and large events throughout the data collection period for this needs assessment, many of the planned in-person survey dissemination and interview opportunities were not available. Despite this, data collection still included 100 survey responses and 10 interviews.
The survey was disseminated via the Fresh Eyes on Ice Facebook page; the Tanana Chiefs Conference social media channels, the Fresh Eyes on Ice website; through email lists of recreation, science, tribal, and other relevant associations; through virtual workshop events; and through personal contacts in research, subsistence, and winter recreation spaces.

Responses were cleaned for spam responses, resulting in a total of 100 valid responses. Due to the two advertised $250 raffle prizes offered to those who complete the survey, several responses were received that were flagged as fake. Criteria for deletion as spam was at least two of the following (though notably, no responses that were received had only one of these criteria): multiple responses were received in the same short span of time with identical answers for some sections; email addresses for the raffle entry were randomized characters; open responses were not related to the content or were just reiterating words in the prompt; elapsed time taking the survey was extremely short for the length of the survey, such as two or three minutes.

Closed-ended responses were analyzed in Excel using descriptive statistics. Open-ended responses were coded in Excel for emergent and a priori themes, and analyzed using descriptive statistics where relevant.

Interviews
The evaluator reached out to 80% (about 40) of the survey respondents who had indicated they were interested in a follow-up interview. A total of 10 survey respondents replied and participated in a follow-up interview. As with survey respondent affiliations, the pool of interviewees represented a generally diverse group of individuals. Interviewees represented federal agencies, state agencies, university, private citizens (recreational users), private business, a tribal employee, and a school principal.

Interviews consisted of a review of survey responses; each set of responses was reviewed before the interview and probing questions were prepared. Participants were offered a $25 gift card to a venue of their choosing; two participants declined. Participant interviews were recorded and transcribed, and transcriptions were coded for emergent and a priori themes in ATLAS.ti.

Limitations
When designing the survey, the project team strove to provide enough open-ended questions to provide space for nuance, for respondents to share their thoughts from their own frame of reference rather than from a prescriptive set of options. While this approach resulted in a great deal of rich data, it also resulted in a few responses not addressing the question. In a few cases where these off-topic responses were rich and relevant to other questions elsewhere in the survey, responses were described in the section in which they were provided, and appropriately earmarked as relevant to a different topic.

Additionally, while the dissemination of the survey aimed to garner responses from a wide variation of user groups, and self-identified location and affiliation information indicate a wide survey reach, dissemination was not randomized, and the findings of this report do not necessarily represent all user groups of river ice information.

Findings

Needs assessment findings follow below and are organized into the following sections: characterizing users of river ice data, characterizing uses of river ice data, and feedback on methods of gathering data about ice.

Characterizing Users of River Ice Data

This section describes survey respondents in three ways: how they self-describe as interacting with river ice, how they describe their institutional affiliation, and where they are located. Since interviewees were all also respondents to the survey, interviewee-specific breakdowns of these three aspects of respondents were not analyzed beyond what is featured in the Methods section, above.

Self-Reported Community
The most common locations of residence for respondents was the Interior region, with 24% of respondents reporting living in urban areas such as Fairbanks, and 27% reporting living in rural locations in the Interior. Altogether, Interior respondents, whether rural or urban, represented 51% of respondents. A total of 20% of respondents were from Southcentral, either in Anchorage (16%) or in other urban southcentral locations (4%). The total count

Table 1. Please share what community (or communities) you are in. This can include where you live, where you work, or where you're from. (For example: I live in Fairbanks, I work in Tok, I'm from Akiak, etc.)

Region	Count (n=100)	Percent
Interior rural	27	27.0%
Interior urban	24	24.0%
Anchorage	16	16.0%
Western rural	11	11.0%
Southwest rural	5	5.0%
Canada	5	5.0%
Lower 48	4	4.0%
Southcentral urban	4	4.0%
Alaska/statewide	2	2.0%
Southeast rural	1	1.0%
None indicated	1	1.0%
Resides urban, performs rural field work	**13**	**13.0%**

Note: Although respondents were asked to describe their community broadly (where they live, work, or are from), nearly all chose to identify first with the communities they live in (the two that did not, either left this field blank or indicated only "statewide").

of rural Alaska-based respondents was 44%. While most respondents indicated only one location (where they resided), thirteen respondents (13%) indicated that they resided in urban locations (whether Interior or Southcentral) and performed periodic field work in remote rural locations. Codes for all self-reported community affiliations are described in the table below.

Self-Reported Institutional Affiliation

The most prevalent affiliation response type indicated was tribal council affiliation (19.2%), followed by university affiliation (18.2%), then by K-12 school system affiliation (17.2%) and federal agency (17.2). State agencies and private businesses were represented by 8.1% of responses and 5.1% of responses, respectively.

A total of 4.0% of respondents self-identified as being affiliated with the Indian General Assistance Program (IGAP), an EPA grant that helps develop tribal capacity to administer environmental programs; 3.0% of respondents identified as representing a regional Native organization (tribes from within a given geographical/cultural regions in Alaska are often also organized within a region-wide umbrella organization working on behalf of all tribes in the region) or individual tribes in Alaska, and 1% represented a Canadian tribal entity. There was no overlap in respondents for these affiliations, making the total Indigenous-affiliated response rate 27.2%, or nearly a third of survey responses.

Most of the affiliations that were present in 2% or fewer responses co-occurred with other, more prevalent affiliations. For example, where private businesses cited their area or expertise, these responses were tagged with a second affiliation for the expertise topic. For example, a private business that specializes in geological research and consulting is represented in the code counts for both "private business" and "geologic."

Table 2 describes all coded affiliations from the relevant open response question.

Self-Reported Relationship with River Ice
The most common way respondents noted they interact with river ice is for travel, with 40.0% of all responses mentioning some form of river ice travel. Also prevalent were responses that cited recreation as a way in which the respondent interacted with river ice (38.0%), followed closely by subsistence (34.0%) and research (30.0%). Education-related ice interaction was also a prevalent theme (18.0%), as well as community monitoring. Most responses featured one or more of these main ways in which respondents interact with river ice. Additional codes describe

Table 2. What is/are your main affiliation(s)? This can be things like what institution you work for (like a school district or health center), what tribe or tribal council you are a part of, etc.

Affiliation	Count (n=99)	Percent
tribal council	19	19.2%
university	18	18.2%
school system	17	17.2%
federal agency	17	17.2%
state agency	8	8.1%
private business	5	5.1%
retired	4	4.0%
Indian General Assistance Program (IGAP)	4	4.0%
health agency	3	3.0%
student	3	3.0%
regional Native organization or tribal association	3	3.0%
Canadian state agency	3	3.0%
nonprofit	2	2.0%
recreational clubs	2	2.0%
watershed council	2	2.0%
naturalist/guide	2	2.0%
fashion	1	1.0%
religious	1	1.0%
geologic	1	1.0%
web-based data sharing	1	1.0%
airlines	1	1.0%
environmental consulting	1	1.0%
homeschool	1	1.0%
Canadian tribal entity	1	1.0%
unemployed	1	1.0%
unsure	1	1.0%
private citizen	1	1.0%

Note: Participants were also asked to share their main affiliation in their own words (via an open-ended item), and were provided a few descriptive examples: “This can be things like what institution you work for (like a school district or health center), what tribe or tribal council you are a part of, etc.”

more-specific topics that were mentioned in responses; these topics included specific mentions of hydrology or watershed research (7.0%), rather than just river ice research in general. Notable percentages include mentions of breakup (6.0%) being slightly more prevalent than mentions of freezeup (2.0%), as well as the gap between mentions of subsistence (34%) and specific description of traditional knowledge (5.0%). The table below describes all codes from this first open-ended question and their prevalence.

Interest, Willingness, and Confidence to Use and Share Ice Data

Participant agreement was high with three statements that asked if knowing about ice conditions is important to them personally, professionally, or to their community. The highest agreement (4.5 average, on a scale of 1 = strongly disagree to 5 = strongly agree) was with the statement “Knowing about ice conditions is important to my community.” Scores for knowledge of where to find information about current ice conditions (3.6), ability to find enough needed information (3.5), and knowledge about how to share information about current ice conditions (3.5) were about a full point lower. Table 3 describes the data for this survey item.

Scores related to level of excitement, interest, and willingness to use information about current ice conditions were generally high, between 4.2 and 4.4 for these related scale items. Respondents also indicated feeling that they generally have the time available to use information about current river ice conditions, averaging a 4.1 (agree) response to the item “I have the time to use information about current river ice conditions.” However, respondents were not in agreement that they are able to locate the necessary information in an amount of time they are satisfied with. The response average for the item “It takes too much time to find information about current ice conditions” was 3.0, neither agree nor disagree. When compared to other survey and interview data, it may be the case that the 41% of respon-

Table 3. Please describe the different ways you interact with river ice. (For example: I mush on frozen rivers, I teach about ice, I study ice for my research, I share about cultural knowledge related to ice, etc.)

Themes	Count (n=100)	Percent
travel	40	40.0%
recreation	38	38.0%
subsistence	34	34.0%
research	30	30.0%
education	18	18.0%
monitoring/community monitoring	16	16.0%
concerns	8	8.0%
hydrology/watershed	7	7.0%
public water/drinking water	6	6.0%
thinning ice/ice thickness	6	6.0%
breakup	6	6.0%
traditional knowledge	5	5.0%
safety/public safety	5	5.0%
forecasting	4	4.0%
flooding	4	4.0%
integral to life	3	3.0%
under ice research	2	2.0%
oil spills	2	2.0%
observations	2	2.0%
freezeup	2	2.0%
engineering/infrastructure	2	2.0%
habitat protection	2	2.0%
no/little interaction	1	1.0%
climate trends	1	1.0%
flood impacts	1	1.0%
aesthetic value	1	1.0%
satellite data	1	1.0%
snow chemistry	1	1.0%
lake ice	1	1.0%

Note: Participants were asked to describe in their own words the different ways they interacted with river ice, and were provided with these examples: “I mush on frozen rivers, I teach about ice, I study ice for my research, I share about cultural knowledge related to ice, etc.” Relationship with river ice responses varied widely. For this open-ended response, data was coded to surface as many different permutations of responses as possible. Later in the survey, additional open-ended questions about respondents’ relationship to ice garnered feedback that was often similar, with respondents often echoing aspects of their initial response to this first survey question. Those subsequent open-ended responses are coded with the goal of describing the main themes that emerge. Therefore, coding for this first survey question reflects nearly 30 different codes, while coding for subsequent open-ended questions utilizes fewer codes.

Table 4. Thinking about river ice, please indicate how much you agree or disagree with the following statements.

	n	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Weighted Average
Knowing about ice conditions is important to me personally.	94	1.1%	1.1%	9.6%	40.4%	47.9%	4.3
Knowing about ice conditions is important to me professionally.	94	1.1%	7.4%	10.6%	27.7%	53.2%	4.2
Knowing about ice conditions is important to my community.	94	0.0%	0.0%	10.6%	30.9%	58.5%	4.5
When I have to, I can find out enough about current ice conditions to meet my needs.	94	2.1%	19.1%	22.3%	37.2%	19.1%	3.5
I know where to find the information I need to learn about current ice conditions.	94	4.3%	17.0%	21.3%	34.0%	23.4%	3.6
If I know something important about current ice conditions, I know how to share that information.	94	5.3%	18.1%	18.1%	36.2%	22.3%	3.5

Table 5. Please indicate how much you agree or disagree with the following statements about using information.

	n	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Weighted Average
I am interested in using information about current river ice conditions.	92	1.1%	3.3%	10.9%	37.0%	47.8%	4.3
I am willing to use information about current river ice conditions.	92	0.0%	4.3%	4.3%	40.2%	51.1%	4.4
I have the time to use information about current river ice conditions.	92	0.0%	3.3%	16.3%	48.9%	31.5%	4.1
It takes too much time to find information about current ice conditions.	92	5.4%	27.2%	41.3%	18.5%	7.6%	3.0
I am excited about using current information about ice conditions.	92	0.0%	2.2%	16.3%	40.2%	41.3%	4.2

dents who indicated neither disagreeing or disagreeing with this item are not sure because they are not sure where they would go to locate information beyond their current personal observation and contacts-related methods. Table 5 describes the data for this item.

Scores for respondents level of excitement, interest, and willingness to share information about current ice conditions items were generally positive, with respondents giving an average score of 4.4 to "I am willing to share information about current river ice conditions," and a score of 4.3 to "I am interested in sharing information about current river ice conditions. Scores dipped slightly when asked "I have the time to share information about current river ice conditions" (3.8), but this may be related to a sense of not knowing where to go to efficiently and effectively share current ice condition information. Table 6 describes the data for this item.

In interviews, responses varied from expressing a sense of knowing exactly where to look to feeling like they do not know at all where to go for ice data – though, interestingly, despite lower confidence of some in this response, these same respondents also often went on to articulate resourceful use of personal connections and their own observations, such as in this example:

> *I actually do not have the faintest idea of where to look for ice conditions information. The reason I did not put a one is because I'm fairly resourceful. If you wanted me to find out about ice conditions, I would know whom to ask and I would start poking and prodding, just asking by word of mouth, but basically, no, I don't know. (Participant 3)*

Interviewees also expanded on their responses about sharing data. Responses regarding sharing data were similar to those that touched on where to find data –

Table 6. Please indicate how much you agree or disagree with the following statements about sharing information.

	n	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree	Weighted Average
I am interested in sharing information about current river ice conditions.	92	0.0%	2.2%	12.0%	38.0%	47.8%	4.3
I am willing to share information about current river ice conditions.	92	0.0%	1.1%	8.7%	42.4%	47.8%	4.4
I have the time to share information about current river ice conditions.	91	0.0%	4.4%	31.9%	40.7%	23.1%	3.8
It takes too much time to share information about current river ice conditions.	92	4.3%	42.4%	35.9%	13.0%	4.3%	2.7
I am excited about sharing information about current river ice conditions.	92	1.1%	2.2%	21.7%	38.0%	37.0%	4.1

interviewees were willing to share, especially if the information might keep others safe or help others make choices, but some, especially if they already collect data for work, noted they may not always think to do so when they are recreating, and if they did want to do so, were not sure where a central database for that information might be currently located. Instead, they'd be more inclined to share ice condition information with personal and professional contacts. The following quote is representative:

> *I was actually talking to my [professional contact], who does a little bit of river ice stuff. And we were talking about how, even as professionals, if we're out recreating, it may not necessarily... Like if I see something funky going on with ice on a river or a lake or something and I'm out recreating, I may not necessarily, even, it may not occur to me to take a note or like take a GPS point or something and like share that later because I'm having fun and my work hat is off. …So maybe I wouldn't necessarily occur to me to try to share all that information all the time, but if I wanted to, I would have no idea where to do that, really other than personally calling up my professional contacts. (Participant 7)*

Some participants implied that some observational data is more worthy of the effort than other data, such as when there is a particularly dramatic breakup, or potentially dangerous open leads – although the first interviewee excerpted below went on to clarify that focusing on one tool one year and a different tool the next had as much to do with habit and which scientists and tools she was interacting with through work as it did any judgment about the value of the data per se:

> *[Reflecting on sharing photos with River*

Watch in previous years but not this year]: And our breakup this year wasn't as dramatic as last year, last year was kind of dramatic…. I mean, I think people were okay. There was some significant bank erosion. I saw a fish wheel that got smashed 'cause they hadn't pulled it up... And the ice was so deep, I mean the ice must have been six feet deep. So there were these huge chunks of ice that violently went through this side channel, because there was an ice jam in the main channel. And so there's scarring up on the trees pretty high. … My neighbor's yard was flooded and full of icebergs. (Participant 5)

I don't know formal channels, but if I saw something really scary, like there's a big hole in the [pond name], I would put that on our [neighborhood] Facebook page. Tell my neighbors not to go get hypothermia. (Participant 3)

Terminology

While designing the survey, the decision was made to not ask explicitly about terminology used for ice conditions, but instead see what terms emerged through open-ended responses. Specific terms that were used by at least one respondent to describe the conditions of ice beyond general terms such as "ice," "ice thickness," "dynamics of ice," "ice conditions," "breakup," "freezeup," "ice jam," etc. were the following:

- Needle ice
- Pressure ridges
- Raised center ice
- Rotting ice [discrete from breakup]
- Jagged ice
- Smooth ice
- Ice-up
- Ice-out
- Ice formation [discrete from freezeup]

Across both surveys and interviews, individuals used the above specialized terms in the contexts of what they need to know about ice, and what their relationship with ice is. No interview or survey participants referred to terminology in other languages; however, they were not asked explicitly about what terms they use for ice, nor were they asked about the utility of layering such terminology into resources about ice conditions.

