

Co-Production and Collaboration: Examining the Application of Co-Production of Knowledge
Principles and Practices at the Arctic Rivers Summit in Anchorage, Alaska

By
Jacklyn S. Florman
University of Colorado Boulder

A thesis submitted to the
University of Colorado Boulder
In partial fulfillment
of the requirements to receive
Honors designation in
Environmental Studies

Defense date: April 11, 2023

Thesis committee

Cassandra Brooks, Department of Environmental Studies, Thesis Advisor
Colleen Scanlan Lyons, Department of Environmental Studies, Honors Council Representative
Laura Dee, Department of Ecology and Evolutionary Biology, Outside Reader
Nicole Herman-Mercer (ex-officio), United States Geological Survey, Additional Committee
Member

Abstract

In the face of climate change impacts in the Arctic and sub-Arctic regions of Alaska and northwest Canada, there is a growing need to improve collaboration between Indigenous communities and western scientists to address multifaceted socio-environmental problems. These problems include shifts in the freezing of river-ice transportation corridors, permafrost thaw, and decreased salmon abundance in the Yukon River. These environmental problems pose drastic impacts for Indigenous communities in the region who depend on rivers for transportation, subsistence fishing, and cultural heritage. Addressing these challenges holistically and equitably requires employing a co-production of knowledge framework for producing useful and usable knowledge. This process requires high capacity for and commitment to building relationships between Indigenous Knowledge holders and western scientists. The Arctic Rivers Project is a multidisciplinary project led by Yukon River communities and organizations, the University of Colorado, Boulder, and the United States Geological Survey. The project attempts to employ a co-production of knowledge framework to understand climate change impacts in Alaska's Yukon River basin with the goal of producing useful and usable knowledge.

In this work, I explore the application of co-production of knowledge principles and practices in the planning, preparation, and execution of the Arctic Rivers Summit, held by the Arctic Rivers Project in Anchorage, Alaska, December 6-8, 2022 to bring together Yukon River stakeholders and community members. I write a narrative of the preparation and sessions held at the Arctic Rivers Summit, analyzing them for their applications of co-production of knowledge principles and practices. I then explore the extent to which co-production of knowledge principles were employed, the scalability of co-production efforts, and challenges in co-production of knowledge between western scientists and Indigenous communities. In my analysis, I found that co-production practices were utilized throughout the process, beginning with the event's co-production by the Arctic Rivers Project research team, Indigenous Advisory Council, and the Institute for Tribal Environmental Professionals. The processes that were used in planning, preparing for, and executing the Arctic Rivers Summit serve as an example for how academic institutions can work to integrate co-production of knowledge processes and practices into events and research projects with Indigenous communities.

Acknowledgements

First off, I would like to thank Cassandra Brooks and Nicole Herman-Mercer for their continued advising, support, and proofreading throughout the process of writing this Honors thesis. These two incredible women have been integral to producing this research. I feel incredibly inspired by both of them. I would also like to thank my other committee members, Laura Dee and Colleen Scanlan Lyons for reviewing my work and participating in my thesis process.

Special thanks to Arctic Rivers Project Indigenous Advisory Council, as their guidance and vision for the Arctic Rivers Summit was paramount to the success of the event. A big thank you to the Arctic Rivers Project team for carrying out the Arctic Rivers Summit event and for supporting my travel to Anchorage, Alaska. I am endlessly appreciative that my travel to Alaska was supported by the National Science Foundation's Navigating the New Arctic grant. Additionally— a special thank you to Keith Musselman for all of the work he has put into the Summit and the project.

I would also like to acknowledge all of the participants who participated in the Arctic Rivers Summit for sharing their wisdom, advocacy and management experiences, and knowledge of Arctic rivers. I learned so much from all of these passionate people with incredible dedication to protecting these rivers and all they support. I would like to extend a special thank you to Valerie Tony, an inspiring person whose perspectives and knowledge sharing influenced this work. Thank you for discussing what it means to Indigenize my way of thinking— your thoughts will stay with me.

Preface

This Honors thesis project, in its current form, is the result of several iterations of topics, research questions, and changing circumstances regarding the data availability within a large, multidisciplinary project. When I first began working on this project in the Spring of 2022, it was intended to be an analysis of participatory mapping data generated during “Inform the Modeling” sessions held by the Arctic Rivers Project at the Arctic Rivers Summit in Anchorage, Alaska in December of 2022. In preparation for the Summit, I extensively investigated and read the literature about Indigenous communities in the study region, participatory mapping methods, and co-production of knowledge practices. These preparations familiarized me with the region and with the sensitivities of working with Indigenous communities. Additionally, prior to the event, I participated in pre-Summit meetings with the Arctic Rivers Project team. These meetings before the summit helped equip the team with the necessary background and skills for working with Indigenous community members at the Summit. Finally, I completed the CU Boulder CITI human subjects research training for conducting research at the event, and participated in a decolonization training from NativeMovement.

I then spent the last week of the Fall 2022 semester in Anchorage, Alaska to provide support at the Summit, and to serve as a facilitator for participatory mapping sessions. In Anchorage, I participated in behind-the-scenes event preparation, from Office Depot runs to stuffing Summit registration packets and producing name tags. The Summit was a wonderful event that brought a wide variety of stakeholders together in Anchorage, despite the many challenges presented by the historic snowfall that hit Anchorage the week of the event, delaying many speakers and our transportation to and from the Alaska Native Heritage Center.

Unfortunately, as a result of several challenges within the participatory mapping sessions relating to data sparsity and lack of representation for many regions, I (along with my advisors) realized I would not be able to have enough data for my thesis research. Thus, I shifted my focus to compiling and analyzing information generated in the SWOT (Strengths, Weaknesses, Opportunities, Threats) sessions conducted at the Summit. After working on this analysis for several months, I once again needed to pivot topics as a result of concern over utilizing the SWOT data in a single-author thesis project within a multidisciplinary project involving many stakeholders. The SWOT was seen as something that had to be more inclusively co-produced by all participants at the Summit, including in the analysis and publication. A single-author thesis is inherently contrary to co-production, and since multi-author theses are not permitted, I had to again pivot my research direction.

As a result, with approximately six weeks before my defense, I needed to begin writing the Honors thesis from a different direction. This iteration is the third topic I have attempted to work on, in which I assess the implementation of co-production of knowledge principles and practices at the Arctic Rivers Summit. Thus, the thesis presented here does not fully capture the extensive work I have put into my honors process working with the Arctic Rivers project. While I greatly enjoyed working on this research, I wished that I had more time to spend time with the literature, interview members of the Indigenous Advisory Council, and otherwise more fully

explore this incredibly complex topic. However, with the condensed timeline to complete both research and writing, I did my best to bring this thesis together. I hope to one day more fully expand upon what I have begun learning in this project.

Throughout this project, I have truly enjoyed working within a large, multidisciplinary research team and a diverse array of stakeholders despite the challenges that come with it. Working with the Arctic Rivers Project has been an excellent experience in understanding these challenges and how to work within them to produce research.

Finally—I recognize the irony of creating a work about co-production of knowledge with attribution to only one author. Due to the Honors process, this work is required to be a single-author piece, but were I permitted to do so, I would include the many participants at the Arctic Rivers Summit and the project team as authors. It should be recognized that my role, as author of this work, is simply compiling information about and analyzing the work that others have put into both the Arctic Rivers Summit and the associated Arctic Rivers Project. My acknowledgements list the many people—from the rest of the research team to the Arctic Rivers Project Indigenous Advisory Council to the participants of the Arctic Rivers Summit—who put an immense quantity of effort into developing an incredible project and event.

Land Acknowledgement and Positionality Statement

It is important to acknowledge that the Arctic Rivers Summit occurred on Dena'ina land, and that the study area for the Arctic Rivers Project is on Athabaskan, Inupiaq, and Yup'ik land. The University of Colorado, Boulder— from which I am writing and conducting this research—is the ancestral homeland of the Arapaho, Cheyenne, and Ute people. Acknowledging that the Arctic Rivers Summit, the Arctic Rivers Project study zone, and the University of Colorado exist on land stolen from Indigenous people is essential for understanding why co-production of knowledge is paramount for working in these spaces.

I acknowledge my positionality as a white, western student and researcher on Indigenous lands, and include this acknowledgement out of respect for the people who have stewarded these lands for time immemorial. I attempt to foreground Indigenous observations and perspectives in this Honors thesis, but I do not hold an Indigenous perspective. This said, my goal throughout the process of conducting this research has been to listen and learn from the wisdom of Indigenous voices. Thank you, to all of the Indigenous Knowledge holders, scientists, managers, and community members from whom I have learned from throughout this process. I am aware that I have much to learn, and that the process of Indigenizing my perspectives is an ongoing and conscious effort.

Introduction

Understanding Climate Change in the Yukon River basin through Indigenous Knowledge and Western Science

As the Arctic warms, Indigenous communities in Alaska's Yukon River basin are experiencing shifts to their environments and lifeways in the face of a changing climate (Herman-Mercer et al., 2011). Anthropogenic climate change has led to warming in the Arctic at between two and four times the global rate (Rantanen et al., 2022). These faster rates of warming in the Arctic region can be attributed to the process of Arctic Amplification, a series of positive feedback loops that contribute to rapid warming in the Arctic in comparison to other regions on Earth. These feedback loops in the Arctic include ice-albedo feedbacks resulting from decreasing sea ice, cloud feedbacks, and ocean heat transport, to name a select few (Rantanen et al., 2022).

In St. Mary's and Pitka's Point, two lower Yukon River basin communities, Indigenous observers have noticed increasing temperatures, shifting precipitation patterns, and less predictable weather patterns as a result of the changing climate (Herman-Mercer et al., 2011). In the same community, observers noted that river ice has been substantially decreasing in thickness and that species composition in the region is changing, from ptarmigans disappearing to moose observations in areas they have infrequently been observed historically (Herman-Mercer et al., 2011). These Indigenous observations of change in the Yukon River basin form the basis of knowledge from which the Arctic Rivers Project seeks to build on, in hopes of understanding the future impacts of climate change in the basin and on the people who live there.