Characterizing Uses of River Ice Data

Survey and interview respondents were asked

Table 7. In your own life or work, what information, if any, do you need to know about river ice? (Open-ended) (n=89)

Themes	Count (n=89)	Percent
ice thickness	48	53.9%
safe for travel/trail conditions	43	48.3%
Is it breaking up/rotting?	22	24.7%
Presence/location of overflow	15	16.9%
presence/location of open water	13	14.6%
Is it freezeup?/When will freezeup happen?	12	13.5%
Location or forecast of ice jams	7	7.9%
Flood mapping or predictions	4	4.5%

a series of questions about what information they need to know about river ice, and how that information is helpful.

What Information is Needed About River Ice?

For both professional and personal use, the clear top river ice knowledge needs were thickness of the ice (53.9% of responses) and whether it is safe to travel (48.3% of responses). Survey respondents were slightly more likely to articulate specific needs around the timing of breakup or the existence of rotting ice (24.7% of responses) than the timing of freezeup (13.5% of responses). The table below illustrates the percentages of the top eight emergent themes from open-ended responses.

Interviews provided additional context around what information is needed about river ice. Some interviewees noted that they would value ice thickness data, or even forecasting of ice thickness, if they knew where they could reliably view current, in-the-moment information about ice thickness so they can make decisions about their own actions. The following quotes are representative:

> *I can go chop a hole in the ice and that's generally how we do it, but I haven't been able to get... We are constantly watching the weather and we can see the water level and we can just pull that up online. But I haven't been able to find much for ice measurement. Maybe it's out there and we just don't know about it. (Participant 4)*

> *I think it was kind of hard to answer that question because it's like, I do know the websites. NOAA has some websites. The River Forecast Center has information. And the Municipality of Anchorage has a nice website that I can't think of the name of it offhand, but Google it. And for lakes in the Municipality of Anchorage do have people who go out occasionally and drill a hole to see how thick the ice is. And those are for places where people like to ice skate, or sometimes cross country ski…they drill a hole there every once in a while, measure the thickness, and post it on that Municipality of Anchorage website. Possibly the reason I was kind of neutral about it is it's like, yeah, I know that those websites exist, but their data sets are so limited because they only have so much time and resources to get. So it's like I know where the data are, but there's not enough. (Participant 7)*

How Does River Ice Information Help You or Your Work?

Respondents most commonly indicated that river ice information was needed for either safety (46.6%) or travel (25.0%). These two reasons sometimes co-occurred in responses;

the total number of responses that indicated needing river ice information for either safety or travel was 52 – or 59.1% of responses. Other prevalent themes were subsistence and accessing resources (12.5%), gaining specific types of data knowledge for use in specific data application contexts (including assisting institutions such as tribes) (11.4%), and long-term monitoring and understanding (10.2%). Other themes that were less common and usually co-occurred with one or more of the above themes included classroom use, break-up prediction and mitigation, and validation of satellite data. Less common but worth featuring here were three responses that underscored the importance of river ice information to cultural knowledge or practices:

- *Cultural knowledge for classroom lessons. River conditions for travel.*
- *Eagle is located on the river and its conditions are EVERYTHING to our community! We use it for travel, for food resources--fish, caribou herd crossing, moose hunting, etc.--for accessing the international border, and for local cultural events, like deaths (spreading ashes or burials beside it).*
- *It helps me to be safe with my students and to plan fundraisers that would bring folks in from other villages*

Table 8 describes all emergent themes for this survey question.

Interview responses elaborated on many of these uses of river ice data. Several referenced the need for additional ground observations or photographs to help validate or supplement satellite data, especially during specific period of the year:

> *And then I actually made contact with a person through there, an [inaudible] who had taken a picture of the river and it was during the winter when it's hard to get satellite imagery because basically we don't get images from November to April, or at least November to March. (Participant 2)*

Table 8. How does River Ice information help you or your work?

Themes	Count (n=88)	Percent
Safety OR Travel	**52**	**59.1%**
safety	41	46.6%
travel	22	25.0%
subsistence/accessing resources	11	12.5%
cites specific knowledge gained (includes gaining knowledge to pass to tribe)	10	11.4%
long-term monitoring/understanding	9	10.2%
decision-making	8	9.1%
no use	7	8.0%
classroom lessons/student use	5	5.7%
breakup prediction/mitigation	5	5.7%
allows short-term measurement/data to happen	5	5.7%
infrastructure design/preservation	4	4.5%
validation of/with satellite data	3	3.4%
cultural knowledge/practices	3	3.4%
oil spill mitigation	3	3.4%
collaboration	2	2.3%
general interest	2	2.3%

Many described how ice thickness data would help them in their life and work. One interviewee remarked that, in their role as a state employee, they need to make informed choices about infrastructure building and repair such as erosion protection projects along riverbanks. Recent ice thickness and ice and water velocity data from recent breakups would be extremely useful in making better-informed decisions about materials selection and design planning for such infrastructure work. They were able to make decisions using a scientist's work on the probability of a significant breakup event in the next 20 years, but specific ice thickness and velocity data would help fine-tune the cost-benefit analysis of construction going forward:

> *I didn't find a lot of very useful ice thickness information when I was trying to decide. Not only ice thickness, but water and ice velocity during these breakup events. What size of rip rap is appropriate? What [happened] in the past, is that a good thing to design for the future? Because we're expecting this rip rap to last for at least 20 years. We seem to have a project at these various communities every 20 years, so that tends to be our design event, but it would be nice to have it last longer. Anyway, I couldn't find a lot of good information. We ended up hiring [name], who as I understand it is a climate scientist works with, or maybe he's actually on the staff or faculty at UAF. He wrote me a report and said the probability of a significant breakup event at [village] in the 20 year life of this structure we're designing was 50%. (Participant 6)*

Respondents selected numerous ways in which either they or people in their community might use data about ice conditions. All of the usage purposes that this item had been populated with received a check from at least

50% of respondents to this question. Travel safety received the largest percentage, with 82.6% of respondents indicating either they or their community would use ice condition data to travel safely. The second most chosen use was breakup forecasting, which was indicated by 78.3% of respondents.

Responses that were written in for the "other" were the following:

- *Flyfishing*
- *Ecosystem health*
- *Validating satellite observations with trusted insitu observations that can help improve situational awareness and decision making.*
- *Recreational use*
- *Recreation: ice fishing, skating rinks*
- *Design erosion protection.*
- *Public water system monitoring and operation.*
- *Forecasting freeze-up timing and patterns*
- *Subsistence fishing*
- *Recreation safety*
- *Recreation*

Short-term vs. Long-Term Information Needs

This section discusses responses about what information about river ice respondents needed on shorter-term time scales, such as day to day or week to week, as well as what information they needed about river ice on longer-term time scales, such as year to year or decade to decade.

Information Needs Day to Day or Week to Week

Respondents were most likely to indicate needing to know information about whether or not the ice was thick enough or of good enough quality to travel on safely, whether for work, subsistence, or travel (21.6%) in the short-term. A few of these responses stated or implied that the data they use to learn informa-

Table 9. Please check all items that describe ways that either YOU or people in your COMMUNITY might use data about ice conditions: (Check all that apply.)

Answer Choices	Count (n=92)	Percent
Travel safety	76	82.6%
Breakup forecasting	72	78.3%
Search and rescue efforts	61	66.3%
Analyzing long-term trends	59	64.1%
Adapting to new or changing conditions	55	59.8%
Operational work (for example, ice road management)	47	51.1%
Documenting societal or environmental issues	46	50.0%
Other (please specify)	11	12.0%

tion about ice safety is the presence of a trail – i.e., are others in the community deeming the ice safe enough. Additionally, 17.6% of respondents highlighted the need to know where open water is, and 14.9% highlighted the need to know information about ice conditions daily or very frequently. A total of 13.5% cited needing information during breakup in particular. Finally, 10.8% of respondents cited needing to know about the location of overflow.

Notably, three respondents noted they need to know where to go to find information about ice thickness or breakup (4.1%). Three respondents noted the need for photos (4.1%).

Table 10 describes all themes that emerged for this question.

Information Needs Year to Year or Decade to Decade

The most common theme among responses about longer-term information needs was for information about changes to freezeup and breakup timing. Both freezeup and breakup were mentioned by more than 21.4% of respondents. The total number of respondents who mentioned either freezeup or breakup was 18, or 25.7% of respondents. References to breakup and freezeup co-occurred with concerns about habitat health, travel safety (part of the "how can we adapt" code), and subsistence timing. Interest was in both historical data and tracking of data going forward. Gaining a better understanding of when ice can be expected was foremost on respondents' minds when thinking about long-term data needs. Representative responses follow below:

- *How thin it has gotten, or when it starts to freeze over during the times we need to subsist*
- *This [data about river ice] would be important info in context of breakup and freeze up dates and fish movements in and out of lagoons in NW Alaska. Sentinel-2 imagery for this is only available since 2016, so there isn't a lengthy dataset for this yet.*
- *I'm curious how ice-up and ice-out dates have trended in recent decades. Also incidences of extreme events that cause midwinter melting.*
- *When on average there is ice so we can adjust our lifestyle accordingly.*
- *I would be curious to know how ice crossing times have changed over decades*
- *Ice thickness and snow depth. Timing of ice formation, freeze up, break up. How ice thickness and travel duration changes between seasons.*
- *Ice thickness, freeze-up patterns, freeze-up and breakup dates. This is mostly to investigate the direct and indirect impacts*

Table 10. What information do you need (or what questions do you have) about how ice changes from day to day or week to week?

Themes	Count (n=74)	Percent
ice thickness	16	21.6%
open water	13	17.6%
frequent/daily info	11	14.9%
do not need	10	13.5%
info during breakup	10	13.5%
overflow	8	10.8%
ice in relation to temperature/weather	6	8.1%
info during freezeup	6	8.1%
where is flooding possible or occurring?	4	5.4%
how have trends changed over the years?	4	5.4%
snow cover	3	4.1%
where to find ice thickness and breakup information	3	4.1%
where there are ice jams?	3	4.1%
photos (incl. geotagged, photos to supplement satellite data)	3	4.1%
overall trends in dates for safe travel	2	2.7%
pressure ridges/raised center ice/"ice wedges"	2	2.7%
how can we prepare/adapt? (incl. infrastructure)	2	2.7%
water flow	2	2.7%
river water temp	1	1.4%
affect of warming climate	1	1.4%
why do certain ice phenomenon happen?	1	1.4%
instruction on when/how to start collecting local community data	1	1.4%
information about flow (incl. evidence of increasing flow/raised center ice)	1	1.4%
water depth	1	1.4%
quality of surface of ice	1	1.4%
timing (vague)	1	1.4%
Not sure	1	1.4%

of climate change on cold region rivers

- *How are sequences of ice formation and decay change over time and from river to river. How this changes how people and other organisms use rivers.*

After timing of breakup and freezeup, the most common theme to emerge from coding was a specific desire not just for data about the presence of ice, but data specifically about trends in the thickness and overall quality of that ice (17.1%). This theme was coded separately from a desire to know ice thickness in general (i.e., no specific mention of past or future trends). Taken together, the number of unique respondents interested in any ice thickness data totaled 17, or 24.2%.

Interestingly, several responses indicated they don't really need information about long-term trends. Such responses, where reasons were given, most commonly cited that their needs were more immediate, relating to current ice conditions and safety decisions. One respondent noted they made decisions for recreational purposes: "I don't think knowledge of change in general is as critical to my recreation. Seasonal variability is probably more important."

All response codes and corresponding counts and percentages are featured in Table 11.

For one interviewee, long-term forecasting was noted to be connected to funding decisions. Data helps decision-makers understand what infrastructure needs should be anticipated; this lets agencies begin funding and taking action on those needs preventatively now rather than reactively later:

> *We have [state funds] that go out to communities to build new water treatment plants, and waste water treatment plants and some water infrastructure. And so, I think having longer term, maybe forecast or models to show that a community is increasingly becoming more susceptible*

Table 11. What information do you need (or what questions do you have) about how ice changes from year to year or decade to decade?

Theme	Count (n=70)	Percent
ANY mention of breakup or freezeup trends	**18**	**25.7%**
ANY mention of ice thickness data	**17**	**24.2%**
impacts of climate change on freezeup	15	21.4%
impacts of climate change on breakup	15	21.4%
desire for ice thickness/quality trend data (past or present)	12	17.1%
no info needed	9	12.9%
sense of cultural loss/importance of ice to way of life (incl. access for subsistence, interest in historical practices)	8	11.4%
how can we adapt (incl. safety concerns)	7	10.0%
ice thickness/quality/condition	6	8.6%
future impacts of weather/change on ice (not specifically breakup or freezeup)	6	8.6%
currently tracking trends on own/locally	4	5.7%
is ice changing?	4	5.7%
how is ecosystem changing?	4	5.7%
flooding	4	5.7%
“see previous response”	3	4.3%
ice is always changing; no different from short-term info needs	3	4.3%
global warming	2	2.9%
snow depth/cover	2	2.9%
not sure	2	2.9%
occurrence/severity of ice jams	2	2.9%
data sharing	1	1.4%
desire for knowledge of where to get ice data and/or how much is available	1	1.4%
does ice “encapsulate debris”	1	1.4%
sentinel-2 imagery only goes back to 2016	1	1.4%
temperature of water or ice	1	1.4%
effects of changes in local practices (ex: new power plan owner/operator) on quality of ice	1	1.4%
remote sensing data for recent past	1	1.4%

to more routine or regular flooding, I think that could be important piece of information when we look at how to divvy up some of that money to different communities. It could help us prioritize. So recently, we worked with [another state agency]…They did a coastal erosion forecast project for several communities throughout the state. So, we looked at that information to look at, in the next 10, 20, 30, 40, 50 years, where is this coastal erosion expected to spread and what infrastructure might it take out? (Participant 1)

For interviewees, long term climate change trends need to be understood in order to update long-standing rules of thumb about safety measures when interacting with ice. As one interviewee noted, neighbors used to be able to live by certain rules validated over time by local observations of long-term trends, but now things are changing and data can help those who use ice adapt safely:

I think climate change is making it really extra freaky. A lot of the old timers that I've talked to had these rules of thumb about when things were safe and when they weren't. And my instinct just did not trust that anymore because so much is changing. But it would be good to see some data. Kind of interest in long term trends. (Participant 4)

Scientists Need Local Observers

As noted in several places throughout this report, the need for local, current information about ice conditions is considered, across all user groups, to be a top need when it comes to river ice condition information. However, several interviewees elaborated on the challenges that can arise from trying to use a larger volume of local observations in a way that seeks to analyze these data together; that is, it can be hard to draw conclusions from data that may not be gathered consistently or use comparable frames of reference:

I had used [the LEO Network] to look up things before and I see, sometimes the [observation] data is not very useful, but sometimes the observations are. It's not very scientific that way, but it is good to have people reporting observations. So I think that crowdsourcing capability is going to be – it's going to be useful. I think the difficult part is taking data from a diverse population of people and trying to integrate that into all of our agency databases, and schema, and stuff like that. That's what the tricky part is. (Participant 1)

But, while the need for data consistency, exportable and analyzable formats, and clear shared definitions was underscored in both survey and interview responses (see "Ideas for Improving Current Tools," below), it was also the case that survey respondents and interviewees – particularly those coming from state or federal agencies or other Western scientific positionalities – underscored the indispensable nature of local observations of ice conditions, especially during freezeup and breakup. One interviewee described exactly why such observations are needed for understanding flow during breakup – and noted that these observations are about one spot over time (with wider coverage during breakup), and are logged through a specific form used by observers:

We do streamflow gaging. And one of the difficult aspects of that is, what was the flow during breakup? Like I said, we measure stage and then use the relationship between stage and discharge to get the discharge, because discharge is what you want for in-stream gaging. When there's ice, that relationship is ever changing, because the ice changes the channel, blocks water, backs up water. Yeah, it does all sorts of things. That relationship that you've developed is no longer applicable. So, very often there is a weather service… river observer … usually daily… takes stage during the winter and during breakup is putting in notes about conditions. And we use those quite a bit to estimate flow during breakup, when there's ice on the river….. in some of the remote villages, they'll have one person that goes down. It's difficult to keep a full, real time gauge going, but this is a daily take on conditions and the water surface elevations….Standard comments are like, "The ice is lifting." As the flow starts increasing under the ice, the ice will start lifting up. They'll give descriptions of if the ice is rotting in place or if it's starting to move, or percent of ice cover, things like that…. [in] one specific spot. We're often close by, so it's a little extrapolation site. And some of the bigger rivers... Actually, during breakup the weather service itself sometimes flies the rivers, but they also have a network of the commercial scheduled airline pilots that will... So during breakup, you'll have a wider look at conditions, both from weather service personnel themselves, and they have a network that they've built up. And even I, they have a form that if I'm out there at one of my gauges, I can go in and fill out a form and say, "Ooh, I've got a big ice jam here," and they'll put that into the notes. (Participant 9)

This interviewee went on to describe how those direct observations are exactly what is needed for him to know current information about ice conditions, perhaps better than daily photos:

Yes. Yes. [Observer notes are] the only place I can get information like that. Although we are starting to put out cameras and take a picture once a day. It will give me a little bit more, but we just lost a person at [village name], a gauge near there. But he had been there for, I want to say decades. So he knew the river well. I [would talk to him] when I came through town to ask him about things that happen on the river. Yeah, It's a great source of information. Yeah. (Participant 9)

Another interviewee described that, while data that can be analyzed numerically holds power, not all phenomena are most accurately de-

scribed using numbers. In fact, the "real" data may be missed entirely if an approach that is not "forcing things into boxes" is not somehow also factored into data about river ice conditions:

> *I think it's also hard to draw the line between numbers versus verbal reports. It's often hard to assign numbers to things when you're describing ice conditions, but only when you have numbers can you process the data in aggregate? It's really hard to deal with large numbers of words….I mean, as an engineer, I love numbers. If I say rank everything from 1 to 10, it's so great. I can make graphs. I can make them pretty. I can do average, moving average, but the thing is, is it real? I mean, if you start forcing things into boxes, that's not data. That's just something that appeals to my nerdy little heart, but that doesn't mean it's useful. (Participant 3)*

Some responses from non-career scientists reflected an understanding of the importance of making the data accessible and comparable to data from other locations across the state. An interviewee who has facilitated multiple citizen science projects with students and had extensive interaction with scientists around the value of community-collected data cited a desire for sharing out his site's data in a way that is accessible to not just scientists or other industry partners such as the Federal Aviation Administration (FAA), but to other communities who may want to use local data from other regions in the state to compare

> *Yeah, again, that sharing information, I think, was specifically in regard to how we work with the FAA and want to share that out with them. I'm trying to recall where my mind was answering that. I'm pretty sure that's what I meant. I was thinking through like, "Hey, we have a lot of people that are really interested in what these conditions are," so sharing it out in a not appropriate way, but sharing it out in an accessible way, is the word I'm looking for, is really important for us. (Participant 8)*

Feedback on Methods of Using or Sharing Data about Ice

This section highlights respondent feedback on specific tools for learning or sharing about river ice information, as well as what respon-

Table 12. If you have ever used this to use or share river ice observations: How frequently do you use this?

	n	Never	Seldom	Sometimes	Frequently	Weighted Average
Talking in person, face to face	77	6.5%	16.9%	41.6%	35.1%	3.1
Facebook	76	19.7%	14.5%	34.2%	31.6%	2.8
Phone (calling or texting)	70	27.1%	20.0%	28.6%	24.3%	2.5
National Weather Service River Forecast Center website	72	26.4%	18.1%	30.6%	25.0%	2.5
Fresh Eyes on Ice Photo Observer website	70	45.7%	11.4%	30.0%	12.9%	2.1
Social media other than Facebook	71	49.3%	16.9%	19.7%	14.1%	2.0
TV broadcast	66	57.6%	16.7%	18.2%	7.6%	1.8
National Weather Service River Watch conference calls	70	58.6%	18.6%	10.0%	12.9%	1.8
GLOBE website or app	64	56.3%	17.2%	21.9%	4.7%	1.8
VHF radio	66	63.6%	13.6%	15.2%	7.6%	1.7
LEO network website	66	71.2%	18.2%	7.6%	3.0%	1.4
Voice of Denali radio broadcast	63	87.3%	0.0%	7.9%	4.8%	1.3
SIKU website or app	1	100.0%	0.0%	0.0%	0.0%	1.0
("Other" item, if listed below)	26	34.6%	19.2%	15.4%	30.8%	2.4

dents valued most about the tools they found most useful. While interview participants were asked about individual tools as well as what they most valued in the tools they used, interview feedback on tools focused on what they valued and what suggestions they have for improvement; as such, interview responses are shared only in the sections "Most Valuable Aspects of Tools Used" and "Ideas for Improving Current Tools" further below, and not the section "Perceived Usefulness of Specific Tools" immediately below.

Perceived Usefulness of Specific Tools for Using or Sharing Current Ice Observation Data

Across all ice data observation tools that were included in this item, the tools that respondents reported using most often were talking in person (3.1), Facebook (2.8), calling or texting on their phone (2.5), the National Weather Service River Forecast Center website (2.5), "Other" (2.4), Fresh Eyes on Ice Photo Observer website (2.1), and social media other than Facebook (2.0). Table 12 illustrates these data.

While 26 respondents indicated they used something they classified as "Other," not all of these responses were further described by respondents using the open-ended response field provided. Of the 14 open-ended responses that were provided, seven – 50% – cite either leveraging relationships with specific individuals or entities making local observations, or using already-existing community-based monitoring tools that are driven by individual observations:

- *Local observation from people traveling on the river*
- *Working with our Tribal Transportation Planner.*
- *Emails to local emergency response community and info on Yukon.ca*
- *Email to person living along river of interest*
- *UAF Instructors*
- *Nations' internal community based monitoring reporting sites. [Canada]*
- *NB [New Brunswick] created an app for river observers to upload observations based on km markers including photos.*

Six responses highlighted resources that were less clearly grounded in community observations, but may still feature community observations (two of these responses were elaborations on what social media they find useful):

- News *paper*
- *KSKO Radio Station*
- *GeoCollaborate*
- *yukonriverbreakup.com*
- *Instagram*
- *Instagram and Snapchat*

Finally, two respondents noted using Sentinel satellite resources:

- S*entinel-2 satellite imagery*
- *Sentinel Hub*

For tools that participants indicated ever using, participants were asked to indicate how well these tools work. The most useful tools were talking in person to someone (2.3) and "Other" (2.3). As described above, "other" write-ins included many resources that were linked to direct communication with individuals. The next-most useful tools for those respondents who had ever used them were the National Weather Service River Forecast Center website (2.2), calling or texting (2.1), and VHF radio (2.1). Other tools that were ranked as 'helpful" (2) or close to it were Facebook (2.0), other social media (2.0), the National Weather Service River Watch conference calls (2.0),

Table 13. How well does it work?

	n	Not Reliable	Helpful	Exactly What I Need	Weighted Average
Talking in person, face to face	63	0.0%	71.4%	28.6%	2.3
National Weather Service River Forecast Center website	45	2.2%	73.3%	24.4%	2.2
Phone (calling or texting)	42	11.9%	64.3%	23.8%	2.1
VHF radio	23	13.0%	65.2%	21.7%	2.1
Facebook	53	11.3%	77.4%	11.3%	2.0
Social media other than Facebook	34	20.6%	61.8%	17.6%	2.0
National Weather Service River Watch conference calls	28	7.1%	82.1%	10.7%	2.0
Fresh Eyes on Ice Photo Observer website	36	11.1%	75.0%	13.9%	2.0
LEO network website	22	22.7%	54.5%	22.7%	2.0
SIKU website or app	1	0.0%	100.0%	0.0%	2.0
TV broadcast	24	16.7%	75.0%	8.3%	1.9
GLOBE website or app	25	24.0%	60.0%	16.0%	1.9
Voice of Denali radio broadcast	12	41.7%	41.7%	16.7%	1.8
("Other" item, if listed below)	18	16.7%	38.9%	44.4%	2.3

the Fresh Eyes on Ice Photo Observer website (2.0), the LEO Network website (2.0), and the SIKU app (2.0 – however, in the previous question about frequency of tool use, this respondent also indicated they had never used the SIKU app). The lowest scoring tool was the Voice of Denali radio broadcast (1.8). Table 13 illustrates all data.

Finally, participants were asked to indicate what time of year they found the tools they had ever used to be the most useful. No tools stood out as most useful only during freezeup, or only during the middle of winter. Most tools were cited as useful any time, particularly the Voice of Denali radio broadcast (88.9% of this tool's 9 respondents noted it was useful any time), the Fresh Eyes on Ice Photo Observer website (79.3% of 29 respondents), the GLOBE website or app (77.8% of 18 respondents), and the LEO Network website (76.5% of 17 respondents). Tools that stood out as most useful during both freezeup and breakup were the National Weather Service conference calls (37.5% of 24 respondents) as well as "other" items related to community-level observations. The highest score for breakup was the National Weather Service website (37.2% of 43 respondents). Table 14 illustrates all data for this survey question.

Feedback on GLOBE Land Cover Observation Tool

Most respondents had not ever seen the GLOBE Land Cover Observation tool before (73.0%). A little more than a quarter of respondents (27.0%) had seen the Land Cover Observation tool before.

While only about half of all respondents noted they were likely or very likely to use the Land Cover app in the future, when responses were

Q14. What time of year is it most useful?

	n	Freezeup	Breakup	Freezeup and Breakup	Middle of Winter	Any Time
Talking in person, face to face	59	5.1%	8.5%	18.6%	0.0%	67.8%
Phone (calling or texting)	41	2.4%	14.6%	17.1%	0.0%	65.9%
Facebook	49	0.0%	12.2%	14.3%	4.1%	69.4%
Social media other than Facebook	34	2.9%	5.9%	8.8%	8.8%	73.5%
TV broadcast	20	10.0%	5.0%	10.0%	10.0%	65.0%
VHF radio	22	0.0%	13.6%	18.2%	0.0%	68.2%
National Weather Service River Watch conference calls	24	0.0%	29.2%	37.5%	0.0%	33.3%
Voice of Denali radio broadcast	9	0.0%	0.0%	0.0%	11.1%	88.9%
Fresh Eyes on Ice Photo Observer website	29	3.4%	3.4%	10.3%	3.4%	79.3%
National Weather Service River Forecast Center website	43	2.3%	37.2%	14.0%	2.3%	44.2%
LEO network website	17	5.9%	5.9%	11.8%	0.0%	76.5%
GLOBE website or app	18	5.6%	5.6%	11.1%	0.0%	77.8%
SIKU website or app	0	0.0%	0.0%	0.0%	0.0%	0.0%
("Other" item, if listed below)	15	6.7%	20.0%	33.3%	0.0%	40.0%

filtered by whether respondents had ever used the Land Cover app, nearly 80% of respondents who had ever seen the Land Cover app noted they would be likely or very likely to use it in the future. Only about 5% of respondents – whether filtered by those who had ever seen the app or not – noted they would be unlikely or very unlikely to use the app. See all responses in Table 16.

The one respondent who had seen the app but indicated they were very unlikely to use the app did not provide a response to an open-ended question about why they are likely or unlikely to use this tool. Those who had seen the app but were unsure if they were likely to use it in the future cited user interface issues, a perception that the app needs an internet connection to work, and a sense that though they had bene exposed to it, they would need to use it more or learn more about it to judge whether it would be something they would use consistently.

Notably, even among those who had seen and used the Land Cover app before, there seemed to be some variation in understanding of what the exact offline capabilities of the app are. Some respondents praised the fact that the app could collect data while offline, and then upload data later at the user's convenience when near, for example, some connectivity at the local school. Other participants cited the supposed inability of the app to work offline as a barrier to their use of the app.

Notably, for all respondents as well as the subset of respondents who had ever seen

the Land Cover app before, the number one reason respondents gave for why they were or were not interested were positive. For all respondents, the most common responses expressed general interest in the app and the usefulness of the data it collects (31.5% of all responses). For those who had ever seen the Land Cover app, interest in the app and its data was also high (20% of responses, tied for second most common response), but the most common reason provided for why they would use the data in the future was that the app itself is easy to use (35%), especially because the mechanism for data collection is right on their smartphones. Furthermore, the other second-most cited reason for interest, tied with general interest in the app and its data, was the capacity for data to be collected entirely offline (30%). When combined, this means that of those who had ever seen the Land Cover app, 55% of respondents noted they would consider using this smartphone-based app in the future specifically because of its ease of use and ability to operate offline.