Indigenous communities in the Arctic are at the frontlines of the effects of climate change: once-reliable ice travel corridors are freezing up later and breaking up earlier in the winter, and sweeping fishery closures along the Yukon River have been implemented as a result of record low salmon return rates (Alaska Department of Fish and Game, 2022; Brown et al., 2018). Changes in ice travel corridors and fish abundance have led to shifts in the safety, food security, and lifeways for Indigenous people in the Yukon River basin.

Frozen rivers serve as vital transportation corridors in the north, as roads are few and far between in Alaska and Northwest Canada's Yukon River basin. For a large part of the year, river ice is the most efficient travel corridor through the region. These river ice transportation corridors are especially essential to subsistence harvesters who travel on rivers via snowmobile and dog team (Brown et al., 2018). The length of the season for safe ice travel has declined as a result of the warming climate, with long periods in which traveling on ice is hazardous due to potential for breakthrough. Changes to these ice corridors include later freeze-up of rivers, earlier melt-out, and decreasing ice cover throughout the season. These changes result from increased temperatures in the region. Ice impacts have led to increasingly dangerous travel conditions on basin's rivers, as breaking through river ice becomes increasingly common (Brown et al., 2018). These safety concerns have impacted numerous communities in the basin, and have limited people's ability to travel during a significant portion of the year.

Salmon is a key subsistence food source for many communities in the Yukon River basin. Salmon runs in the basin have sharply declined in recent years, leading to the closure of

subsistence fisheries along the Yukon River (Alaska Department of Fish and Game, 2022). For Indigenous communities, subsistence fishery closures are devastating for food security and cultural heritage (Loring & Gerlach, 2010). As of Summer 2022, fishery closures on the Yukon River applied to Chinook salmon and summer chum, two integral subsistence species for Alaska Native communities (Alaska Department of Fish and Game, 2022). The decline in salmon return has been among the most impactful environmental changes in the Yukon River basin for Indigenous communities, as salmon and other subsistence fish play a key role in the food security and culture of communities in the region. (Alaska Department of Fish and Game, 2022). As salmon returns become sparser, community interest is high in understanding why returns have decreased, and how to bring the salmon back in their historical numbers.

As Alaska and Canada's Arctic regions warm, and environmental changes become more pronounced, the environmental phenomena are becoming increasingly difficult to predict (Herman-Mercer et al., 2011). Changes to river ice and fish abundance are unprecedented, even with the longest running knowledge system in existence: thousands of years of Indigenous Knowledge. Despite this extensive history and continued observation, the skill and accuracy with which many Indigenous Knowledge holders were once able to predict the way their environment functions has declined as a result of the impacts of anthropogenic climate change (Herman-Mercer et al., 2011).

This shift in the ability of Indigenous people to predict and plan for hydrologic and climate events, and where and when subsistence plants and animals will be found has serious impacts on Yukon River basin communities. These impacts are rooted in the destructive capacity of unpredictable hydrologic and climate events, the safety implications of changes in ice travel transportation corridors, and deteriorating food security resulting from declining fish abundance and fishery closures. For both western scientists and Indigenous communities who have lived along these rivers for time immemorial, the changing climate poses a new environmental problem that will require extensive collaboration and resources to understand and adapt to.

Organization of Thesis

I begin this work by discussing Indigenous observations of change in the Yukon River basin and how these changes are impacting communities. Observations from and implications for riverside Indigenous communities should be the starting point and center of the discussion of climate change impacts in the Yukon river basin. Indigenous community members are the experts and key observers of climate change in the basin, with longer and deeper understandings of change than any data set produced through western science methodologies. Additionally, the impacts of environmental change on the lifeways of these communities is the reason behind conducting this work, and centering these human impacts is paramount. Indigenous Knowledge and western science should not be utilized to validate one another, but be used in tandem as equally valid points of data. For this reason, I first highlight Indigenous observations of change in the Yukon River basin to introduce and set up the problem that the Arctic Rivers Project seeks to address.

In the thesis research presented below, I define Indigenous Knowledge and co-production of knowledge with Indigenous communities. I then introduce the Arctic Rivers Project and the questions under investigation by the Arctic Rivers project team. Next, I will introduce the study area for the Arctic Rivers Project, the Yukon River basin, located in the interior of Alaska and western Canada. After this, I then provide an overview of the Arctic Rivers Summit held in Anchorage, Alaska on December 6-8, 2022, which brought together project collaborators from across the study region. Next, I outline my research question and the Arctic co-production framework that I utilize to answer it. After this, I present my results through tables and a narrative of the preparation, planning, and execution of the Arctic Rivers Summit. My discussion analyzes the extent to which co-production principles and practices were utilized at the Arctic Rivers Summit, and how the challenges encountered at the Summit pertain to challenges of co-production work in general.

Defining Indigenous Knowledge

Indigenous Knowledge is a living and systematic process of observation and long-term experience, developed and passed on in communities through intergenerational connection (Inuit Circumpolar Council, 2015). Indigenous Knowledge systems are often rooted in place, and are both semantic and episodic, meaning that Indigenous Knowledge systems are both fact- and event- based (Herman Mercer et al., In Review). There are many different Indigenous Knowledge systems, and each knowledge system is unique to the community in which it was developed. The Arctic Rivers Project utilizes the following definition of Indigenous Knowledge, developed by the Inuit Circumpolar Council (2015). This definition was selected by the project's Indigenous Advisory Council.

“Indigenous Knowledge is a systematic way of thinking applied to phenomena across biological, physical, cultural and spiritual systems. It includes insights based on evidence acquired through direct and long-term experiences and extensive and multigenerational observations, lessons and skills. It has developed over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation.”

Under this definition, [Indigenous Knowledge] goes beyond observations and ecological knowledge, offering a unique ‘way of knowing’ to identify and apply to research needs which will ultimately inform decision makers. There is a need to utilize both, Indigenous and scientific knowledge. Both ways of knowing will benefit the people, land and animals within the Arctic.” (Inuit Circumpolar Council, 2015, p.7)

Understanding the world through Indigenous Knowledge systems is crucial to understanding future changes in the Yukon River basin, and the globe. Climate change impacts in the Arctic are among the most drastic in the world, and understanding and managing land through Indigenous Knowledge and practices is crucial for better understanding and stewarding

the environments that Indigenous people have stewarded for time immemorial (Rantanen et al., 2010). Centering Indigenous Knowledge is also paramount for decolonization of research on Indigenous homelands, and for producing useful and usable knowledge.

Defining Co-Production of Knowledge

According to Ellam Yua et al., 2022, “Co-production of knowledge (CPK) is the process of bringing together two different knowledge systems, in true partnership and equity, to enhance, learn, and create new understandings on a specific topic” (p.6). In the case of the Arctic Rivers Project, the objective of co-production is to combine Indigenous Knowledge systems and western science to produce knowledge and understandings of the world “that would likely not be achieved through the application of only one knowledge system” (Ellam Yua et al., 2022, p.1). This process hinges on equity, allowing for more diverse and meaningful engagement in the research process by both western scientists and Indigenous Knowledge holders. Equity, in this context, is understood as “ensuring that space is fairly provided for all knowledge systems and knowledge holders in an agreed-upon process” (Ellam Yua et al., 2022, p.3).

This emphasis on equity is where co-production diverges from collaboration. While collaboration indicates people working together, co-production indicates working together under understandings of reciprocity and equity:

“It is a common problem to mistake work that uses some CPK tools for CPK itself. For example, it is not uncommon for a project or proposal to engage communities in some way or share results after publication, but not engage communities in designing the project, yet still be labeled as a CPK project.” (Ellam Yua, et. al 2022, p.6).

Co-production of knowledge frameworks contrast the practices by which research with Indigenous communities has historically been conducted. Under a colonialist regime, western researchers have conducted research in an extractive manner, without properly crediting or collaborating with the Indigenous people with whom they were conducting research. This regime has led to the stealing of and improper interpretation of Indigenous Knowledge. Additionally, Indigenous Knowledge systems have not received the same respect as their western science counterparts, and academic funding mechanisms have historically prioritized the questions asked by and in the form of western science as opposed to Indigenous Knowledge (Ellam Yua et al., 2022).

The methods by which western researchers have historically conducted studies have not afforded Indigenous people the agency or reciprocity that they deserve as partners in research (Ellam Yua et al., 2022). Employing a co-production of knowledge framework requires that any research involving Indigenous people or their homelands should be conducted with equity and reciprocity at the forefront of all research and the relationships embedded in the process. Building deep relationships between researchers and Indigenous communities is essential to the

co-production of knowledge process. These relationships should be grounded in recognition of historical traumas resulting from colonialism. Additionally, these research relationships should give Indigenous voices a leading role in driving questions, methods, and understandings generated in research. These relationships should also ensure adequate financial compensation for Indigenous co-producers, and give proper attribution for use of Indigenous Knowledge in research (Ellam Yua et al., 2022).

In the context of a rapidly changing climate, co-production of knowledge is necessary in order to inform “research, resource management, and policy” (Ellam Yua et al., 2022). In any case in which Indigenous people are impacted by decisions, it is essential to forefront their knowledge systems and perspectives in every step of the process through good co-production of knowledge practices. This means not only soliciting Indigenous perspectives, but Indigenousizing the ways in which complex environmental problems are addressed.

Overview of the Arctic Rivers Project

The Arctic Rivers Project is a collaborative research study seeking to weave together Indigenous Knowledge and western science in effort to create collaborative narratives of climate change impacts in Alaska and northwest Canada’s Yukon River basin. The goal of the project is to provide useful and usable climate, fish, and river data that Indigenous communities in the Yukon River basin can refer to for community planning in a warming world (Arctic Rivers, n.d).