The following table illustrates all reasons respondents provided that affected whether or not they would use the Land Observer app. Responses that were positive are highlighted in green, negative responses are highlighted in red, and neutral responses are not highlighted. Responses are shown from all respondents, then also the subset of responses that were provided by respondents who had ever seen the Land Cover app before.

Most Valuable Aspects of Tools Used

Across surveys and interviews, respondents most valued tools that were locally grounded and reflect a first-hand understanding of river ice, that featured current data (preferably daily during breakup), that fulfilled a specific data need, that were easy to use, and that were reliable (though direct reference to the reliability of data was less common, and what kind of data was “reliable” to each respondent varied).

Locally-Grounded First-Hand Knowledge

A third of respondents (32.1%) noted that what gives value to the tools they use is the fact that they are locally grounded and provide a first-hand understanding of river ice that informs daily ice-related choices. Stand-out examples included the following:

- *Talking to the elders about the changes*

Table 15. Have you ever used the Land Cover observation tool in the GLOBE Observer app (see image above)?

Answer Choices	Count (n=90)	Percent
No	66	73.0%
Yes	24	27.0%

Note: Survey respondents were asked to indicate if they had ever used the GLOBE Land Cover observation tool in the GLOBE Observer app. Along with this question, respondents were shown an image that featured a screenshot of the GLOBE Observer app's welcome screen, as well as a screenshot image of the Land Cover tool.

Table 16. How likely are you to use this tool in the future?

	All Respondents (n=73)		All Respondents Who Had Used Land Cover App (n=24)	
Answer Choices	Count	%	Count	%
very unlikely	2	2.7%	1	4.2%
unlikely	2	2.7%	0	0.0%
not sure	38	52.1%	4	16.7%
likely	16	21.9%	11	45.8%
very likely	15	20.5%	8	33.3%

what they see and if they followed any signs to help them live day to day.

- *NWS and Facebook; communities use FB to communicate river conditions- that's the key- use what the locals are using*
- *I being an older male and giving current ice conditions during freeze up and break up is very important to others in warning them to stay off or not travel at all.*
- *Southcentral wild ice recreation Facebook group is the one I use primarily as they are in my typical area and are out frequently to report on ice conditions in areas I want to use*

Responses that were categorized under this theme underscored the importance of access to current, first-hand observations of conditions, but at least two respondents noted that such data is "usually not available" from others for the exact routes they are planning to travel, or is not available via "official" river conditions database:

- *Direct contact with people who have recently observed ice conditions on my intended route is the most useful but usually not available. Gives me the info I really need, generally related to safety of river crossings, e.g. Beaver Creek in the White Mountains National Rec Area.*
- *I do not know of any official river conditions for us to use. We have to observe ourselves and communicate with others using the Chitina and Copper to know what the conditions are.*

Another respondent stated that the word-of-mouth data they rely on to make safety decisions is "not very scientific or helpful," and they often verify this data with their own ice thickness observations: This perception of observa-

Table 17. Please share a few words about why you are likely or unlikely to use this tool.

	All Respondents (n=54)		All Respondents Who Had Used Land Cover App (n=20)	
Answer Choices	Count	%	Count	%
interesting/interested/sees relevance in general	17	**31.5%**	4	**20.0%**
not sure	15	**27.8%**	0	0.0%
app/user interface is easy; having on phone makes use more likely	9	**16.7%**	7	**35.0%**
personal limitation (no smartphone, don't interact with rivers, don't use tech while recreating, etc.)	4	7.4%	3	15.0%
connectivity limitation	4	7.4%	3	15.0%
works offline	4	7.4%	4	**20.0%**
user interface has issues/some features not intuitive	3	5.6%	2	10.0%
useful for work	3	5.6%	2	10.0%
citizen science/student engagement	2	3.7%	1	5.0%
already use other tool	2	3.7%	0	0.0%
institutional/sociocultural limitation (incl. Elders or workplaces not interested in onboarding this)	1	1.9%	0	0.0%
required	1	1.9%	1	5.0%
access to others' data	1	1.9%	1	5.0%

tions not being reliable due to their subjectivity is worth noting and may indicate that there would be high value for users if an app with data collection protocols – such as GLOBE observer protocols – were available.

- *I mostly use direct communication with friends and neighbors which isn't very scientific or helpful. We chop holes weekly for water and fishing so try to keep our own tabs on nearby conditions.*

In addition to survey responses underscoring the importance of personal communication as a source of information about ice conditions, interview responses also made evident the importance of personal communications in understanding river ice conditions. Of particular note, those interviewees who needed to know about river ice conditions for their work at state or federal agencies spoke about how information direct from local observers, whether written or in conversation, are a critical tool that they utilize for their jobs:

> *Well, they're people we've known ... well, mostly that's a work comment I would say, the people we know from being out at those stage sites all the time. A lot of our gauges are connected to villages either by location or by road, someone who lives nearby or we stay in the village … they're aware that we're in town. And so we talk to the people and they know what we're doing since they know that we're curious about river condi-*

tions. And so we'll just prod them during the transition season to be like, "Hey." Or pilots even, say, "Hey, if you fly over, could you get a picture of our water gauge during this two week period, things are transitioning so we know what's going on? (Participant 2)

I know some of the people at the River Forecast Center, or like I said, places where I've been working at… and talked with the actual river observer. So if there's a question, or about a description or if somebody hasn't been down there for a while, I can call up people I know and get a little deeper understanding of actually what's going on. (Participant 9)

Another interviewee working for a federal entity recalled needing such observations as part of her PhD work as well:

When I was working on my dissertation, my fieldwork was in the Brooks Range, and there's no ice information there other than talking to local people or going out and drilling the hole yourself. (Participant 7)

Conversely, while local observations are highly valued, sometimes an individual's or institution's access to local connections don't always extend to new areas where they may find they need to travel through or otherwise know the ice conditions of. This underscores the value that a centralized, standardized, frequently updated location to find ice observations would have for the majority of users of river ice information in Alaska. As one interviewee noted:

We know the area around us pretty well. But we don't necessarily know like 30 miles that way, I don't really know what's going on. So, it would be handy to be able to access any recent information about trail conditions. (Participant 4)

Data is Current

Nearly 25% of survey responses noted they most valued knowing that the data they are using is current. While this theme often co-occurred with the theme of locally-grounded first-hand data, it was attributed separately as timely data is not necessarily generated by local observations. The following responses are a representative sample:

- *At break up it can be crucial to have up to the minute information*
- *In person discussion. This was helpful*

because they were usually "real time" observations.

- *Our [New Brunswick, Canada] app lets us get realtime data on our river systems. An email is sent to a list of forecasters and emergency officials when an ice jam is submitted. We also have the ability to archive data and export data based on a query.*
- *National Weather Service River Forecast Center website is probably the most frequently used because they have a standardized format and update their info on a regular basis.*

This theme was prevalent in interviews as well. In one example, an interviewee working for a federal agency highlighted how useful the Weather Service's daily ice conditions observations, made by a locally-based trained observer, are – especially during breakup:

> *In some of the remote villages, [the Weather Service will] have one person that goes down. It's difficult to keep a full, real time gauge going, but this a daily take on conditions and the water surface elevations. (Participant 9)*

Not Sure/Unclear

A full 16% of survey responses were either unclear, or only re-listed which tools they use the most without elaborating on what makes them valuable. This may be due to survey fatigue, or the way the question was worded (the actual information sought – what respondents valued about these tools – is not stated until the end of the question). Notably, this theme was not present in interviews. This may be because those who indicated they were interested in an interview, and then responded when asked to schedule one, were a self-selective subset of respondents with opinions about what they valued most in ice data tools.

Fulfills Specific Data Need

About 11% of responses noted that they most valued the tools they used because they fulfilled a specific data need (discrete from timeliness of data). These data needs varied, and included satellite imagery (against which ground photography can be checked to validate the satellite data), photos taken from one location over time, ice thickness, breakup timing year over year, and breakup conditions in a format that is compatible with other tools to compare data sets. In one response, the

importance of an established relationship to the ability to access specific information was underscored. The following responses are representative:

- *Satellite images and photos taken from the same location on a regular basis are the most useful to me, much more than a description that would use any terminology*
- *I use the web map service of breakup conditions and overlay it on our GIS web map showing public water system locations. https://www.arcgis.com/home/item.html?id=86fc8e2eceee4662880b040c2ef96c93*
- *River ice thickness and breakup information over numerous years helps understand changes with time to design erosion protection.*
- *Email contact has been on river for many years & understands what info we need. FB photos/observation show full ice cover or not.*

Interviews reflected this theme as well – with the definition of "specific data needs" ranging from more detailed line data to use in overlay layers in GIS and specific flow rate data for rivers, to time-lapse video or photo of specific, locally-defined points of interest along a given river. For one interviewee who noted that she learned about the LEO Network through word of mouth, she decided to take a time lapse video of breakup at a point in the river that, through her own familiarity with her local river, she knew would be draining in an interesting way due to it being a main slough drainage point. This quote underscores both the appeal of a community observation resource such as the LEO Network, and the value of local knowledge about what locations in a given river are of interest:

> *That would be cool if somebody could do an app. But also, I've been doing some updates, not a whole lot, onto the LEO Network. And I just started getting into it. I've been hearing about it ever since I started this job. So I was like, "Oh, I got to get into that, see what's going on." …I started doing the river. I started on like May 1st when I knew the river was going to be going out shortly, and I did a video lapse of every day, and how different it looked every day. So I didn't upload it or I didn't post anything about it yet, but it's pretty cool.…around the same time in the same exact position… There's this little eddy that I wanted to be next to because I knew that the slough was going to be draining out of it. So every day, the slough has this like brown mucky looking water, then the river was just completely different. So in the video, you could tell the slough is draining out, and it just looked different when it mixed with the river. So it looks pretty cool. (Participant 10)*

Additionally, while the following praise for the Fresh Eyes on Ice website and project team is more for the support in using the tool and youth gaining self-advocacy skills than it is for the Fresh Eyes tools fulfilling a particular data need, it speaks to the power of what community members can accomplish when equipped with both the exact data they need locally and the skills to take powerful action with that data:

> *Just the incredible gratitude that the students and I have for the Fresh Eyes on Ice team in working as diligently as they have, especially under current global conditions, to support our kids in giving them the tools that they need to advocate for themselves. It's huge. It's absolutely huge. (Participant 8)*

One user who had had exposure to the GLOBE app, but was not part of the Fresh Eyes on Ice project, noted that her direct ice measurements are exactly what she needs, but GLOBE does not feature that data:

> *With the GLOBE [app] I've just wanted different measurements than what that program is going for. So, that's not really the critique of that…. [ice thickness], yeah. And I'm interested in water quality over time.*

And I think more transparency in Fairbanks, in general, about any water. Wouldn't it be cool if any water quality testing that was going to the lab, if you could like see that online? (Participant 4)

Easy to Use

Nearly 10% of survey respondents noted that they most valued how easy the tools were to use. Most responses of this type underscored that the tools were easy because that were already part of respondents' lives, such as social media, television, and school projects. One response noted that the Fresh Eyes on Ice website was easy due to its intuitive user interface and that data inputs "don't require lengthy responses":

- *Facebook post are easy and accessible*
- *social media because i use it already so seeing updates or posts on anything weather will catch my eye inevitably*
- *I listen when my family has the news on. I do GLOBE at school.*
- *The Fresh Eyes on Ice facebook page is in my facebook feed, so it is easy to look at. I don't have to make a special "trip". I also look at the Fresh Eyes on Ice camera that is near where I live periodically to see what is happening upstream from me. It should be noted that I'm a somewhat casual river ice user. If the ice is good, I can ski along the edge of the river. If it isn't I go somewhere else. I'm not really using the river ice to get anywhere in particular.*
- *Collectively we put our school's data in monthly into the FEI website, I add photos and observations monthly to the FEI FB page I appreciate that the data inputs are pretty intuitive and don't require lengthy responses*

This was a strong theme in interviews as well, though as mentioned elsewhere, different users found different tools "easy."

Reliability

While responses that described the value of local, current information might be considered to imply that part of the value is in the reliability of locally-generated, current observations, only 8.6% of responses articulated outright that the quality of reliability was what they valued in their most useful tool(s). Furthermore, different respondents varied in what kind of informa-

tion they found reliable. One respondent, for example, found Sentinel-2 imagery to be more reliable than word-of-mouth descriptions of ice conditions, while another respondent valued in-person, word-of-mouth communication the most because of the "up to the minute" information such communication provides:

- *The Sentinel-2 imagery is most useful as it helps me plan fieldwork around break-up and freeze-up and is more reliable than word-of-mouth reports (if imagery is available). I also use it heavily to find out when lakes and rivers break up so I can boat or fish on them.*
- *Local people and the weather service. I believe they are the most reliable because of local conditions varying due to the river location and surrounding conditions.*

These data corroborate other survey and interview remarks about subjectivity (discussed in the section "Consistency of Data," below); it may be the case that there is a need for sources of river ice information that are perceived as reliable.

Specific Tools that Held Value in Multiple Ways

Three respondents provided particularly robust descriptions of how the specific web-based tools or apps they prefer are helpful for collaboration, being able to find the needed data, and timeliness. These tools were GeoColaborate, the National Weather Service River Forecast Center website, Fresh Eyes on Ice resources, and an app specific to New Brunswick, Canada that provides real-time river ice data and notifications. These tools are examples of what could be most useful in an app- or web-based resource for people who need to know or share about Alaskan river ice conditions:

- *GeoColaborate accesses any source and unifies those data sources in a collaborative common operating picture. If a connection to the Globe server could be made this would further enhance a collaborative experience for NWS, NOAA and decision makers. Fresh Eyes on Ice is an excellent opportunity to access trusted observations as long as location, time, date, pictures are included with every report.*
- *Our [New Brunswick, Canada] app lets us get realtime data on our river systems. An email is sent to a list of forecasters and emergency officials when an ice jam is submitted. We also have the ability to archive data and export data based on a query.*
- *NWSRFC [National Weather Service River Forecast Center] website, as there is a helpful aggregation of different data and information from forecasters and observes downstream on the Yukon and Porcupine Rivers. I also communicate by phone, text or email with local contacts and NWSRFC forecasters.*

Prevalence of all emergent themes for this open-ended question are featured in Table 18.

Ideas for Improving Current Tools

Suggestions for improvements to current tools varied on the survey. Interestingly, the most common theme (21.2%) among those who chose to provide a response to this item on the survey was a sense of not being sure of what to suggest, or noting that they are not qualified to provide feedback. Representative responses follow:

- *I'm not too sure at the moment*
- *You're way ahead of me!*
- *None. I'm a total newb!*
- *Not sure just getting my feet (wet)*
- *None. This is all new to me*

Possibly relatedly (though it isn't clear if this suggestion is self-referential or meant to be for those seeking to develop a new app for river ice data), one survey respondent noted that, to improve existing tools, it would be good to first "get to know the apps being developed thoroughly."

Table 18. Please think about the one or two examples above that you use most. What makes them useful to you?

Themes	Count (n=81)	Percent
locally-grounded/first-hand understanding of how to make daily ice-related choices	26	32.1%
current “up to the minute” information	20	24.7%
(not sure how to interpret, or just says what they use most)	13	16.0%
it fulfills a specific data need	9	11.1%
ease of use	8	9.9%
reliable	7	8.6%
large audience/good reach/good amount of info - incl. “use what the locals use”	7	8.6%
photos	6	7.4%
one-stop shopping/lots of info in one place	4	4.9%
comparing/collaborating data sets	4	4.9%
standardized format	3	3.7%
only outlet for needed info	2	2.5%
space to communicate/ask questions of real people with knowledge	2	2.5%
use with students	2	2.5%

Tied for second most common response themes were suggestions related to physical tools and other data collection hardware (13.5%), and suggestions for output and reporting improvements (13.5%). Recommended physical tools and hardware included computers, an ice shovel, the incorporation of drones for visual data, installing more satellite-tethered cameras also for more visual data (photos), and a structure for those collecting data to warm themselves and access internet:

- *Ice shovel*
- *Computer*
- *Keep them clean and organized. The students put the tools away and learn how to care for the tools they use. We also keep the tools for ice apart from any other tools.*
- *drones are always discussed to help see areas you can’t see. But currently these are only used if there’s an emergency*
- *Install more fixed satellite cameras*
- *A constant monitoring system or easier ways to communicate, or maybe a little house on the other side of the river for our crews to warm up and get cell service at.*

Output and reporting improvement recommendations included specific data set recommendations, more general recommendations for simple data packages and making data sets tailored to high-traffic spots on rivers, and recommendations for how data should be shared out (with recommendations ranging from LinkedIn to print-outs that can be posted in locations with poor internet connectivity:

- *A web report on the Susitna breakup would be helpful, along with flow and clarity*
- *Use NHD flow lines for mapping breakup river conditions.*
- *Including information for certain areas*

heavily used by people that is gleaned from Sentinel-2 imagery would be new and helpful

- *availability of real-time data in a simple package is only way that it will be useful to most*
- *Publicize/Publish river ice info on LinkedIn.*
- *Without cell phone service or good internet here in [village name], it's hard to share our information via technology methods. If there's a way to print and post (at the local PO) people who aren't digitally connected could feel informed too. It's truly a safety issue--for everyone.*

Recommendations for standardizing available data were fourth most common (9.6%). Counted together with other output/reporting recommendations described above, a total of 12 tool refinement suggestions (23%) were related to output refinements. Standardization recommendations included the following:

- *Easily "exportable" data to the RFC/ NWS data records*
- *The biggest thing is to provide the observations as GIS services so they can be accessed by other GIS systems. No one app is a one-stop shop but making these observations findable, accessible, interoperable and reusable will ensure wide adoption.*
- *that everyone uses the same method and that as a standard in reporting conditions related to ice and other related climate conditions*

A few responses suggested emulating specific tools. These included the LEO Network (for standardization via moderators and subject matter experts), the Indigenous Sentinels Network, and an app used and possibly developed by Northern Alberta, Canada tribal entities:

- *Crowdsourcing is a great way to compile info, but information does need to be vetted in some way. Perhaps a model similar to LEO network, with local moderators or subject matter experts.*
- *The Indigenous Sentinels Network run by the Aleut Community of St Paul has already developed an app for collecting environmental data from individuals in Alaska communities, website https://www.beringwatch.net/*
- *Would need to get permission from the [Mikisew Cree and Athabasca Chipewyan First] Nations, but we have an app for collecting ice data and also an app/website for sharing information that might be useful for you to review. [Northern Alberta, Canada]*

While only two responses were related to improvements for student engagement, these

Table 19. What ideas do you have to improve the tools you use to learn about ice conditions?

Themes	Count (n=52)	Percent
not sure	11	21.2%
physical tools/hardware	7	13.5%
additional data output/reporting	7	13.5%
better communication/collaboration	6	11.5%
standardized outputs	5	9.6%
cite example tool	4	7.7%
access to data/better internet/ability to work offline	3	5.8%
robust retrieval/archiving capability	3	5.8%
additional data collection (water quality, water temp, flow, clarity,	2	3.8%
improved monitoring	2	3.8%
improved data collection methods	2	3.8%
youth outreach/education	2	3.8%
data from multiple websites in one place, such as an app	2	3.8%
Get to know existing tools	1	1.9%
how to interpret data to stay safe on ice	1	1.9%
include cultural knowledge	1	1.9%
UI suggestions	1	1.9%
ability to credit sources and/or reach out to sources	1	1.9%

are worth featuring here. These responses noted the need for outreach kits specifically for working with children, as well as a desire for engaging and explanatory materials that help students really understand the data they are measuring or retrieving (notably, the Fresh Eyes on Ice protocol may fill these needs):

- *Education and Outreach kits to work with our children*
- *Could you make them more interesting for students to learn with? I don't want to just know what is happening, but why.*

Table 19 describes all themes found in responses to this question.

In interviews, responses also varied.

One suggestion that several respondents mentioned was increasing ease of use. For one respondent, making the Fresh Eyes on Ice Facebook page more searchable, and increasing the types of data available via clickable pin drops at each data collection location on the map would streamline the experience. The GLOBE website, in particular, can be unwieldy, particularly for students:

> *So accessibility, to go back to the Facebook page and making some of that more accessible on there. Going to the Fresh Eyes on Ice webpage, I've found recently, has been really good to look at the breakup observations. If we had similar pin drops with other data that was collected, that would be really great too. Just one central space to get all*

of that information. And I know there is the other database too [GLOBE website], but that's just a little bit more bulky, especially for middle or secondary students. (Participant 8)

This same participant went on to indicate, however, that others in her community were not as interested in making this kind of observational documentation or interacting with the LEO Network platform to see the observations of others, partly due to the lack of widespread internet use:

I've been trying to get community members to participate in it and post stuff that changed to them over the years or this year or last year. … Everybody's skeptical. Not much of the older folks are good with technology. Nobody really gets on the internet… We're still in the old days, the good old handwritten mail letter days. (Participant 10)

Several survey responses and interviewees noted that, across several different tools, photo uploading was an area that needed improvement. One interviewee elaborated on her frustrations when she needs to upload photos from multiple nearby locations at a time to the Fresh Eyes website, and recommended a profile-building option that has photo points pre-marked and reduces burden for those who may not have georeferenced photos:

The way that I've been accessing the Fresh Eyes on Ice, I have to navigate from the map of Alaska to my local area. I have not figured out how to zoom into my local area efficiently. And so that's the most difficult, the most time consuming part is I wish I could just go back to [my location] easily [after uploading a photo]. I don't have a smartphone, so I'm just taking pictures with my camera and then I'm uploading them and then manually putting a point on the map. It's not like I'm using a GPS enabled camera. Or like a phone, like there's … The GLOBE Observer, [scientist name] was saying like, "You go to a spot and you

take pictures of all different directions and then you hit a button and it just uploads it. And it knows where you are." Well, I don't have that option…. If you could set up an account...So each time you go in, you say like, "Here's who I am" or, "I'm new." Maybe there's a way you could set up an account and then you can have like your favorite spots. (Participant 5)

This informant also noted that she had shared directly with individuals from one ice-interested institution in a previous year, and then shifted to posting to the Fresh Eyes Facebook page this past ice season – which indicates that while having a variety of methods for sharing may accommodate a variety of users, a given user may be more inclined to gravitate to mostly one method of sharing, especially if they know they will reach most target recipients via one mode and not the other:

Mostly [I share through] the Fresh Eyes on Ice [Facebook page]. …I'm not sure who I would share information with beyond say, my other friend who goes and skis on the rivers. … I know that we had a conference two years ago, and we had some people from River Watch. The NOAA folks. And so that winter, I actually shared some breakup photos with them. I didn't do it this year. I just got in the habit of posting them to the Fresh Eyes on Ice. But I think some of the River Watch folks might look at the Fresh Eyes on Ice photos. (Participant 5)

Suggestions for Possible Future River Ice Information App

Respondents were most likely to want the ability to see or share data about one location over time (76.1%), then the ability to upload or see pictures (75%), then the ability to work offline (69.6%). Only 16.3% of respondents indicated they don't use apps at all, and a mere 4.3% noted they probably wouldn't use an app for sharing or using data about current ice conditions. A total of 4.3% reported they didn't know if they would use an app. About 10% of respondents provided additional write-in items, including specific output types, reemphasis of interests such as photos, expert tips, and space for qualitative description and connection with community members:

- *Apps feature community contributed photos, observation, tips from experts*

Table 20. What things would you want in an app that let you share and use data about current ice conditions? Check all that apply.

Answer Choices	Count (n-92)	Percent
Ability to see or share data about one location over time	70	76.1%
Ability to upload or see pictures	69	75.0%
Ability to work offline	64	69.6%
Ability to see or share observations from many locations in a region	60	65.2%
Ability to georeference (note the precise location of the observation)	56	60.9%
I don't use apps.	15	16.3%
I don't know	4	4.3%
I probably won't use an app for this.	4	4.3%
Other (please specify)	10	10.9%

and enthusiasts, and updated maps
- *Provide those observations as data services such as KML or REST endpoints to be accessed by GeoCollaborate and other GIS applications*
- *warnings or trends*
- *A list of frequently measured/used river and ice parameters.*
- *New Brunswick has an app that does these things. :)*
- *Breakup conditions and how this impacts bank stability.*
- *having a graph might be helpful*
- *Access to photos from satellite cameras located high above the river*
- *Ability to share "metadata" or real time anecdotal information along with the quantitative data*
- *ability to share one's own observations/ comments*

More Effective Data Sharing and Awareness of Tools

Some participants expressed a sense of wanting to improve information-sharing within their own contexts, or noted they or others have already begun working towards more effective data sharing. One way in which data sharing has been improved, according to interviewees, has bene through shifting away from reactive actions and towards more responsive strategies:

> *I made it part of my job. Yeah. It's not written as part of my position. I have an interest [in sharing data about current river ice conditions]. I think it's important. I would say probably 10 years ago, it was more about coming up with fact sheets on what to do with your well after a flood. And I thought that doing all we can to prepare people to shut things down and be more protected prior to a flood, I think, helps in the recovery phase of dealing with the drinking water. Yeah. So, I made it part of my job to seek out this early warning data and to share that with people [in the] hope that it improves recovery. (Participant 1)*

There needs to be increased awareness across institutions and communities about the available resources. The same participant reflected on the usefulness of a recent meeting that highlighted interagency coordination, and the need to communicate with communities:

> *I thought the…workshop was really cool.*

I think timing wise worked out really well because we just had our [statewide interagency] meeting, right before this workshop happened. And I think…having this workshop annually around the same time before the river forecast.... And just tying into this workshop a little bit more agency coordination discussion, there's a lot of technical stuff that's really great to know, but how do we use it? How do we coordinate? How do we work together? What resources do our agencies have, and our groups have, and how can we communicate to the communities? A little bit like a portion of that workshop, taking the technical information and translating it to useful information. I think a little bit more focused on that would be valuable. …I see that as important to what I do. (Participant 1)

Suggestions for increasing awareness of tools included user interface refinement suggestions for the River Forecast Center website, and periodic emails highlighting new databases or methods of data retrieval:

A more centralized website that gets away from... Yeah. I'm trying to think, if something separate from the River Forecast Center site with all its national stuff would be an easier, more intuitive clearing house for some of this stuff. And it would also include more ground weather service stuff. …To have a page where new stuff was advertised, something I would look at once or twice a year and be like, "Hey, we've got this new database or this new interface," would probably be nice. A little more intuitive dropdown… The River Forecast Center is using the national website template… It's not always intuitive, what they have chosen to put [different data resources] under. (Participant 9)

Another interviewee noted that another benefit of increasing data sharing efficiency is giving data collection deeper meaning for those collecting it – "giving authenticity" to work that students are doing, for example:

I think part of that too, I'm just thinking, to give authenticity to what it is that the students are doing. Because we build that on our own and we find out reason and meaning for being part of the project. And to have more connections with other teams, with other areas, with other citizen scientists in specific, I think, would be cool. (Participant 8)

Several interviewees echoed this sentiment in their descriptions of ways in which there need to be enough people sharing useful information in a crowd-sourced database for that tool to then be useful to others looking for relevant information. As one interviewee put it when asked why she valued the tools she used to learn or share ice information:

Well everybody has a phone. Everybody has a VHF. It's like a radio. Everybody's on channel 10. Everybody will hear the TV. …And then [we use] Facebook. We have a [village name] page where the whole community is on. Not just the community, but community members that live outside of [village name]. They would be able to know everything too, what's going on. …It's pretty effective when you use the social media, because everybody's on it, and the people that are not on it is usually the older folks, and their kids tell them. (Participant 10)

Another interviewee noted that the Fresh Eyes on Ice website and social media pages are less useful to him than other tools because he is the only one posting observations for his area:

I don't go to the Fresh Eyes on Ice database or their social media pages to gather the data I need. That's probably one of the last places. Part of the reason for that is I'm the only one updating conditions in my area. So if I'm looking for local information, I'm the one that's already providing it. (Participant 8)

Consistency of Data Across All Users

Emergent interview themes included feedback regarding how to ensure data is both locally relevant and specific to a place while also useful and reliable across a larger scale.

> *[Regarding Facebook neighborhood pages as a source of information about trail conditions] I don't think that's very accessible. In fact, I've had neighbors say to me that they feel there's a little bit of elitism about our trails. Like, "Oh, did you do the [local trail name] loop today?" I'm like, "What the hell is the [local trail name] loop?" We have names for trails, and that might not be so accessible to everyone. I think, if anyone's talking about making a database where people share ice conditions all the time, that would be really handy. (Participant 3)*

This same participant underscored that any tool should be useful for individuals going about their day on and around ice, as well as those who may be looking for larger-scale aggregate data:

> *Obviously, just for personal use, local people want to know what local conditions are, but I also think it just happens to be that … there are a lot of people that study Alaska coming from Texas. …There's definitely a non-local usage in that sense. (Participant 3)*

Other participants implied or stated outright that there needs to be space in data collection tools for both qualitative and quantitative data.

> *I had used that to look up things before and I see, sometimes the data is not very useful, but sometimes the observations are. It's not very scientific that way, but it is good to have people reporting observations. So I think that crowdsourcing capability is going to be it's going to be useful. I think the difficult part is taking data from a diverse population of people and trying to integrate that into all of our agency databases, and schema, and stuff like that. That's the tricky*

part. Making sure that the data meets quality standards that a lot of organizations and agencies try to build. (Participant 1)

Across several respondents, photos were seen as an integral part of creating space for objective data about ice conditions. Photos can be especially useful when considering what safe or unsafe conditions look like:

You're talking about an app where people log ice conditions. You definitely need to put photos. This is what we consider a dangerous condition. This is what we consider a safe condition, you know? I know people have different levels of that... Like how to get people consistent. How to make subjective observations funnel into some objectivity…. I think they have to train the inputters a little bit, like for photos, rank how dangerous this condition is and then say, "Oh, this is a 1, show a picture. This is a 2, picture." It would need a lot of guidance in order to get consistency. (Participant 3)

A few respondents who help facilitate local data sharing with state or federal agencies noted that local observers may not have the bandwidth to provide photos via email or an app, but will provide them via flash drive or other mechanism either via mail or when someone travels to the remote location.