The Arctic Rivers Project receives funding from the National Science Foundation’s Navigating the New Arctic Program. The project is being managed in collaboration between the University of Colorado, Boulder (CU Boulder), the United States Geological Survey (USGS), and the National Center for Atmospheric Research (NCAR). Other collaborators include the Yukon River Inter-Tribal Watershed Council (YRITWC), the Institute for Tribal Environmental Professionals (ITEP), the University of Saskatchewan, and the University of Waterloo (Arctic Rivers Project Storymap, 2022). The study began on January 1, 2020, and will be continuing through December 31, 2024 (Arctic Rivers, n.d).

The project hinges on the existing relationship between the USGS and the YRITWC , who have been collaborating since 2006 on the Indigenous Observation Network which conducts river monitoring in the Yukon River basin. The YRITWC and Arctic Rivers project partners developed the project’s research proposal and questions in collaboration (Herman-Mercer et al., In Review).

The Arctic Rivers Project’s driving research question is:

“How will societally important fish habitat and river-ice transportation corridors along Arctic rivers be impacted by climate change including permafrost degradation, transformed groundwater dynamics, shifts in streamflow, and altered river temperatures?” (Arctic Rivers, n.d)

Project goals and deliverables are multipart, with the aim of building storylines of climate change, enhancing community-based monitoring capacity, and environmental modeling at multiple scales. The storylines are intended to combine Indigenous Knowledge and western scientific knowledge in our understanding of climate change in the Arctic. These storylines will be created through mapping, interviews, and discussions at the Arctic Rivers Summit. Community-based monitoring will involve water quality and temperature monitoring conducted in conjunction between Indigenous communities, the USGS, and the YRITWC to ground-truth models. Multiple models will be developed and utilized in order to predict future river, climate, and habitat conditions in the Yukon River. Modeling elements include climate, river discharge, temperature, and ice, and fish bioenergetics (Arctic Rivers, n.d).

The proposal for the Arctic Rivers Project outlined a plan to form and seek guidance from a project Indigenous Advisory Council in order to ensure that Indigenous voices are factored into every step of the research process. The project Indigenous Advisory Council was formed by an application process open to individuals enrolled in or working for an Alaska Native Tribe or Yukon First Nation (Herman-Mercer et al., In Review). A review panel composed of Indigenous leaders, the Arctic Rivers Project Principal Investigators, and a tribal liaison reviewed Indigenous Advisory Council member applications, selecting 11 total members, with 9 from Alaska and 2 from Canada. These 11 Indigenous Advisory Council members each serve a 2-year term on the council (Herman-Mercer et al., In Review).

Indigenous Advisory Council meetings occur on a bi-monthly basis, facilitated by 3 Arctic Rivers research team members and a rotating basis of other team members with relevant topics to bring to the Council. Below, I outline the scope of Indigenous Advisory Council guidance responsibilities, from the charter developed by the Arctic Rivers Project team and the Indigenous Advisory Council (Herman-Mercer et al., In Review).

Table 1: Arctic Rivers Project Indigenous Advisory Council responsibilities, as described in the Indigenous Advisory Council Charter from Herman-Mercer et al., In Review

The ethical and equitable co-production of knowledge
Protection of Indigenous Knowledge
Research design, analysis, and deliverables to ensure that research is relevant, understandable, and usable by the Indigenous communities it is intended to serve
Best communication pathways to distribute project information and products
Identifying proper channels of consent and authorization before conducting any field work in Indigenous communities and best methods for engaging communities

Leading the design of an Arctic Rivers Summit bringing together Indigenous leaders, knowledge holders and western trained scientists and land managers to discuss the current and potential future of Alaskan and Yukon rivers and how we can adapt

The Indigenous Advisory Council’s role in leading the design of the Arctic Rivers Summit is most relevant to my research regarding co-production of knowledge at the Arctic Rivers Summit. The Council had a primary role in crafting Summit priorities, objectives, and the final agenda. Understanding the Council’s role in planning the Arctic Rivers Summit is foundational to understanding how knowledge co-production principles and practices were utilized in the development, planning, and execution of the Summit.

Overview of the Yukon River Basin

The Yukon River basin is the fourth largest drainage basin in North America, draining 330,000 square miles in central Alaska and Northwest Canada. The river is fed primarily by glaciers, snowmelt, and rainfall, flowing downstream from the Llewellyn Glacier and eight major rivers. The Yukon flows northwest from its Canadian headwaters into Alaska, and then arcs towards the southwest, draining into the Bering Sea (Brabets et al., 2000).

The Canadian portion of the basin is home to several habitat protection areas and national parks. In the Alaskan portion of the basin, 68% of the land is managed by the federal government (Brabets et al., 2000). Native corporations, by contrast, administer only 1% of the Yukon River basin, despite the large population of Indigenous residents.

The large disparity in land ownership between Indigenous people and the federal government is in large part a result of the Alaska Native Claims Settlement Act (ANSCA), passed by the United States Congress in 1971 (Administration for Native Americans, n.d.). ANSCA gave Indigenous Alaskans \$960 million in exchange for all land claims, and affirmed Alaska Native ownership of 40 million acres of land in Alaska. Surface rights to 22 million acres were allocated to 200 newly-incorporated villages. 18 million acres of this land, in addition to the subsurface rights in all 40 million acres were allocated to Alaska Native Regional Corporations. ANSCA land allocation accounts for the lack of Indigenous land tenure in the Yukon River basin (Administration for Native Americans, n.d.)

Table 2: Land administration within the Yukon River basin (from Brabets et al., 2000)

Land Administration in the Yukon River Drainage Basin, by the numbers
United States Fish and Wildlife: 32% of basin
Bureau of Land Management: 22% of basin
National Park Service: 10% of basin

Native corporations: 1% of basin
US military: 1% of basin

Population centers are sparse in the Yukon River basin. Fairbanks, Alaska and Whitehorse, Yukon Territory are the two largest population centers in the region, which are home to 84,000 and 23,000 residents, respectively. The remainder of the Yukon River drainage basin's residents live in villages, primarily along the Yukon River and its tributaries, with populations ranging from 30 to 800 residents (Brabets et al., 2000). Many of these communities are Indigenous. For many villages, waterways like the Yukon form the only connection between population centers, as roadways in the region are limited. The river thus serves as a vital transportation corridor for communities residing in the region, and especially those in its most remote reaches (Brabets et al., 2000).

The Arctic region is the traditional and current homeland of many Indigenous people who have developed complex, place-based knowledge systems in the context of their homelands (Ellam Yua et al., 2022). Approximately 20% of Alaska's population identifies as Alaska Native, making it the U.S. state with the largest Indigenous population (Lawlor & Herman-Mercer, In Review) Cultural groups in the region include, but are not limited to, Athabascan, Inupiaq, and Yupik communities (Loring & Gerlach, 2010). The Yukon River basin study area for the Arctic Rivers Project encompasses 150 communities, 100 tribal councils and First Nations across Alaska and Canada, and 15 ethnolinguistic groups (Arctic Rivers Project Storymap, 2022). These many groups are extremely diverse with their own knowledge systems developed over thousands of years.

As of 2000 demographic data, the basin was home to 126,000 people, approximately 10% of whom maintain a subsistence lifestyle (Brabets et al., 2000). Demographic data for the region have not been updated, but populations throughout the region are following an increasing trend (Herman-Mercer et al., 2016). Many people in the region, Indigenous or otherwise, depend upon the Yukon river and its tributaries for subsistence fishing, drinking water, and all-season transportation.

The Arctic Rivers Summit objectives developed by the project's Indigenous Advisory Council were streamlined into the following three goals, described on the Arctic Rivers Project website (n.d.)

1. Facilitate discussions on the current and potential future conditions of Alaskan and Yukon Rivers
2. Inform the Arctic Rivers Project's climate, rivers, and fish modeling efforts
3. Develop action plans

These objectives were intended to be achieved through a variety of knowledge exchanges, discussions, and breakout sessions that will be described in detail below.

Table 3: Arctic Rivers Summit Agenda with Session Descriptions

Arctic Rivers Summit Session	Session Description	Session Type
Opening Welcome	Opening prayer, Alaska Native Heritage Center Welcome, Project welcome, Indigenous Advisory Council Welcome	All participants
Icebreaker Activity	Informal activity dedicated to meeting Summit participants	Small group activity
Knowledge Exchange: Elder Share	Panel of Indigenous Elders	All participants, led by Elders
Knowledge Exchange: Arctic Rivers Project Overview	Overview of goals, methods, and outcomes of the Arctic Rivers Project, presented by Principal Investigator	All participants, led by ARP team
Inform the Modeling: River Transport through the Seasons	Discussion of river ice extent and mapping session in which participants drew relevant factors to ice transportation in their community on maps to inform project modeling	Small group discussion and mapping exercise
Inform the Modeling: Fish Through the Seasons	Discussion of fish abundance and health and mapping session in which participants drew relevant factors to fishing in their community on maps to inform project	Small group discussion and mapping exercise

	modeling	
Tour: Alaska Native Heritage Center	Tour of six Alaska Native dwelling places at the Alaska Native Heritage Center	Small group activity, led by Alaska Native Heritage Center Culture Bearer
Knowledge Exchange: Status of Arctic Rivers	Question and Answer panel of Indigenous experts on the current status of Arctic rivers	All participants, lead by Indigenous experts
Knowledge Exchange: Weaving Together Indigenous Knowledge and Western Science and Management	Panel of Indigenous experts regarding using western science and Indigenous Knowledge in environmental management	All participants, led by Indigenous experts
Taking Action: SWOT Analysis	Structured discussion of Strengths, Weaknesses, Opportunities, and Threats, with groups dedicated to four topics: <ol style="list-style-type: none"> 1) State of Rivers 2) State of Salmon 3) Partnering Indigenous Knowledge and Western Science for Management 4) Youth and Elders: Building a Bridge 	Small group activity
Inform the Modeling: Climate	Discussion and observations of climate change and what types of climate information communities desire, with an emphasis on how this information should be communicated	Small group discussion
Taking Action: Translating SWOT Analysis to Actions	Utilizing SWOT analysis results to develop plans for action on the four topics analyzed during SWOT analysis	Small group discussion
Gallery Walk	All SWOT analyses and action plans from sessions were posted for those in other	Unstructured time

	topic groups to view	
Closing Prayer	Formal event closing with a prayer to send participants off	All participants
Closing Banquet	Shared meal at the Lakefront Anchorage hotel for all Summit participants	Unstructured time

Research Question

In my research, I apply the co-production of knowledge framework outlined in Ellam Yua et al., 2022 to assess how knowledge co-production principles and practices were utilized at the Arctic Rivers Summit held in Anchorage, Alaska December 6-8, 2022. In order to do so, I outline the events of the Summit and analyze the extent to which the preparation, protocols, and Summit sessions met the criteria of this co-production framework. I seek to answer the question: How were co-production of knowledge principles and practices applied and utilized in the planning, preparation, and execution of the Arctic Rivers Summit? As I answer this question, I reflect on the extent to which co-production of knowledge principles and practices were employed, the scale at which knowledge co-production is possible, and the challenges associated with co-producing knowledge with a wide range of stakeholders.