Subjectivity of Risk Tolerance

When those who recreate or otherwise engage with ice for personal use described what ice data is useful to them personally, nearly all noted that verbal or other non-photographic information about ice conditions should be interpreted with the knowledge that how viable ice is for travel is subjective. (While not featured in the quotes below, two different interviewees also utilized comparison to Covid risk tolerance to help illustrate their point.)

When people talk about ice conditions, is it safe to go out today, is it not safe to go out today, there's definitely like, you should know who you're talking to. …Maybe trust isn't the right word. I do trust their judgment for themselves, you know? But viewed through my level of risk tolerance, which is really low, I would draw my line differently from where they would draw theirs. (Participant 3)

> *Different people have different levels of comfort. …Going across the river, if I felt like the situation was controlled, I would do it….And we were following the snow machine trail….So there were just a bunch of things that made me think, well, we can go across this channel and we didn't know that it was the main channel. (Participant 5)*

> *There's so much variability in what people consider good and safe. It's a slippery subject to be like, "What's the river like?" You get a wide variety of answers. And if I'm just literally talking to somebody that's passing by the river in front of my house, I don't really know them or anything about their risk assessment. (Participant 4)*

As noted elsewhere above, photos were framed as one way to clarify observation data that might otherwise be subjective. One interviewee noted, when asked what sort of guidance they would want for taking photos of ice conditions, that any guidance that would aid with consistency of data would be beneficial:

> *Any guidance. I would assume that that has more to do with break up and freeze up, or maybe it could be anything. When you look up… "Oh, how are the roads in Alaska?" We had that really bad storm and you go to that website and you can see pictures. Again, that's way more helpful because somebody might be like, "This is a terrible road right now." And you look at it and you're like, "It's fine." (Participant 4)*

As described elsewhere but worth highlighting here in more depth, evidence of this theme also emerged in open-ended survey responses. For example, when asked what information they needed about ice conditions in the short term (day to day or week to week), one participant articulated a desire for daily ice condition data, and followed that by noting a general reluctance to declare ice "safe" or not due to liability – implying that what one person can safely navigate may not be what another person should attempt:

> *Regular ice measurements along the trail in the early and late season and having it posted where it is easily located. I fear that no one wants to take liability for saying the ice is "safe" or not. (Survey response)*

In another response to this survey question, a respondent articulated a desire for objective information on safety criteria, while simultaneously underscoring the variability of conditions from one part of the river to the next – one's information needs are related to whether they are crossing one section of a river or travelling a length of a river:

> *Solid information on if these conditions are present then navigating on the ice is not a risk. Crossing one section and traveling the whole river are two different things. (Survey response)*

Ability to Remotely Access Data About an Observation Site Itself

Several other suggestions for improving tools

moving forward included the ability to access data about observation sites remotely, such as described here by this educator:

> *That's sometimes hard, especially when I'm working between two communities. And I don't know what that would look like, because a lot of it needs to be hands-on, and the fun of it is to be hands-on. But also to have some remote options just to check in on things, that would be really cool. If we could set up a snow depth monitor, even, and just know like, "Okay, what do we need to prepare for it to get out to our site?" that would be a lot of fun to be able to track that with a web-accessible camera. I don't know how feasible that is. I recognize that that's a huge ask. (Participant 8)*

Two other interviewees cited additional established data collection points that they currently use, such as a telephone company's daily camera output that can be monitored by the public online, and a similarly-publically available shared data portal from a private citizen with an extensive weather data station on his own property, to glean relevant data about their own data collection sites.

Conclusion and Recommendations

The needs assessment succeeded in providing insights into the target areas of inquiry.

To what extent are people interested in and willing to contribute information about river ice conditions? There was a strong desire to use information about ice conditions across all participants. While fewer respondents were confident they know where to go to find river ice information or how to share river ice information, many of these same respondents went on to provide, either via open-ended response in the survey or in interview responses, evidence that they leverage local relationships and resources to learn what they need to know to stay safe when traveling or working on ice, or to gain information about local ice conditions to then build data sets to inform statewide flood alerts and prevention, ecological knowledge, supports for subsistence users, or other river ice-dependent understandings.

What information do people need about river ice and how are they going to use that information? For both professional and personal use, the two most common river ice knowledge needs were thickness of the ice (53.9% of responses) and whether it is safe to travel (48.3% of responses). Survey respondents were slightly more likely to articulate specific needs around the timing of breakup or the existence of rotting ice (24.7% of responses) than the timing of freezeup (13.5% of responses).

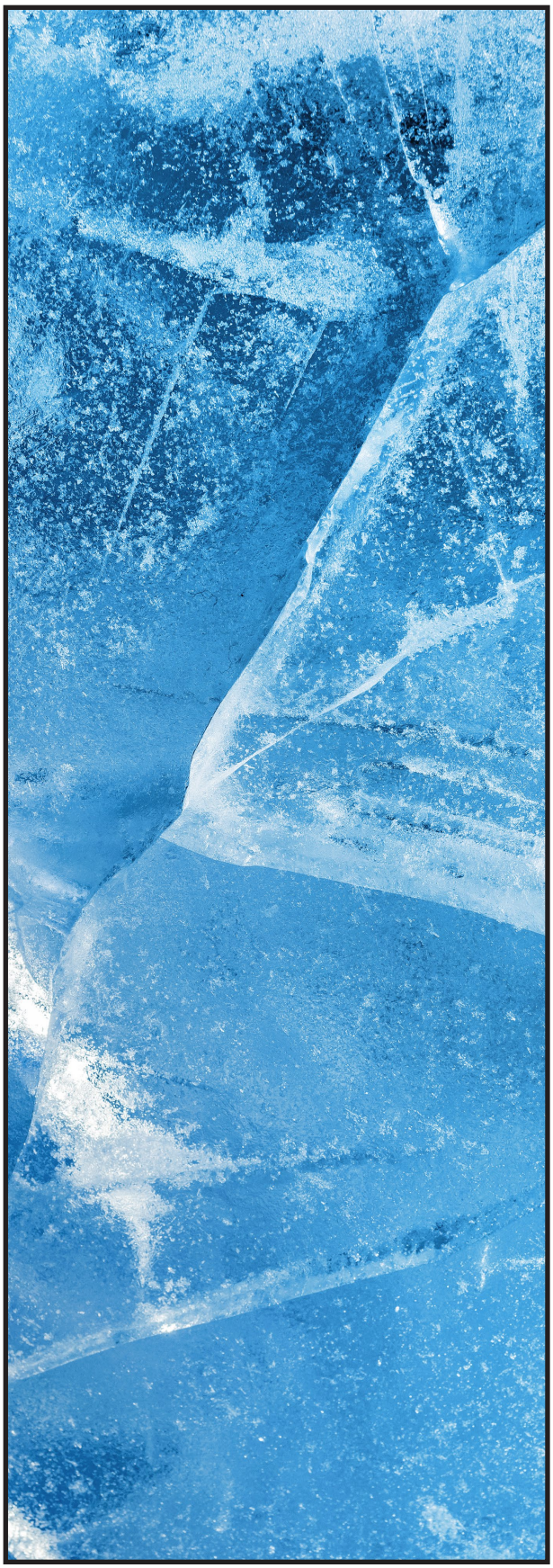
The need for, and value of, local observations was a prevalent theme across all respondents – from urban-based scientists as well as rural and urban recreational and subsistence users. Survey and interview finding indicated that

Alaskans need information not just about the safety of river ice along longer spans of rivers, but also about the safety of specific access points for crossing from one side of a river to the other.

The most common way respondents noted they interact with river ice is for travel, with 40% of all responses mentioning some form of river ice travel. Also prevalent were responses that cited recreation as a way in which the respondent interacted with river ice (38%), followed closely by subsistence (34%) and research (30%). Education-related ice interaction was also a prevalent theme (18%), as well as community monitoring (16%).
How do people describe different qualities of ice? In addition to common terminology used to describe the conditions of ice such as “ice,” “ice thickness,” “dynamics of ice,” “ice conditions,” “breakup,” “freezeup,” and “ice jam,” one or more respondents via either the survey or the interview used the following terms to refer to river ice qualities: “needle ice,” “pressure ridges,” “raised center ice,” “rotting ice,” “jagged ice,” “smooth ice,” “ice-up,” “ice-out,” and “ice formation” (discrete from freezeup).

What are the best ways to share needed information about river ice with different audiences? In tools that they already used to gather information about river ice conditions, participants most valued the fact that they provided easy access to locally-grounded first-hand knowledge, that they provided current data (at least daily during breakup), that the tool provides access to exactly the information that is needed, or the tool is easy to use (for example, it is easy to find all information for a specific community or body of water, or it is easy to upload multiple photos at one time, or it is easy to collect data in the field because the only tool needed is a smartphone).

Several survey respondents and interview participants also noted that any method of sharing information needed to address the need to have reliable data that can be understood and interpreted by anyone. In interviews, several



participants mentioned that observation subjectivity can be countered either by knowing an individual informant's general comfort with risk and adjusting your own actions/choices accordingly (if interacting with someone known to you or your community), or by there being some standard protocol similar to GLOBE Observer protocols to ensure there's uniformity across descriptions. Better yet, many noted, would be the integration of photos that follow a protocol. However, there was some variation across users as to what kinds of photos would be useful.

Some interviewees noted the current Fresh Eyes on Ice Facebook page is less than ideal when it comes to searching for specific data, such as filtering results by season. Several interviewees noted photos of solid mid-winter ice aren't helpful when needing to make decisions during breakup, for example. A searchable photo and ice-thickness record with geotagged photos was of interest to several interviewees.

General desire for a go-to place for local observations was expressed. However, most interviewees had built some form of system in place to get what they needed already -- such as a rural resident noting everyone knows the local river crossing intel needed and they share it over VHF or face to face/phone/text already, or scientists already have either institutionally-supported local observer relationships, or other personal contacts (again: relationships). It's when folks become interested in ice conditions further afield from their usual spots of interest that they become less confident of where to go for that local intel, and express an interest in knowing where to go for that info.

Who will use information about river ice conditions? Participants across Alaska's Interior, Western, and Southcentral regions made up about 90% of respondents, with 44% of respondents representing rural locations. Participants identified as affiliated with Indigenous institutions (27.2%), followed by university affiliation (18.2%), then by K-12 school system affiliation (17.2%), federal agency (17.2%), State agencies (8.1%) and private businesses (5.1%). Nearly all indicated they were interested or very interested in using information about river ice conditions.
What supports do different audiences need to make observations and contribute that information and knowledge about ice conditions to

the community? Supports included hardware resources, as well as instruction on how to gather the most useful data for those who might need to use it, as well as the ability to export specific file types that will work with certain GIS or other similar tools. Ability to use a map interface to locate a point on a map and access photo and metadata through that spatial interface was recommended by several interviewees.

Recommendations

It is clear that ice thickness measurements and current geotagged and non-subjective ice condition information was of interest and currently mostly missing from what rural, recreational, and scientific/statewide context users felt they had easy access to. However, interviews and open-response survey items showed that existing tools do provide some of what is needed already. Existing data-aggregating resources such as Weather Service/ River Watch tools, the LEO Network, GLOBE Observer resources, and the Fresh Eyes on Ice website are already valued by participants; almost no respondents had ever heard of the SIKU app, but features of that tool overlap features of the aforementioned tools, and this Indigenous-created app currently used mostly in Canada may be worth exploring as a potential tool for locally-derived river ice observations in the Alaskan context.

When asked to check all items they would want in an app from a predetermined set of items, respondents were most likely to want the ability to see or share data about one location over time (76.1%), then the ability to upload or see pictures (75.0%). In interviews and in open-ended items, respondents highlighted the usefulness of photos as a way to eliminate subjectivity, as well as validate satellite data. Whether existing tools are enhanced or adapted, or a new tool is created, it is clear that an easy-to-use tool that includes photos and descriptions of local observations, and which also provides guidance for data collection, is desired across the clear majority of participants. Such a tool has the potential

to strengthen the power of already-useful local observations of river ice conditions by enhancing its usability in larger state-wide data analysis that informs decisions related to Alaskan transportation infrastructure, drinking water systems, ecological stewardship, and other funding decisions.

APPENDIX A: NEEDS ASSESSMENT SURVEY

Appendix A: Needs Assessment Survey: Open-Ended Responses

This appendix includes all open-ended responses except a) responses provided in "other" fields at the end of closed-ended questions (those are featured in their entirety in the main body of this report), and b) the initial three open-ended questions at the beginning of the survey that requested information about the respondent's relationship with ice, what community they are from, and what institution they represent. Those initial survey responses contained a large amount of identifying information. For that reason, only the analysis is featured (see main body of this report).

In your own life or work, what information, if any, do you need to know about river ice?
Is the thickness of ice suitable for skating? How safe is it to travel on? Has it broken up yet? Where are the ice jams? Where is the black ice (Upriver/ McGrath ice)?

- When will the river freeze
- The thickness of the ice, and the temperature around the ice
- Current climate change impacts on ice-thickness and how much earlier the rotting of the ice begins.
- The river ice has to be strong enough to have a 4wheeler with blocks of wood to be hauled over, or for the hunters to cross with their snow machine or 4 wheelers
- Areas of overflow and trail conditions
- How thick it is, if it's rotting, when it begins to thaw, if it is covered in a heavy snow layer, what else is using the ice (animal or human traffic affect ice conditions), overflow patterns, Where open water is
- It is culturally important to me and my tribal members that we know the river ice since we use it to travel in the winter to our cabins, it becomes our highways to lands we cannot normally reach.
- Depth, where open leads are, when it is safe to travel. During break up how the melt is progressing up river and locally.
- Thickness for travel and safety
- Depth and security for occasional snow machine trip on the good pasture river
- timing of safe conditions for travel
- Ice thickness for safe travels. Also frequencies of overflow conditions or other known open ice free areas not easily obtained without local knowledge
- trends of the presence of river ice
- I need to ensure that ice on the river is at least 5 inches thick for fishing, skating, cross-country skiing, and walking on it with my friends and family.
- Thickness
- I need to know if the Tanana River ice is safe to snowmachine on to set burbot lines. I need to know when break up and freeze up occurs in Northwest Alaska water bodies to plan for and inform my fisheries research.

- Extent, thickness (whether it is safe to navigate, drive or walk/skate on), water on top of ice & depth of that water, ice jams occurring or imminent, where flooding is or will occur.
- The thickness, safety concerns like river openings, trail conditions.
- Safety in crossing, are the ice freeze up patterns changing?
- Ice thickness per each part of the winter season and if it is a changing overtime
- thickness; ice cover; snow cover; variability & changes through winter; how one year compares with another; potential backwater impacts
- I'm not sure, I'm new to this position
- During SnowSchool, students (especially students in Klukwan) learn about ice formation. I also do stream sampling with students and knowing how to get onto the ice to take our samples is important for safety reasons.
- not sure what other than when our fish are going to be here
- You always have to know the weather conditions. if To warm might be overflows in the river, too cold you have to know about your sno go conditions. Lots of times people think there sno go can go in Cold conditions but in reality sno machines theses days cant make it on the river when its -72 on our coldest months of the year... we have community members on the river daily, and they pass on the word about the ice and how the weather is on the river. (in my village its usually 10 degrees colder in winter months).
- Ice jam possibilities. Ice thickness.
- In my own life, i need to know about the river ice travel conditions
- I know when the ice will go out during spring time. I know how to get water, and set fish nets under the ice.
- How quickly needle ice rots.
- the melting and if temperatures are changing
- ice thickness, it is very important to know when it is beginning to freeze
- Ice jam forecasts and community/ infrastructure risk maps
- I usually wait until it been cold for awhile before we check the ice.
- None
- When and where it is thick enough to skate/bike/walk and clear enough of snow but lacking overflow to be enjoyable
- Historical and future projected ice thickness, break-up timing and flood predictions, aufeis development and severity.
- General info on extent, thickness for safety during wilderness travel and route planning. ice thickness if possible - open sections - ice jams
- Ground based imagery is key to validating satellite based algorithms
- I need to know the conditions of the ice before traveling or near the ice.
- If it is safe to go on to ice fish and when it will become unsafe.
- For my personal live, I need to know whether there is enough ice to ski along local rivers. And honestly, I mostly figure this out by trial and error. If I get to a spot with overflow or open water that impedes my travel, I turn around and go somewhere else. For work, I'm interested in understanding how river ice conditions have changed over time and the what the current conditions mean for subsistence users who might want to travel along or cross the rivers.
- I need to know whether it is thick enough to walk on, ski on, skate on, or drive on.
- Overflow Thickness
- It would be nice to know present conditions, e.g., how thick is the ice, reports of open leads.
- Thickness and if there's any overflow
- Progress of breakup and timing of ice free conditions at my stream gages. Freeze up start date and date of complete ice cover.
- Ice depth, trail conditions on the river.
- Safe river ice for safe travel for trapping and recreating. For example the winter release (a relatively new phenomenon) of Hidden Lake that opens up the Kennicott, Nizina, and then Chitina Rivers affect our

ability to use the Chitina River.
- Thickness, movement, and stability from freezeup to breakup.
- Thickness, overflow
- Whether it can be crossed
- Where flooding may occur.
- For work: river ice/overflow conditions for snow machine travel to streamgage sites in SW Alaska and for foot travel in Southcentral AK.
- Ice thickness is the most important factor to me, but I would also be interested in ice thicknesses at different locations and monitoring the variability of it.
- For recreation in the Matsu valley, it would be good to know if the ice is strong/ thick enough for biking/skating/skiing. Sometimes there is information, when the state (ADFG) or local ski groomers go out and drill holes to measure ice thickness. However, these observations are few and far in-between. For my research, duration of ice cover info would be very helpful.
- When Ice is candling, Depth of Ice come April 30th
- I need to have situational awareness about the formation and thickening of the ice cover over winter, then leading up to break-up the deterioration of the ice cover to inform the evolution and potential severity of break-up.
- Safety for getting on river to walk across for flow under ice measurement purposes. Generally this is a question of the presence of full width ice cover, but it does not have to be continuous up & downstream. For recreation I only need to know if there is a trail on the river.
- We need to know if it is safe to travel on.
- if it is safe to travel on
- Ice thickness measurements at field monitoring sites. In particular is the ice thick enough for safe travel.
- Ice coverage, ice thickness, locations of freeze-up fronts, location of breakup ice jams, flow
- I need to know the quality of the ice and where open leads exist.
- Thickness and locations of poor ice
- Thickness, overflow conditions
- Thickness, frequency of open leads, overflow conditions, spring thaw conditions
- It's thickness and quality and how this varies over time and space.
- Overflow conditions, open leads
- Mid winter breakups, areas of strong/weak ice. Snowpack both on the river and in the immediate vicinity.
- Is it thick enough to walk on? Is it safe for my kids? Is the timing changing? Are there dangerous patches on the river that I need to be aware of?
- Relative thickness - Ice jam potential Spatial extents - Navigation and ice jam potential Ice jams - location, timing and severity
- Always know to wait long enough until the river is frozen solid before crossing the river. I am not one to be the first to cross the river. I wait until there is a solid trail back and forth. Usually, people will do the same. We have certain people that go over first, every year, and thats when we all know its safe to cross.
- I need to know ice depths in the winter. And when the river is frozen enough to travel
- Ice safety
- Knowing about ice conditions is important for the safety of my family when they are traveling by snowmachine.
- I want to know more about the science of how rivers freeze and break up.
- I need to know how soon I can safely go on it. How late can I go on it? What is the thickness of the river?
- I need to know about conditions both downriver and upriver. Downriver we like to travel with our dog teams to remote cabins and to do our trapping. Upriver we need to know what's happening for break-up conditions to prepare for potential spring floods.
- I need to know if it is safe enough to take my students on the ice for skiing and if it is safe enough to commute to/from other villages along the river

- Is the ice safe to travel on - human powered? by snowmachine?
- I need to know if it is safe enough to cross.
- yes it mite help my home one day
- Where the locations of open water zones are.
- Travel, friends use it for trapping, traveling ect.
- The quality and thickness
- Is it safe to take my family on? Can I go ice fishing?
- How does that information help you or your work?
- help me relax
- Helps use make informed decisions and helps us to be safe
- have no use
- It helps a lot
- This is vital information needed to ensure safety of myself, my community and my staff members during Spring Break-up and Fall freeze-up months.
- It helps to know that people will be safe to haul wood or get food.
- Traveling to nearby villages
- It tells me when and where it is safe to send commuters, workers, residents, heavy equipment, aircraft, and subsistence participants
- Since I work in the tribal office, it helps me inform my tribal members where the ice is safe and where to fish.
- Who needs help collecting data and what I can do to help.
- Working with students and FAA
- NA
- lets me know if I can safely travel and work on the river
- Keeps me safe from falling in water while recreating or traveling for work
- knowing the condition of the riparian habitats
- It helps to know the safety issues on the rivers of Alaska as well as the conditions of visiting isolated villages (can we come by snow machine or only by air traffic)
- Safe travel
- Info about Tanana River ice thickness helps me make decisions on whether to go out or not, and good information keeps me safe (avoid breaking through or hitting an open lead). Info on river ice coverage in Northwest Alaska helps me know how early or how late in the season I can conduct open-water fisheries sampling.
- Validate against satellite observations to provide decision support services
- Cultural knowledge for classroom lessons. River conditions for travel.
- It helps the community in traveling, hunting, & fishing to know where the ice is safe and how to check the ice. It helps the students to learn how to observe the ice changes for their future life in this region.
- It helps me focus on changes of weather trends overtime to how the central Yukon stands
- evaluate breakup impact potential
- It helps the hunters or ice fishers know about the ice
- Knowing the depth of the ice allows us to take our stream measurements.
- none
- It doesn't really i guess. just info people need to know every now and then for when they cross the river everyday between the two different villages.
- How to respond to oil and hazardous spills on ice.
- It helps knowing whether or not it is safe to travel to the nearest store, clinic, travel to hub, subsisting. For work, it helps with keeping track of how climate change is affecting traveling on river ice.
- It is very important, because It is apart of my job I do right now. Have to inform the community of ice thawing, or any kinds of spill over ice.
- Save lives.
- accumulating information to pass on to tribe
- not applicable to my work
- It would help me evaluate oil industry contingency plans for spill prevention and response
- Its helpful because we use the river ice to get to another community for heating oil, gas and food.

- It doesn't
- Safe ice is important, I don't care for winter swimming, and if it's clear it is more fun and potentially more photographic
- I use this information to design culverts, bridges, erosion protection, runway and road embankments.
- Not directly relevant to my work at this time.
- Helps with modeling water levels and just gives an overall sense of ice integrity and risk of ice movement.
- Ground based imagery is key to validating satellite based algorithms
- This information is a huge safety concern.
- Keeps us safe.
- It expands my options for ski places to ski. The other ski trails near my house are in the trees, but if I can ski on the river it is more open/in the sun. I started to explain my work interest in river ice conditions above -- how they have changed/ are changing and what this means for subsistence access.
- It lets me know when it is safe to venture out.
- Safety
- For safe travel.
- To stay safe
- Allows me to better understand the fluctuations in river stage seen in the record and make a better estimate of flow.
- Helps me travel safely with guests.
- When the river conditions are unstable that area cannot be used for a winter trapline.
- Help design structures that are stable and not damaged by ice and/or ice movement.
- Planning trips while being as safe as possible
- Knowing if I can get to my destination (recreational cabin or camping destination)
- Helps us communicate to communities with a public water system. Helps staff prepare for response.
- Safety, and determine what type field equipment is needed.
- Knowing how thick the ice is can give some indication as to possible ice jams or overbank flooding that could occur.
- I could probably derive an ice cover duration map myself using remote sensing techniques, which are my speciality for cryosphere research. However, I am already working on seasonal snow research and being able to use someone else's data, rather than derive it myself would save time and possibly allow for more advanced research...if we pooled our skills/knowledge/datasets, etc.
- Planning on spring time flooding
- It allows me to provide early warning for the communities of Dawson and Old Crow on the potential for flooding resulting from break-up ice jams.
- If full ice cover exists we can go out & attempt to cross for measurement purposes. If the observer providing info tells us ice thickness we can decide if landing a plane there (remote location where we will be measuring flow under ice) is safe or not.
- It helps us make a decision on whether to gather river water or well water for consumption.
- supports community safety
- In supporting the communities with understanding whether travel is safe. Understanding how factors such as climate change, upstream hydroelectric releases/ regulation and oil sands withdrawals impact ice formation, safety and travel.
- This helps me to build knowledge and models
- There is no help
- It prevents me from drowning, getting wet, and from leading others into dangerous areas. It also extends my spring hunting.
- Ice links the trail system in NW Arctic Alaska, allows for cheaper travel between communities and access to subsistence activities.
- Keeps me from falling in the water
- I recreate and subsist in the area, which frequently requires traveling on ice.
- I communicate these conditions to other scientists and the public. I also use it for making travel and recreation safe.
- Planning trips, knowing which areas to

- avoid/which areas might be good for recreation.
- Aids me in predicting probability of ice jams and associated flooding.
- Keep my family and community safe. Better understand how climate change is influencing my community and way of life.
- It helps me, because I get my dry wood from across the river. Spending nights at my dad's cabin with my boys is a thing we do every year too. So it helps me personally, not on a professional level, that I know of.
- This information is important for our community so we can keep people safe on the river
- I teach science, so I can integrate everything into my content.
- For safety, teaching my children and grandchildren about recognizing dangerous ice conditions when traveling.
- I want to learn.
- It helps me to safely use the river.
- Eagle is located on the river and its conditions are EVERYTHING to our community! We use it for travel, for food resources--fish, caribou herd crossing, moose hunting, etc.--for accessing the international border, and for local cultural events, like deaths (spreading ashes or burials beside it).
- It helps me to be safe with my students and to plan fundraisers that would bring folks in from other villages
- Our school participates in the monthly Fresh Eyes on Ice Protocols
- It helps me travel to where I want to go for subsistence activities.
- motivation to help my home one day
- It helps me validate satellite imagery classification.
- Thinking of student needs.
- Staying alive and without embarrassment
- Keep my family safe.

What information do you need (or what questions do you have) about how ice changes from day to day or week to week?

- unnecessary
- Mostly during break-up time. Daily can be important.
- I wonder when it will change
- no
- The earliest notification we can get from our neighboring communities of Evansville and Hughes about when the ice goes out, the better prepared we can be.
- It would be nice to know in our area to let local hunters and wood getters be aware of the ice changes.
- Overflow conditions, ice thickness, snow cover and where open water is appearing
- I would likely a weekly report about ice thinning and how global warming is causing a change in the ice.
- Each year is different, but knowing the trends and approximate dates of safe travel are important.
- Are travel conditions safe for dog teams and airplanes
- Not much
- N/A
- Ice thicknesses, overflow, open areas
- how it relates to temp
- _ The timing of spring river ice breakup - The thickness of the ice during the winter - The links and resources where I can find this information
- Overflow, pressure ridges/ice wedges
- Tanana River ice reports are usually available online from NWS or on Facebook ice fishing forums. For NW Alaska, I use Sentinel-2 satellite imagery to assess weekly ice cover (if cloud conditions and satellite coverage allows)
- Ice is dynamic and changes daily. I would also like to know where water is on top of ice, where ice jams are occurring and flooding is possible or occurring.
- Safety conditions for travel.
- I enjoy watching it grow with the students! It shows change over time. How have the ice freeze ups have changed over the years?
- Not much just a annual pattern comparing prior years
- recreationally daily/weekly changes are

important; seasonally helps with breakup
- I'm not too sure at the moment
- I would like to know how ice formation on the Chilkat river and its tributaries has changed over time due to climate change and how that might have impacts on subsistence fishing, stream bed erosion, or impact cultural/traditional ways of life.
- none
- I guess my only question is When or how can we as a community start doing data collection during winter ice conditions to keep track for the next coming years.
- Ice thickness. Ice coverage.
- What are people around the state doing or preparing for limited travel on the river. Are people looking into different types of machines to travel., i seen where the troopers are using vehicles that are able to travel on water and ice., is there any villages thinking of bridges???
- How to tell when it starts getting thinner
- The weather forcast.
- its vital for communities because durning winters we need to know ice thickness
- not really needed
- I don't personally need this info
- N/A
- None
- Ice thickness and snow cover are my main areas of interest
- Frequent ice observations are important to me during break-up to help understand flooding potential.
- Ice extent and safety for travel, especially during shoulder seassons.
- changes could be new open leads or leads already reported are getting bigger. Open sections of water, jams in place, has the jam moved? or worn away and threat of flooding reduced?
- geo-tagged photos help supplement satellite data to provide information on algorithm performance
- I am curious of the temperatures and the changes within the last 10-20 years, and what may be the causes.
- Does it really become unsafe in a matter of a day? Or a week or longer?
- I suppose that if I have more information about widespread patterns of change, such as overflow being widespread, there might be a little less trial and error/turning around and going somewhere else. And I suppose better understanding when there might be overflow or the relationship between changing air temperatures and changing ice conditions.
- Is thickness changing? Are leads forming, and where?
- I'm curious if we could figure out a "forecast" of ice thickness conditions, but I don't know if that is possible.
- My main information need is if the ice is safe to travel by bike on
- During freeze up, percent ice cover on the channel. During breakup condition of the ice, indications of increasing flow (raised center ice) and occurance of ice jams.
- Interested in earlier breakup/freezeup forecasts.
- We have to make these decisions daily depending on the conditions. It would be impossible to wait for this kind of information from some where else.
- Need worst case impacts of ice on culvert, streambank, and streambed stability.
- Dynamics of ice dependent upon water flow, depth, air and water temperature, length of day
- Mostly just need to know when it can be crossed
- Where flooding is forecasted to occur and how serious.
- Ice thickness and overflow conditions
- Ice thickness would be great to know but another great thing to know would be if it is grounded near banks or not. How sensitive is the ice thickness to ambient air temperature? How sensitive is it to water temperature?
- I probably need information at this time scale more for recreation than for my research. Ice thickness in more places where people in the Matsu recreate and measured more frequently.
- Not to much till spring, then checking weather, then when breakup comes,,