Methods

Understanding the Arctic Co-Production Framework

In efforts to analyze the ways in which the Arctic Rivers Summit implemented co-production of knowledge principles and practices, I utilized an existing, recently published framework for co-production of knowledge in the Arctic (Ellam Yua et al., 2022). This framework provides tools and actions for how to structure relationships, actions, and ethical guidelines required for co-producing knowledge with Indigenous communities in the context of Arctic research (Ellam Yua et al., 2022).

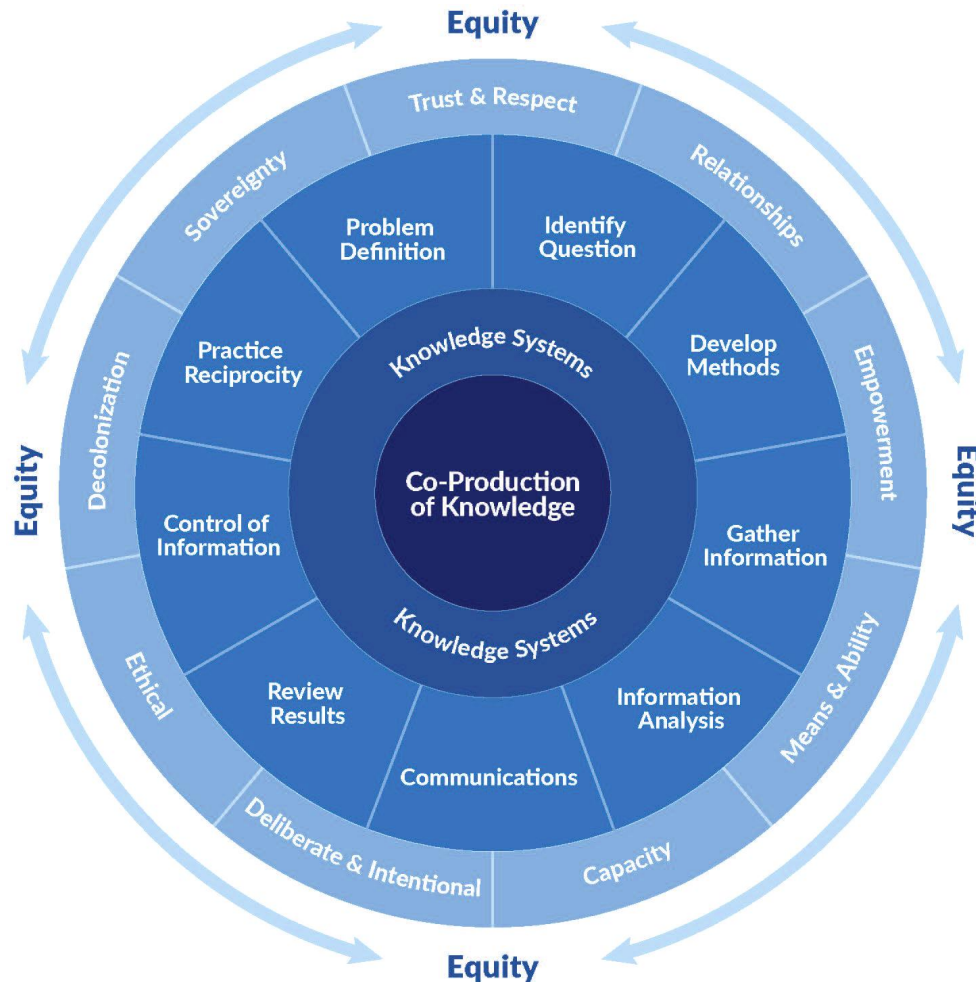


Figure 2: Arctic Co-Production of Knowledge framework visualization from Ellam Yua et al., 2022. Equity encircles this framework, with Tools and Concepts for knowledge co-production depicted within it. One circle inward is the Action Circle, representing guidance on how to utilize the Tools and Concepts in the research process. Moving toward the center is the Knowledge Systems circle, representing the multiple knowledge systems in use coming together. At the center of the framework is Co-Production of Knowledge, which is the end goal resulting from the circles surrounding it.

Figure 2 is an adaptation of the visual representation of the Ellam Yua et al., 2022 framework. The objective of the framework, co-production of knowledge, is at the center of the representation, and the three circles surrounding depict a process to build equity in co-production scenarios. The framework is visualized as a circle because the process of co-production of knowledge in research should be cyclical, as opposed to linear. A cyclical research process is essential to knowledge co-production because this type of process allows tools and concepts to be revisited and reviewed by co-producers throughout the research process. For example – decolonization is not a criterion that can simply be “checked off,” but a process that must be embedded into each component of the Action Circle. Tools and concepts within the framework apply to multiple actions, and the various actions are connected to one another by established guidelines agreed to by co-producers. As a result of this, co-production of knowledge is an iterative process that requires revisiting expectations, revising knowledge according to those expectations, and offering opportunities for review of the work that comes out of the process (Ellam Yua et al., 2022).

Encircling the entire framework is the word “Equity,” as equity is the foundation of knowledge co-production within this particular framework. Equity must be considered in relation to all of the principles and actionable steps highlighted within the circle.

In this context, Equity refers to:

- 1) Providing space for all knowledge systems and holders represented in a co-production scenario
- 2) Identifying and mitigating barriers to full engagement that co-producers may encounter in the process
- 3) Fairness in “means, capacity, decision-making authority, and rights”—including providing access to training and resources for research, in addition to compensation for research benefits (Ellam Yua et al., 2022)

Equity underlies all other parts of the Arctic Co-Production of Knowledge framework. Zooming in on the Outer Ring of the framework, depicted in pale blue, lies the Tools and Concepts circle. This circle represents tools aimed at building equity when co-producing knowledge with Indigenous communities. These tools and concepts include Trust and Respect, Relationships, Empowerment, Means and Ability, Capacity, Deliberate and Intentional, Ethical, Decolonization, and Sovereignty. These tools are defined in full in Table 4 of this document (Ella Yua et. al 2022).

Narrowing in further, the Inner Ring of the framework, depicted in darker blue, is the Action Circle— this circle consists of targeted, actionable steps of the co-production of knowledge research process. The Inner Ring, or Action Circle, depicts the component parts of the research process in which all co-producers should be involved, utilizing the tools of the Tools and Concepts circle. The idea is that each part of the research process should connect back to the Tools and Concepts circle, and build equity (Ellam Yua et al., 2022). These Action Circle

components are Problem Definition, Identify Question, Develop Methods, Gather Information, Information Analysis, Communications, Review Results, Control of Information, and Practice Reciprocity (Ellam Yua et al., 2022). How these components of the research process should be executed in a co-production of knowledge scenario are described in full in Table 5.

Inward from the Action Circle is the term “Knowledge Systems.” This circle of the framework refers to bringing together multiple knowledge systems: in the context of this research, Indigenous Knowledge and western science. These knowledge systems must be considered as whole but distinct ways of understanding the world. In the context of co-production of knowledge, the goal is to bring together the questions, methods, and data sources of both systems to develop new understandings.

I applied this co-production of knowledge framework to the planning, preparation, and execution of the Arctic Rivers Summit in order to evaluate how these principles and practices were used in the context of the event. To do this, I created a Tools and Concepts table and an Action Circle table listing each concept and action with its associated components to utilize as criteria for evaluating Summit preparation and sessions. I then compiled documentation of all pre-Summit preparation tools and Summit activities and research protocol to write a narrative of the event. I also engaged in conversations about the planning process with core Summit-planning team members, and drew on my own experience as a participant at the Summit. In analyzing each of these documents, I used the tables I created to attribute particular component parts of the Summit to fulfilling different parts of the Arctic co-production protocol to evaluate where best practices in co-production were utilized, and where gaps in co-production were present (Tables 4 and 5).

In Tables 4 and 5, I provide summarized criteria of the co-production of knowledge framework components, outlining each principle and practice from Ellam Yua et al. 2022. I pair these components with examples of how these components were applied to Arctic Rivers Summit preparation activities and Summit sessions. While these tables are not exhaustive of all the ways in which co-production of knowledge principles and practices were applied at the Summit, they outline numerous pertinent examples of how these principles were translated into deliberate and intentional actions at the event. They are not exhaustive because in theory, all aspects of the Tools and Concepts circle should be present in every aspect of the co-production process. The tables are intended to map out examples to better understand how principles can be implemented in the real world.

Following Tables 4 and 5, I expand upon the information outlined to explain in full how each aspect of the framework was applied to the planning, preparation, and execution of the Arctic Rivers Summit through a narrative of the pre-Summit planning and preparation process, the event agenda and sessions, and post-Summit proceedings.