where are the jams and how thick.
- I gather information daily in the weeks leading up to break-up.
- Extent of full ice cover & thickness for work purposes. Presence of a trail for recreational purposes.
- N/A
- when ice is thick enough or not
- Ice thickness in field locations.
- Mostly critical during shoulder seasons in Yukon: Any information about change in ice coverage and roughness is useful.
- no
- The most important one that is day to day is what areas have bad overflow and the routes to avoid it.
- Regular ice measurements along the trail in the early and late season and having it posted where it is easily located. I fear that no one wants to take liability for saying the ice is “safe” or not.
- Solid information on if these conditions are present then navigating on the ice is not a risk. Crossing one section and traveling the whole river are two different things.
- Ice formation/loss speed in relation to weather What causes open leads to become or remain open even when temperatures have been freezing for months and is this predictable in the same areas
- Same answer as #5
- Changes in overflow conditions and changes in open water.
- During breakup, I need to know how it is changing day-to-day. Throughout the winter, I only need to know big events.
- What factors change ice conditions over a short period of time? Photo observations, snow, river flow, and temperature data for the rivers would be useful.
- Spatial extents and occurrence (ice/ no ice) helps to validate remotely sensed products that are currently being developed. This information changes rapidly during freeze up and breakup.
- I have never been too interested in the river ice. Just the way it freezes from year to year. Sometimes it freezes over with a lot of jagged ice, that’s when we know the river trail will be rough. We can see when its going to be super smooth and its always good when its smooth. It also helps me identify sandbars in my area, identify channels. We can do this when the water is low, and the river is frozen. We will be able to see the ground elevated, which is a sandbar.
- I need to know when the river is safe for travel

What information do you need (or what questions do you have) about how ice changes from year to year or decade to decade?

- global warming
- I’ve been tracking this info on my own. Maybe we can fill in some gaps for each other
- How to change
- no
- Same as the climate change impacts on the melting and freezing of the rivers.
- I’d like to know if we will ever get to do stuff on ice on our lagoon, it kept people physically fit, fed, and entertainment when I was growing up. Now it’s not freezing enough to have my kids and grandchildren enjoy what I did.
- Thickness and snow depths
- I have been keeping track of when we open our ice road and close it for the last seven years; each year without fail we are able to use it later in the season, and it goes out earlier each year.
- As much information as possible because the ice is a major part of our lifestyle here.
- Historically is the trend different. How many years of ice data is available and what to expect in the future if possible so we can prepare.
- Are travel conditions getting worse from year to year?
- None at present
- Same
- if the ice also encapsulates debris
- - How fast is the river ecosystem changing due to climate change? - How is the local

fauna and flora impacted?
- When freeze up and break up is happening
- This would be important info in context of breakup and freeze up dates and fish movements in and out of lagoons in NW Alaska. Sentinel-2 imagery for this is only available since 2016, so there isn't a lengthy dataset for this yet.
- Very interested in the impacts on ice longevity and how it changes due to climate change and how this is impacting the use of frozen rivers to transport goods and services
- Ice conditions and flooding. Weather patterns affect on ice.
- We are enjoying learning as we do the research. Having help from the UAF Team has made a huge difference in the level of understanding and excitement for our students.
- Be cool to see a graph comparing years
- see above
- How thin it has gotten, or when it starts to freeze over during the times we need to subsist
- How does it change? What impacts do these changes have on human life and the natural world?
- none
- It changes every year. No question but the one on answer 7
- When ice on rivers usually opens up (break up). Average river breakup times.
- Are there Villages seeing ice changes where there are more open holes?
- Climate change and global warming.
- the melting
- not really needed
- high-level syntheses of ice changes on interannual time scales would be useful, as well as projections of future ice changes due to climate change
- N/A
- None
- None really at this time
- Projected ice thickness is important to properly design erosion protection.
- I'm curious how ice-up and ice-out dates have trended in recent decades. Also incidences of extreme events that cause midwinter melting.
- I don't study historical data as much but I'm being asked more and more for this type of historical data by consultants and Academia.
- Temperature of the water, ice, ions, and on a molecular level.
- I never really thought about that.
- Professionally, I'm interested in long term patterns of river ice changes and in particular related whether subsistence users are able to get across the river to access lands on the other side for subsistence activities.
- Fairbanks river ice has been different since MUS sold the power plant. More warm water has come down the Chena, affecting the ice there. More open area in new places occur on the Tanana now. I would like to know more about those changes.
- None
- No specific questions, but I'd be curious to know.
- Timing of freeze up/break up. Timing/ frequency/magnitude of flooding caused by ice jams.
- Just interested in long term trends.
- When on average there is ice so we can adjust our lifestyle accordingly.
- Need worst case for roughly every decade to determine impacts of ice on existing and proposed culverts.
- Ice up duration keeps shortening so it would be great to track how much this changes year to year
- I would be curious to know how ice crossing times have changed over decades
- average freeze up/break up dates and river travel history
- Im assuming it has to do with cumulative freezing degree days for that particular location and particular winter but what other factors may influence it?
- This time scale is more relevant to my research as a postdoc.
- Just to see how the different winters affect the Ice.

- I compare data gathered each year to past years to inform my forecasts of flood risk.
- No practical need.
- Ice formation is changing every year. It seems to follow a natural trend of forming later and later every year. Informational needs are provided locally by observation.
- how has river ice thickness changed over the past and how has climate change negatively affected ice patterns
- Ice thickness and snow depth. Timing of ice formation, freeze up, break up. How ice thickness and travel duration changes between seasons.
- Ice thickness, freeze-up patterns, freeze-up and breakup dates. This is mostly to investigate the direct and indirect impacts of climate change on cold region rivers
- no
- Ice changes each year and the leads change with the currents.. this information is always changing.
- How to identify risky conditions before you get into trouble
- Current conditions and possibly how expected weather impacts those conditions
- How are sequences of ice formation and decay change over time and from river to river. How this changes how people and other organisms use rivers.
- I don't think knowledge of change in general is as critical to my recreation. Seasonal variability is probably more important.
- Year to year ice is an indicator of possible flood potential. Example, if the ice is like 2020, there is a high flood potential, if 2019, lower flood potential.
- Remote sensing data that was easy to find would let me know how ice was in the recent past.
- Dates of freezeup and breakup are an important data set to understand changes in river ice in Alaska. The occurrence of ice jams, during freeze up and breakup for flood forecasting and to improve our understanding and prediction of breakup severity. Relative ice thickness at fixed locations with periods of records greater than 5 years are valuable for understanding the spring ice strength for breakup outlooks.
- Just if the ice is getting thinner through the years, or if it's getting thicker. Just that if there are huge changes that we should be aware of that we don't know. Other than that, I don't think we need much information.
- Has the ice been freezing later and later? Breakup is important to us for flooding reasons

Please think about the one or two examples above that you use most. What makes them useful to you?

- social media. I can read more about this.
- At beak up it can be crucial to have up to the minute information
- glacier
- We rely on fast transmission of important notices via marine radios and that seems to work most of the time.
- Talking to the elders about the changes what they see and if they followed any signs to help them live day to day.
- Personal communication from some that has recently traveled on the ice
- VHF and Text work best, we're off the grid so large reporting stations don't have eyes on our river systems. We have to monitor ourselves
- Facebook because it reaches a wide variety of people. The other option that I use is texting because it is fast and reliable.
- Local people and the weather service. I believe they are the most reliable because of local conditions varying due to the river location and surrounding conditions.
- Facebook—used by the majority of our communities
- Snow machining the Good pasture, or breakup of the Susitna for fly-fishing
- Word of mouth from others who have traveled recently
- talking about ice fishing and the ice conditions for access for subsistence activities

- Facebook is very useful because I follow a lot of pages related to this subject.
- In person discussion. This was helpful because they were usually “real time” observations.
- The Sentinel-2 imagery is most useful as it helps me plan fieldwork around break-up and freeze-up and is more reliable than word-of-mouth reports (if imagery is available). I also use it heavily to find out when lakes and rivers break up so I can boat or fish on them.
- GeoColaborate accesses any source and unifies those data sources in a collaborative common operating picture. If a connection to the Globe server could be made this would further enhance a collaborative experience for NWS, NOAA and decision makers. Fresh Eyes on Ice is an excellent opportunity to access trusted observations as long as location, time, date, pictures are included with every report.
- conversations because I like to ask and learn and share. Website allows me to compare my area with others that are observing ice at this time. I also like to compare the NWSRFC data with our data and see if the students can tell what the conditions were and if more ice formed during specific weather patterns.
- Facebook posts and talking to locals
- NWS and Facebook; communities use FB to communicate river conditions- that’s the key- use what the locals are using
- The weather, and whether we’re able to travel or not, really helps when we would want to subsist or not
- When I work in the classrooms in Haines and Klukwan we discuss the river ice as part of SnowSchool and our stream sampling projects that use GLOBE protocols.
- facebook to be able to connect with various different entities.
- Phone calls, Facebook, or the VHF radio is what our community usually uses to communicate
- NWS Alaska-Pacific River Forecast Center. Their maps are very useful for sea ice extent.
- Facebook is very useful when the internet is accessible. the Transportation Planner is the best option for us, as he often checks the thickness of the ice, and marks the trails to show if they safe, or uses danger decals up.
- I use the National Weather Service Center, and the Facebook.
- Phone calls from firsthand travelers and/or observers.
- facebook
- I being an older male and giving current ice conditions during freeze up and break up is very important to others in warning them to stay off or not travel at all.
- Websites are most useful. Don’t use social media, and I couldn’t view it on my work computer even if I wanted to (it’s blocked).
- Talking face to face and Phone (phone calling or texting)
- None
- Southcentral wild ice recreation Facebook group is the one I use primarily as they are in my typical area and are out frequently to report on ice conditions in areas I want to use
- I use the River Forecast Center to track break-up conditions.
- Direct contact with people who have recently observed ice conditions on my intended route is the most useful but usually not available. Gives me the info I really need, generally related to safety of river crossings, e.g. Beaver Creek in the White Mountains National Rec Area.
- Our App lets us get realtime data on our river systems. An email is sent to a list of forecasters and emergency officials when an ice jam is submitted. We also have the ability to archive data and export data based on a query.
- Word of mouth from professional, experienced, and trust worthy individuals. The Fish and Game or Bureau of Land Management updates.
- People with the same interests have knowledge about current conditions.

- The Fresh Eyes on Ice facebook page is in my facebook feed, so it is easy to look at. I don't have to make a special "trip". I also look at the Fresh Eyes on Ice camera that is near where I live periodically to see what is happening upstream from me. It should be noted that I'm a somewhat casual river ice user. If the ice is good, I can ski along the edge of the river. If it isn't I go somewhere else. I'm not really using the river ice to get anywhere in particular.
- WS ice thickness listings on Facebook are the only thing I routinely see, other than my own observations of who has been out on the river.
- Trust in the people giving advice.
- Biking with confidence on conditions
- observation of conditions in remote locations. Long term records. Real time is not necessary for stream gage data analysis, but is useful for site visit timing.
- I mostly use direct communication with friends and neighbors which isn't very scientific or helpful. We chop holes weekly for water and fishing so try to keep our own tabs on nearby conditions.
- I do not know of any official river conditions for us to use. We have to observe ourselves and communicate with others using the Chitina and Copper to know what the conditions are.
- River ice thickness and breakup information over numerous years helps understand changes with time to design erosion protection.
- People familiar with the area who have more time than I do are great sources of information for me.
- I use the web map service of breakup conditions and overlay it on our GIS web map showing public water system locations. https://www.arcgis.com/home/item
- Communicating by phone or email with contacts in the specific village or area we will be traveling (eyes on the ground) or via Facebook posts by people in the region.
- National Weather Service River Forecast Center website is probably the most frequently used because they have a standardized format and update their info on a regular basis.
- Website to see how the surrounding areas are doing in breakup or snow depths.
- NWSRFC website, as there is a helpful aggregation of different data and information from forecasters and observes downstream on the Yukon and Porcupine Rivers. I also communicate by phone, text or email with local contacts and NWSRFC forecasters.
- Email contact has been on river for many years & understands what info we need. FB photos/observation show full ice cover or not.
- It helps determine if river ice is safe to travel on and or utilize for ice fishing.
- social media because i use it already so seeing updates or posts on anything weather will catch my eye inevitably
- Current conditions and comparison to historical. Predicted ice thickness in the region.
- Satellite images and photos taken from the same location on a regular basis are the most useful to me, much more than a description that would use any terminology
- Facebook has pictures and a variety of input.
- In person, phone and text have the most current info, if you have the right people in your contact list. The others report too infrequently to be of much use or are not specific enough.
- Facebook post are easy and accessible
- Talking to people I trust is the most helpful because I trust their judgement and experience dealing with ice conditions
- Talking to people is always best. Facebook post are useful and interesting. NWS info and forecasts are quite helpful.
- I can focus on the sections of river that are most applicable to me.
- Riverwatch phone calls because it is a river-wide summary of conditions and people's concerns.
- Facebook. You can see what people are seeing.

- FEOI emails - Delivered in a usable format (picture, location, description) to NWS operations Phone Calls and Face to Face - Information from locals/elders in the community is some of the highest value information that the RFC receives on an annual basis.
- Facebook pages on ice and river conditions year around for the middle yukon area. Talking on the phone, or face to face with people that are familiar with river crossing in the winter. VHF radios are used when the river is safe to cross, usually.
- the information on break up is useful
- The GLOBE app has been extremely helpful as I don't send much time on social media.
- We use social media, primarily FB, to share information about intervillage travel on the ice in the winter.
- I listen when my family has the news on. I do GLOBE at school.
- Ice observer because it shows the ground image and get an idea of what the river looks like. Facebook because it is a constant photo engine and community communication
- Facebook page that is designated to ice conditions.
- I love the GLOBE app! I also like to talk to locals about the river conditions, it's nice to get a historical perspective as well as the current conditions.
- I can view them anytime I want and can add information to it whenever I want
- Collectively we put our school's data in monthly into the FEI website, I add photos and observations monthly to the FEI FB page I appreciate that the data inputs are pretty intuitive and don't require lengthy responses
- the eyes on ice will be help with the updates
- Fresh Eyes on ice shore cameras. They are useful to compare to satellite imagery.
- Credibility.
- Facebook. It is shared real time and you can see what happens up river and downriver and also see the stories and things that matter to people.