Results

Applications of the Arctic Co-Production of Knowledge Framework at the Arctic Rivers Summit

Table 4: Analysis of the Application of Co-Production of Knowledge Tools and Concepts Circle at the Arctic Rivers Summit through the Ellam Yua et. al 2022 Arctic Co-Production Framework

Co-Production of Knowledge Principle	Components of Principle	Application of Framework Principle at the Arctic Rivers Summit
Equity	<ul style="list-style-type: none"> ● Shared decision-making power in co-production processes ● Fair compensation of participants ● Covering training and equipment needs ● Inclusive knowledge sharing ● Use of all other conceptual tools in framework 	<p>Indigenous Advisory Council</p> <p>Scholarships for Summit participants</p> <p>Knowledge Exchanges</p>
Deliberate and Intentional and Intentional	<ul style="list-style-type: none"> ● Everyone involved in creating knowledge must make a deliberate choice to be part of the co-production of knowledge process ● Documentation of processes to ensure that authorship and ethical guidelines are documented 	<p>Summit application process</p> <p>Arctic Rivers Summit website</p> <p>Informed Consent</p> <p>Data sharing protocols</p> <p>Pre- Summit Survey</p>
Trust and Respect	<ul style="list-style-type: none"> ● Indigenous Knowledge needs to 	<p>Indigenous Advisory Council</p>

	<p>be respected as a whole system of knowledge and recognized as the expertise that is</p> <ul style="list-style-type: none"> • Experts from western science do not get to decide how or where Indigenous Knowledge is included in research – Indigenous expertise must inform this 	<p>Knowledge Exchange: Elder Share</p> <p>Alaska Native Heritage Center Tour</p> <p>Opening Blessing and Closing Blessing and Land Acknowledgement</p> <p>SWOT Session: Partnering Indigenous Knowledge and Western Science</p>
<p>Relationships</p>	<ul style="list-style-type: none"> • Long term commitments to work together • Mutual participation and effort in the process of producing knowledge • Aimed at developing true understanding between co-producers • Underlined by equity • Sharing stories, time, patience, and worldviews 	<p>Icebreaker activity</p> <p>SWOT Analysis and Action Plans</p> <p>Closing Banquet</p> <p>Listserv</p> <p>Summit White Paper</p>
<p>Capacity</p>	<ul style="list-style-type: none"> • Researchers must have adequate education and training to work with Indigenous communities (e.g., histories, methodologies, values) 	<p>Indigenous Advisory Council</p> <p>NativeMovement</p> <p>Decolonization training for researchers on team</p> <p>National Science Foundation funding for Arctic Rivers Summit</p>

	<ul style="list-style-type: none"> • Funding and institutional support for research are necessary in order to support relationship building 	Human subjects research training
Means and Ability	<ul style="list-style-type: none"> • Indigenous people need necessary resources and appropriate tools and proficiencies to participate in co-production of knowledge • Utilizing and engaging with existing Indigenous networks and organizations 	Indigenous Advisory Council Scholarships for Summit attendance Summit date
Ethical	<ul style="list-style-type: none"> • Building frameworks and practices for ethical engagement between co-producers, other beings, and the environment • Research must be conducted according to guidelines agreed upon before the work begins 	Indigenous Advisory Council Free, Prior, and Informed Consent discussion Summit website Human subjects research training Institutional Review Board Protocol Data Sharing Protocol
Decolonization	<ul style="list-style-type: none"> • Allowing Indigenous perspectives, methodologies, and knowledge to direct knowledge-production 	Indigenous Advisory Council Decolonization training for researchers on team

	<ul style="list-style-type: none"> ● Recognizing and counteracting processes, structures, and institutions imposed on Indigenous people 	<p>Opening and Closing Blessing and Land Acknowledgement</p> <p>Knowledge Exchange: Elder Share</p>
<p>Sovereignty</p>	<ul style="list-style-type: none"> ● Affirming rights to self-determination for Indigenous people ● Exercising respect for Indigenous ethics, laws, and practices in Indigenous homelands, including ● Allowing Indigenous people to decide if they want to partake in knowledge production, establishing all risks and benefits, opportunities and threats 	<p>Indigenous Advisory Council</p> <p>Opening and Closing Blessing and Land Acknowledgement</p> <p>Free, Prior, and Informed Consent</p> <p>Institutional Review Board</p> <p>Summit website</p> <p>Data Sharing Protocols</p>
<p>Empowerment</p>	<ul style="list-style-type: none"> ● Create space for Indigenous people to exercise political and intellectual authority and responsibility 	<p>Indigenous Advisory Council</p> <p>Knowledge Exchange: Status of Arctic Rivers</p> <p>Knowledge Exchange: Weaving Together Indigenous Knowledge and Western Science & Management</p> <p>SWOT Analysis: Action Plans</p>

Table 5: Analysis of Application of Action Circle of the Arctic Rivers Summit through the Ellam Yua 2022 Arctic Co-Production Framework

Co-Production of Knowledge Action	Components of Action	Application of Framework Action at the Arctic Rivers Summit
Reciprocity	<ul style="list-style-type: none"> ● Relationship of mutually beneficial exchange 	Inform the Modeling: Participatory Mapping Inform the Modeling: Climate
Communication	<ul style="list-style-type: none"> ● Transparent and open ● Culturally appropriate ● Understandable ● Reflecting needs of participants with different worldviews 	Arctic Rivers Project Overview Listserv Knowledge Exchange: Weaving Together Indigenous Knowledge and Western Science & Management Knowledge Exchange: Status of Arctic Rivers Inform the Modeling: Climate Summit White Paper SWOT Actions Plans
Control of Information	Guidelines must be generated regarding: <ul style="list-style-type: none"> ● How information is collected ● How it will be maintained ● Where it will be stored 	Free, Prior, and Informed Consent Data sharing protocols Summit website

	<ul style="list-style-type: none"> • How and where it will be used, who will own the information 	
Problem Definition	<ul style="list-style-type: none"> • Experts from both knowledge systems must be present • Indigenous people in affected communities have leadership role 	<p>Indigenous Advisory Council</p> <p>SWOT Analysis and Action Plans</p> <p>Inform the modeling: River Transport through the Seasons</p> <p>Inform the modeling: Fish through the Seasons</p> <p>Pre- Summit Survey</p> <p>Elder Share</p> <p>Project Overview</p>
Identify Question	<ul style="list-style-type: none"> • Experts from both knowledge systems must be present. • Indigenous people in affected communities have leadership role 	<p>Indigenous Advisory Council</p> <p>Pre- and Post- Summit Survey</p> <p>Project Overview</p> <p>SWOT Analysis</p>
Develop Methods	<ul style="list-style-type: none"> • Each knowledge system includes ways of knowing • Indigenous and western scientific methodologies should be used in the suite of methods 	<p>Indigenous Advisory Council</p> <p>Inform the Modeling: Participatory Mapping</p> <p>Project Overview</p>

Gather Information	<ul style="list-style-type: none"> Information gathering must be conducted according to previously established guidelines by co-producers 	Free, Prior, and Informed consent Data sharing protocols Arctic Rivers Summit website
Information Analysis	<ul style="list-style-type: none"> Information analysis must be conducted according to previously established guidelines by co-producers 	Data sharing protocols Arctic Rivers Summit website
Review Results	<ul style="list-style-type: none"> All participants must receive the opportunity to review results 	Summit White Paper SWOT Action Plans Post- Summit Survey

Indigenous Advisory Council and Co-Production of Knowledge at the Arctic Rivers Summit

To understand the ways in which co-production of knowledge principles and practices were utilized in the planning, preparation and execution of the Arctic Rivers Summit, I begin with an analysis of the project Indigenous Advisory Council, and their role in planning the Summit. A sidebar: all co-production of knowledge principles and actions from the Ellam Yua et al., 2022 framework are capitalized and italicized from this point on.

The Indigenous Advisory Council is at the center of the Arctic Rivers Project’s knowledge co-production efforts, as they have been integral throughout the project decision-making and planning process. In addition to their many other roles and responsibilities outlined in Table 1, the Council was responsible for co-producing the Arctic Rivers Summit event with the research team in efforts to build an event that focused on creating equitable knowledge sharing spaces and adhered to best practices in knowledge co-production. In order to understand why the Indigenous Advisory Council is essential to the co-production process, it is necessary to evaluate how the Indigenous Advisory Council was structured and integrated as a key component of the Arctic Rivers Project.

A Council charter was co-developed by the Indigenous Advisory Council and the research team outlining the Council’s role within the project. Next, Knowledge Co-Production Protocols for the Arctic Rivers Project were co-developed by the Indigenous Advisory Council and the research team (Herman-Mercer et al., In Review, Andre et al., n.d.). The founding charter

is a representation of how the Council was established through *Deliberate and Intentional* action, with extensive discussion and documentation of Indigenous Advisory Council expectations. The same is true for the Knowledge Co-Production Protocol (Andre et al., n.d.). This charter, and the protocols established document outline *Ethical* guidelines for the project under which research is conducted.

These Knowledge Co-Production protocols outline qualities and practices for knowledge production. Among these include “Meaningfully involv[ing] Indigenous participants throughout the entire process,” with a list of actions including, but not limited to training Indigenous youth to do research, asking Indigenous communities about research that has already been conducted, involving community members in data collection and decision-making (Andre et al., 4). Documents produced by the Indigenous Advisory Council and research team established *Deliberate and Intentional, Ethical* guidelines with Indigenous voices at the forefront. Creating space for the Council to drive these guidelines respects Indigenous *Sovereignty* in the knowledge co-production process.

Members of the Indigenous Advisory Council are paid for their consulting services to ensure appropriate *Means and Ability* are being met for their expertise. Funding to pay an Indigenous Advisory Council was allocated as a part of institutional *Capacity* from the research team in the grant application process (Herman-Mercer et al., In Review). This financial compensation piece is crucial, as Indigenous Advisory Council members are experts deserving of compensation for sharing their time and knowledge in the midst of their many obligations.

The Council’s large role in the project and in the planning of the Arctic Rivers Summit indicates *Trust and Respect* for Indigenous Knowledge and knowledge holders. The long-term nature of establishing and allocating funding for a Council serving multiple years demonstrates a commitment to building the *Relationships* necessary for co-production of knowledge. These relationships require long-term commitments to build, as well as institutional *Capacity* to support, both in terms of time and finances. The development of the Indigenous Advisory Council and its charter and knowledge co-production principles also depended heavily on building *Relationships* among Council members and the research team (Herman-Mercer et al., In Review). Building *Relationships* within this group and between the Indigenous Advisory Council and research team is essential to their ability to work together to produce knowledge guiding the project.

Prior to the Arctic Rivers Summit, Indigenous Advisory Council meetings were held to set goals, objectives, and an agenda for the event. The document of Summit goals that resulted from these Council meetings is included in Appendix G. Planning of the Summit with the Indigenous Advisory Council began in January of 2021. Consultation with the Indigenous Advisory Council from the beginning of the Summit-planning process was essential to co-production of the event. During these meetings, the Indigenous Advisory Council played a key role in determining the Summit format, with an in-person event format chosen. Next, goals for the Summit were discussed and deliberated upon in Indigenous Advisory Council meetings. These goals outlined what Indigenous Advisory Council members wanted to accomplish at the

Summit. These goals were then divided into objectives, or specific desired results associated with each goal. These objectives were then translated into a Summit agenda, which was the method for achieving the goals set forth by Council (Appendix G).

The first goal that the Indigenous Advisory Council identified for the event was to “Facilitate discussions on the current state of knowledge of Arctic Rivers, considering Indigenous and western science perspectives and including climate change impacts” (Appendix G). This goal was then subdivided into types of knowledge to collect these perspectives on. These included climate and weather observations, culture, river bank erosion, fish, fish riverine habitats, ocean habitats for anadromous fish, food security, Indigenous indicators of ecosystem health, river ice, sea ice, Alaska Native water rights, and wildlife.

The second goal the Indigenous Advisory Council identified was to “Identify areas of concern with respect to Indigenous livelihoods, river transportation, and fish species shifts and survival... [to] inform project modeling” (Appendix G). These areas of concern were identified as climate, rivers, fish, and people .

The third and final goal identified by the Indigenous Advisory Council was to “Brainstorm and exchange information on solutions for communities and species to survive and thrive” (Appendix G). The objectives that they decided upon to meet this goal were strengthening relationships and developing action plans. The *Relationships* referred to included relationships between Indigenous Advisory Council members, as well as *Relationships* between western scientists, managers, and Indigenous Knowledge holders. *Relationship*-building is an integral part of the Arctic Co-production of Knowledge framework (Ellam Yua et al., 2022).

The goals and objectives set forth by the Indigenous Advisory Council were essential to the planning and success of the Summit. From these goals and objectives, the agenda of the Summit was created to target as many components of these goals as possible. These goals, and how they were implemented through the Summit agenda, are outlined in Table 6. A pertinent example of how Indigenous Advisory Council goals were translated into the Summit agenda is the SWOT analysis process (Institute for Tribal Environmental Professionals, n.d.). This agenda item began with the Indigenous Advisory Council’s goal of leaving the Summit with action plans to help *Empower* communities to take action. In order to understand what actions needed to be taken, Institute for Tribal Environmental Professionals, a vital collaborator on the Arctic Rivers Project, suggested that the participants conduct SWOT analysis. These SWOT analyses were then translated into Action Plans, to be published in the Summit White Paper. Because action plans were a high priority for the Indigenous Advisory Council, the majority of the second and third day of the Summit were dedicated to the SWOT process.

Table 6: Overarching goals for the Arctic Rivers Summit, finalized goals shared with Summit participants, and how these goals were to be achieved through Summit sessions.

Arctic Rivers Summit Goals Developed in Indigenous Advisory Council Meetings (Appendix G)	Finalized Goals, Shared With Participants in Summit Materials (Arctic Rivers Summit, n.d.)	Arctic Rivers Summit Agenda Session to Meet Goal (Appendix A)
1. Facilitate discussions on the current state of knowledge of Arctic Rivers, considering Indigenous and western science perspectives and including climate change impacts	1. Facilitate discussions on the current and potential future conditions of Alaskan and Yukon Rivers	Knowledge Exchanges: Elder Share, Partnering Indigenous Knowledge and Western Science and Management Strengths, Weaknesses, Opportunities Threats (SWOT) Analysis
2. Identify areas of concern with respect to Indigenous livelihoods, river transportation, and fish species shifts and survival... [to] inform project modeling	2. Inform the Arctic Rivers Project's climate, rivers, and fish modeling efforts	Inform the Modeling Sessions (Mapping): Fish and River Ice Inform the Modeling (Discussion): Climate
3. Brainstorm and exchange information on solutions for communities and species to survive and thrive	3. Develop action plans	Strengths, Weaknesses, Opportunities Threats (SWOT) Analysis SWOT Action Plan Building

The process of setting the goals, objectives, and agenda of the Arctic Rivers Summit was focused on building an *Equitable* process in which Indigenous Advisory Council members and research team members had shared decision-making power throughout the planning process. This goal-setting process demonstrated *Trust and Respect* for one another, Summit participants, and the knowledge systems from which participants of the Summit adhere to. Documentation of the Indigenous Advisory Council goal-setting process highlights *Deliberate and Intentional* efforts to ensure these goals were met. Finally, *Decolonization* is the ultimate objective of producing an event and research guided by an Indigenous Advisory Council. While

Decolonization is an ongoing process requiring extensive and continued effort from western researchers, prioritizing the voices of the Indigenous Advisory Council in decision-making is a crucial part of the process.

Without the Indigenous Advisory Council at the helm of Summit priority-setting and agenda-building, co-production would not be possible. As shown in Tables 4 and 5, the Indigenous Advisory Council came up more frequently than any other part of the Summit planning process or events, with their role playing into all co-production principles. This demonstrates how essential the body is to co-production of knowledge efforts within the Arctic Rivers Project, and in planning and executing the Summit.

Pre-Summit Preparation: Arctic Rivers Summit Website and Listserv

Prior to the Arctic Rivers Summit, a public-facing Summit website was created outlining the event agenda with information regarding research activities planned for the Summit and Data Sharing protocols (Arctic Rivers Summit, n.d.). This Arctic Rivers Summit website detailed the Summit goals and agenda, potential risks and benefits of participating in the event, and how Indigenous Knowledge shared would be protected. Protocols for retracting Indigenous Knowledge shared during the event were also provided on the Summit website. Pages on the site clearly lay out concepts such as the Cause No Harm principle and Free, Prior, and Informed Consent (Arctic Rivers Summit, n.d.). The informed consent document and Data Sharing protocols for project and Summit data were made available on this website to ensure that participants understood that research was occurring at the event, and where this research would go (Appendix C). This was done with the goal of giving Summit attendees enough time to consider whether they wanted to share their knowledge and participate in research at the event.

The information provided on this website best shows the research team's work to operate in an *Ethical* manner by providing documentation of a plan of how data would be collected and shared with community members. Providing Summit participants with documentation of their rights, potential benefits and harms of sharing knowledge, and the intentions behind the Summit were a critical part of ensuring that good ethics were practiced before and during the event, supporting Indigenous *Sovereignty* to decide whether or not they wanted to partake in research. This was also a part of being *Deliberate and Intentional*, as data sharing guidelines and ethical protocols were well-documented and shared with all participants prior to the event, allowing participants to decide if they felt comfortable with the protocols. Documentation of these protocols allowed participants to make a *Deliberate* choice to partake in the process.

The Data Sharing Protocols shared on this Arctic Rivers Summit website outlined how *Control of Information* would occur throughout the project with guidelines regarding how information would be collected, maintained, stored. Other information in these protocols outlined how data would be used, and who owns information generated in the project (Arctic Rivers Summit, n.d., Appendix C). Additionally, these Data Sharing protocols play a key role conducting *Information Analysis* according to pre-established guidelines by co-producers. By providing information about how data would be used, and who has access to it, the Summit

website ensured that *Information Analysis* from the Summit would occur according to guidelines shared with event participants.

Additionally, an email Listserv was set up in order to communicate with Summit participants and others interested in the Arctic Rivers Project. This Listserv was a means of practicing good *Communication* with people who wanted to be involved with the project before, during, and after the event. Communication with participants and stakeholders in the project is essential to co-production of knowledge, as participants need to stay informed with the project to co-produce with the research team.

Human Subjects Research Training and Institutional Review Board Process

Several members of the Arctic Rivers research team, including myself, enrolled in and completed a Collaborative Institutional Training Initiative (CITI) program in Human Research for Social Behavioral Research Investigators and Key Personnel. This Human Subjects Research training provided background on the history of human subjects research, criteria for evaluating what is considered to be human subjects research, and how to conduct this type of research according to good ethical practices. Enrolling in the CITI Program training was essential to ensuring that research team researchers had the *Capacity* to work with Indigenous community members, and was also a part of conducting research in an *Ethical* manner.

An Institutional Review Board (IRB) application was filed at the University of Colorado, Boulder to conduct human subjects research at the Arctic Rivers Summit, in the form of Inform the Modeling and participatory mapping sessions. Despite the research team being informed that an IRB was not required for their research, in efforts to operate in the most *Ethical* possible way in regards to the sensitivity of Indigenous Knowledge and knowledge holders, the research team moved forward with the IRB process. While western science institutions do not necessarily consider environmental research to be human subjects research, in many Indigenous worldviews, activities impacting the environment have significant human impacts that must be considered when scientists want to conduct research in Indigenous homelands (Ellam Yua et al., 2022). The research team voluntarily engaged in the IRB process, seeking review for the Summit research process by an external institution at the University. Opting for voluntary review was a part of *Ethical* engagement in the research process with respect for Indigenous *Sovereignty*.

Scholarships and Event Funding

In order to ensure that Summit participants had appropriate *Means and Ability* to attend the event, scholarships were offered to nearly 40 Indigenous participants to join the Summit. In the Summit application process, participants were asked whether they had institutional support from an organization, agency, or tribal council to attend the event (Arctic Rivers Summit, n.d.). For those who indicated that they did not have institutional support, participants were asked what they would require in order to attend the event. Scholarships were provided to all Indigenous Summit participants who indicated that they needed assistance for any combination of hotel accommodations, airfare, and meals at the Arctic Rivers Summit. Scholarship funds were also

utilized to bring Indigenous speakers and Indigenous Advisory Council members to Anchorage for the Summit (Arctic Rivers Summit, n.d.).

The scholarship process was essential to creating an *Equitable* process that made it feasible for key stakeholders to attend the event. The existence of these scholarships recognized differences in *Means and Ability* to attend the Summit, and supplied the necessary resources and *Capacity* in order to ensure that all stakeholders who wanted to attend could join without excessive financial burden. This was a vital aspect of bringing diverse voices to the table to discuss the current and future state of Arctic Rivers.

The scholarship funds given to Indigenous participants were allocated in the Arctic Rivers Project's Navigating the New Arctic Grant from the National Science Foundation. Additional funding was provided by the First Nations Institute to provide broad financial support for participants to attend. Ensuring that scholarship funding for Indigenous stakeholders was factored into the original grant application for the Arctic Rivers Project. Putting this scholarship funding into the grant was essential to ensuring that the Arctic Rivers research team had appropriate *Capacity* to bring all necessary stakeholders to the table at the Arctic Rivers Summit.

Arctic Rivers Summit Scheduling

After being rescheduled from its original date in March 2022 due to COVID-19-related complications, the Summit was scheduled for December of 2022. This is in part due to the fact that summer is an extremely busy time in the majority of Alaska Native communities, making a winter gathering easier for people from these communities to attend. The long daylight hours of summer make for a busy time for communities in the Yukon River basin, as it is frequently a time in which fish camp and other intensive subsistence activities occur. The short time window of summer is thus an inconvenient time for people who live subsistence lifestyles to leave their communities. Ensuring that the date of the event was convenient for people in study region communities was key to bringing important stakeholders to the table. Factoring in the availability of participants demonstrated attention to the *Means and Ability* of those attending.

Research Team Preparation and Decolonization Training

The Arctic Rivers project team held several team meetings before the Arctic Rivers Summit focused on cultural competency and good co-production practices. A participatory mapping training was held at one of these project team meetings to familiarize team members with how a participatory mapping process works prior to engaging in the activity at the Summit. These *Capacity*-building activities were intended to equip research team members with the appropriate tools, education, and training for working with Indigenous communities.

All Arctic Rivers research team members were required to complete a decolonization training from NativeMovement, an Indigenous non-profit organization dedicated to providing education on colonialism's impacts on Indigenous people (Untangling colonialism, 2023). This training was self-paced and completed by team members prior to the Summit in efforts to ensure that the team was familiar with the basic history and ongoing process of colonization in Alaska

and the United States. This training, entitled “Untangling Colonialism,” covered the history of colonialism, federal and state policies related to colonialism in Alaska, the conservation movement’s connection to white supremacy, and tools for moving forward in the process of decolonization (Untangling colonialism, 2023).

Engaging in this NativeMovement training was a part of building research team *Capacity* providing research team members the opportunity to self-educate regarding the impacts of colonialism, boarding schools, and white supremacy on Indigenous people. While one training is not sufficient for understanding the myriad impacts of colonialism, this training provided essential background information to research team members. This was an effort to self-educate regarding a painful and sensitive ongoing process and history of colonialism that is pertinent to understand when working in Indigenous communities. Self-education is essential to avoid burdening Indigenous communities with teaching western researchers about this painful history.

Arctic Rivers Summit Events

The Arctic Rivers Summit began on December 6, 2022 in Anchorage, Alaska, in the midst of a massive snow storm. During the limited daylight hours of Alaska in December, a group of 85 participants gathered at the Alaska Native Heritage Center for the Arctic Rivers Summit. At least 85 people attended the event, in addition to the Arctic Rivers project team, with 56 participants identifying as Indigenous. 38 First Nation and Alaska Native communities were represented, in addition to eight federal, state, and tribal agencies, seven non-profit organizations, five universities, and six Indigenous Advisory Council members.

Opening Blessing and Knowledge Exchange: Elder Share

To begin the event, a welcome, introduction, land acknowledgement, and opening blessing was given prior to any other activities. In many Alaska Indigenous cultures, gatherings begin and end with a blessing. Ensuring space for an opening blessing for the event was a means of demonstrating and establishing *Trust and Respect* among participants and research team members from a wide variety of backgrounds. This opening blessing, land acknowledgement, and discussion of the impacts of colonialism on Indigenous people was also a part of *Decolonizing* the event. These were vital sessions for engaging in a co-produced event, and setting the tone for co-production of knowledge with *Equity* at the forefront.

The first session of the Summit, following the opening blessing, was an Elder Share in which a panel of Indigenous Elders were invited to open the event and speak freely about the knowledge they wished to share with the participants at the Summit. This allowed the Elders the opportunity to set the tone for the event, creating an open space for Elders to share their perspectives and thoughts regarding Arctic rivers, fish, communities, and other knowledge that they hoped to pass on to Summit participants. Three panelists were selected to begin the session, with the floor opened up to other Elders who were present after the panelists spoke.

Giving Elders the opportunity to share first is customary in many Alaska Native traditions, as Elders are regarded as the knowledge bearers and teachers in these communities.

Thus, this knowledge exchange was intended to build and show *Trust and Respect* among Summit participants, Elders, the Indigenous Advisory Council, and the research team. This is showing respect both for the Elders in the room, and to the cultural traditions of many participants in the room for whom making space for Elders to speak first is expected. This was also a part of ensuring that Elder voices were a part of the *Problem Definition* process at the Summit, guiding the conversations surrounding problems in co-production of knowledge and the health of Arctic rivers and the communities who have lived near and with them for time immemorial.

Pre-Summit Survey

Participants were provided with a pre-Summit survey in their Summit registration packet, which they were asked to fill out and submit during the event. The survey is included in Appendix E. This pre-Summit survey asked participants what organization or community they were representing and their goals for the event. The survey also asked about participants' familiarity with knowledge co-production, Free, Prior, and Informed consent, and feedback on project co-production protocols. Additionally, it asked participants to evaluate the Summit website and the information available on it (Appendix E). This survey was designed to inquire whether participants had reviewed the co-production of knowledge and data-sharing protocols for the project, and what their expectations and understandings were going into the event. Additionally, asking questions regarding familiarity with Free, Prior, and Informed Consent was a part of engaging *Ethically* (Appendix E). The pre-Summit survey was also a part of being *Deliberate and Intentional*, referring back to documentation of ethical guidelines and allowing participants to express their goals for the event.

Arctic Rivers Project Overview

During this Project Overview session, principal investigators from the University of Colorado, Boulder, gave a presentation regarding the current status of the Arctic Rivers Project to update the group on what had already happened in the project, and what was to come. This project overview discussed the Arctic Rivers Project's research questions and goals, which were co-developed with the project Indigenous Advisory Council. This project overview summarized key points from the *Problem Definition, Question Identification, and Method Development* process co-produced by the Indigenous Advisory Council and research team. It was also intended to target good *Communication* of the project and the science in a transparent and open, culturally appropriate, and understandable manner.

Free, Prior, and Informed Consent

As per the Institutional Review Board application that was filed prior to the Summit, which reviewed the research process and gave permission to engage in research activities with human subjects at the Arctic Rivers Summit, a session was dedicated to establishing Free, Prior, and Informed consent of participants to partake in research (Appendix B). The informed consent

release for research activities is included in Appendix B. These research activities included the three “Inform the Modeling” sessions, which consisted of two participant mapping exercises and focused discussions. A Free, Prior, and Informed Consent (FPIC) protocol was read by principal investigators on the research team to all Summit participants to inform them of their rights to opt in or out of the research process. The FPIC information outlined the following:

- 1) How research study activities would be conducted
- 1) The type of information that research participants would be asked to share
- 2) How information would be utilized and shared
- 3) Research participant opportunities to review information derived from the study
- 4) Information regarding ability to leave research sessions at any point
- 5) How to opt in to the informed consent form (Appendix B)

Finally, opportunities to ask questions of research team members were provided after reading the protocol. The FPIC process was key to *Ethical* practice of research activities, outlining how the *Gathering of Information* would occur during the session, and how *Control of Information* would work after research was completed. Providing participants with information regarding how the information they share could be used was essential to *Ethical* research practices, especially in the context of a co-produced project where all participants’ voices should be factored into research activities.

Inform the Modeling: Participatory Mapping Sessions

After providing information regarding Free, Prior, and Informed consent, Summit attendees were divided into regional groups for two sessions of participatory mapping activities. Those who did not come from a particular region in Alaska were either assigned to a region they were familiar with through their work, or were randomly assigned to one. These two participatory mapping sessions were intended to gather information related to fish and river ice along the Yukon River and its tributaries to inform the modeling being conducted by the research team. These sessions were entitled River Transport Through the Seasons and Fish Through the Seasons (Appendix D).

The purpose of Fish Through the Seasons was to discuss and map knowledge of fish species, habitat factors, and fish locations throughout the Yukon River basin and other river drainages in Alaska. The most important information solicited during this session involved the identification of priority subsistence fish in the Yukon River basin to determine which fish futures should be modeled by the research team in their Fish Bioenergetics models. Other information generated in this participatory mapping session was intended to inform other parts of the fish modeling in the Arctic Rivers Project.

During these Fish through the Seasons sessions, group members introduced themselves, and facilitators guided a 35-minute discussion according to the prompts outlined below. In the Fish Through the Seasons sessions, facilitators were instructed to ask groups to share the priority information outlined in Table 6.

Table 6: Data collection categories and prompts for Fish through the Seasons discussions and participatory mapping sessions. These prompts were given by facilitators before releasing participants to begin mapping exercises. Full protocols for mapping activities are provided in Appendix D.

Knowledge of Fish Species and Timing	Fish Location and Habitat Knowledge	Knowledge of Changes in Fish Health
Species harvested in communities across Alaska	Type of rivers in which species are found	Indicators of fish health
Timing of harvest for fish	Important locations for different life stages of fish	Changes in fish health
Changes in timing of fish harvest	Why these locations are important for fish survival	Change in juvenile and nest abundance
If fish are harvested based on age or size	Changes in timing of spawning and migration	Differences in age or size of harvested fish
	If particular fish species are found together	
	Changes in where fish are found	

The purpose of the River Transport Through the Seasons was to identify knowledge and information about winter trails along rivers and river ice quality. This information was intended to inform river ice modeling in the Arctic Rivers Project with the goal of identifying priority river and stream reaches for ice modeling.

During these sessions, group members introduced themselves, and facilitators prompted a 35-minute discussion according to the prompts outlined below. In the River Transport Through the Seasons sessions, facilitators were instructed to ask groups to share the priority information outlined in Table 7.

Table 7: Data collection categories and prompts for River Ice through the Seasons discussions and participatory mapping sessions. These prompts were given by facilitators before releasing participants to begin mapping exercises. Full protocols for mapping activities are provided in Appendix D.

Winter Trail Knowledge	Ice Quality Knowledge
Percentage of community who travel over river ice	Observed changes in river ice
What mode of transportation people use to travel over river ice	Locations where the river never freezes
Where people travel via river ice	Obstacles encountered when traveling over ice
Typical months for travel over river ice	Places that freeze early or late
How ice trails are established each year	Years that ice was thin, or with more open water
	Communication of river ice safety issues

After a 35-minute discussion of these topics in their respective fish and ice sessions, participants were instructed to decide which features they wanted to draw onto pre-printed regional maps of Alaska and western Canada. These features were intended to reflect key parts of the discussions held before the mapping sessions. Maps of each region were printed at multiple scales. Each group then was instructed to create a legend to represent the features that they wanted to represent on their maps. For example, a group may have decided to map out important juvenile salmon spawning locations. The group would then decide that they would represent these locations with a red dot. Different symbols for the various features participants chose to map were agreed upon by groups and written on a legend at the front of the room (Appendix D).

Participants were then provided 15-20 minutes to map out the features that they had identified on their regional maps. This mapping was conducted collaboratively within the group, with multiple people working on each map. Participants were given full discretion on whether they wanted to participate in mapping, and what they wanted to draw on the maps (Appendix D).

These participatory mapping activities at the Arctic Rivers Summit involved event participants in fish and river ice modeling by providing on-the-ground observations of changes in rivers and identifying priority regions for research and modeling efforts. The mapping activities helped researchers identify fish species of interest to communities to develop the most useful

possible fish models. Asking for more information regarding important fish species to map and important river reaches involved Summit participants in *Problem Definition*— that is, ensuring that the research team was asking the right questions about the right places. *Problem Definition*, in this context, is an iterative process involving asking questions, discussing those questions with stakeholders, and revising them in order to provide more useful and usable information.

These Inform the Modeling sessions were also focused on practicing *Reciprocity*. Practicing *Reciprocity*, in this case, meant ensuring that information being provided by the research team is useful to communities in the study region. Providing useful information hinges on asking the correct research questions guided by good practices in the *Problem Definition* process. Fish Through the Seasons sessions solicited Indigenous indicators of ecosystem health to factor into the research and modeling process. These sessions provided an arena for stakeholders beyond the Indigenous Advisory Council to provide input on their indicators and methods for understanding change and places in which more information from the research team would be useful.

Tour of the Alaska Native Heritage Center

During the afternoon rotation, Summit participants were guided by a Culture Bearer at the Alaska Native Heritage Center on a one-hour long tour of traditional dwelling places of Indigenous people in Alaska. Participants had the opportunity to experience six re-created Indigenous dwellings representing a variety of regions and cultures across the state. These six dwellings were sited around Lake Tiulana, in the space behind the Alaska Native Heritage Center. The Culture Bearer spoke about traditional lifeways of Indigenous people who would have lived in each dwelling type, highlighting the many innovations and lifeways of each cultural group. This tour was a part of establishing *Trust and Respect* by honoring the cultural heritage of Indigenous participants at the Summit through celebration of Indigenous history. It also provided education about Indigenous cultural groups and lifeways in Alaska to participants from a western background.

Knowledge Exchanges: Status of Arctic Rivers and Weaving Together Indigenous Knowledge and Western Science and Management

The Status of Arctic Rivers Knowledge Exchange involved a Question-and-Answer session with a panel of Indigenous experts with vast experience and knowledge of Arctic rivers. This knowledge exchange focused on their perspectives on the current status of Arctic rivers. Speakers engaged in story-telling in order to communicate their observed changes and knowledge of these rivers. During the knowledge exchange entitled Weaving Together Indigenous Knowledge and Western Science and Management, a panel of Indigenous speakers and managers spoke about their work and perspectives regarding incorporating Indigenous Knowledge and Western Science in management contexts. This knowledge exchange highlighted the perspectives of Indigenous professionals in environmental management positions, focused on

real-world use of knowledge co-production and the integration of Indigenous Knowledge in western management frameworks.

These sessions of the Summit highlighted *Equity* and *Empowerment*, elevating the voices of Indigenous experts in the Arctic Rivers science, Indigenous Knowledge, and management space. These panel discussions highlighted the importance of Indigenous Knowledge and knowledge holders in environmental work related to Arctic Rivers. They also made space for inclusive knowledge sharing from multiple knowledge systems. Both knowledge exchanges focussed on culturally appropriate and understandable *Communication* of the current status of Arctic Rivers and their management through Indigenous Knowledge and western science.

Strengths, Weaknesses, Opportunities, and Threats Analysis

A Strengths, Weaknesses, Opportunities, and Threats Analysis (SWOT analysis) is a methodology utilized in the business sector to guide strategic planning. The methodology is used to identify factors vital to developing a comprehensive plan for action regarding a problem or challenge that an organization may face. A SWOT analysis examines both external and internal factors that could impact an organization or problem, in addition to current and future problems and opportunities the organization could encounter (Kenton, 2022).

While SWOT analysis is most frequently used in the business sector, the process can also be utilized as a systematic methodology for assessing environmental and socio-cultural issues. At the Arctic Rivers Summit, the SWOT analysis process was utilized to identify Strengths, Weaknesses, Opportunities, and Threats for four topics of interest to the Arctic Rivers research team and the project's Indigenous Advisory Council (Institute for Tribal Environmental Professionals, n.d.). This process brought a wide range of stakeholders to the table to discuss multifaceted issues, ensuring that diverse perspectives were brought to the table and given equal weight during discussion.

SWOT analyses conducted by these breakout groups at the Summit were intended to be utilized as the basis of Action Plans for addressing the multidimensional environmental and human challenges being studied by the Arctic Rivers Project. The SWOT analysis methodology was chosen by the Institute for Tribal Environmental Professionals to solicit information used to develop Action Plans for Rivers, Salmon, Co-Production of Knowledge, and Building a Bridge of Traditional Knowledge at the end of the Summit (Institute for Tribal Environmental Professionals, n.d.).

Developing these Action Plans from SWOT analysis results were a part of fostering community *Empowerment*: that is, providing a road forward for addressing problems with collective action. Building Action Plans was identified as a high priority for the Indigenous Advisory Council during pre-Summit meetings as a way to bring stakeholder communities together to take initiative on common goals. This Summit deliverable was essential to paving a road forward after the event.

Below, I outline the process of this SWOT analysis, and define Strengths, Weaknesses, Opportunities, and Threats in the context of this exercise.

Table 8: SWOT Analysis component breakdown, defining Strengths, Weaknesses, Opportunities, and Threats in the context of this exercise (Institute for Tribal Environmental Professionals, n.d.)

Strengths	Strengths are defined as current factors that are helpful in achieving the desired state of affairs
Weaknesses	Weaknesses are defined as current factors or actions that are presenting challenges in achieving the desired state of affairs.
Opportunities	Opportunities are defined as future factors that are helpful in achieving the desired state of affairs
Threats	Threats are defined as future factors or actions that are presenting challenges in achieving the desired state of affairs.

Participants were encouraged to consider the following factors in their SWOT analysis (Institute for Tribal Environmental Professionals, n.d.):

1. Laws and policies
2. Environmental and biological factors
3. Social factors and Indigenous Knowledge
4. Technology and infrastructure
5. Economic factors
6. Research, monitoring

The four SWOT analysis groups were dedicated to the following topics (Institute for Tribal Environmental Professionals, n.d.):

1. State of Rivers
2. State of Salmon
3. Partnering Indigenous Knowledge and Western Science for Management
4. Youth and Elders: Building a Bridge of Traditional Knowledge

For this exercise, participants at the Summit self-selected into their breakout group, and stayed with the same group for both days of the exercise. Groups varied in size and composition

depending upon the results of self-selection: while some groups were composed mostly of Indigenous community members, others were composed of primary western managers or scientists, or had an even split. Each breakout group featured at least one facilitator to guide discussion through the SWOT framework. Group facilitators were instructed to follow the protocols listed in the Arctic Rivers Summit Facilitator Guide (Institute for Tribal Environmental Professionals, n.d.).

Sessions began with introductions to one another and to the activity at hand. Next, participants were instructed to write and/or draw their vision for the future of their topic on a Post-it note. Participants were instructed to think about what they would like to preserve, add in, remove, or keep out in the context of their topic. This was followed by a discussion of the differing and converging visions that participants had (Institute for Tribal Environmental Professionals, n.d.).

Next, participants were told to write down strengths related to their topic on a Post-it note. If participants needed more than one Post-it note to express their opinion, they were given extras. Post-it notes were added to a large easel pad with “Strengths” written across the top. Facilitators read through these “Strengths” and opened the floor for discussion to ensure that all thoughts and perspectives were added to the easel pad. Participants were given time to discuss, add Post-it note responses to the pad, and share experiences. In some breakout sessions, facilitators listed key themes that surfaced multiple times in individual responses. After the “Strengths” section was completed, the same process was repeated for Weaknesses, Opportunities, and Threats (Institute for Tribal Environmental Professionals, n.d.).

The SWOT analysis process emphasized *Trust and Respect* for observations and knowledge from both Indigenous Knowledge systems and western science, ascribing equal value to knowledge from both systems. This process involved Summit participants from diverse lived knowledge, management, and scientific backgrounds in the *Problem Definition* process, identifying Strengths, Weaknesses, Opportunities and Threats for their breakout group topic. This Problem Definition process involving a wide array of stakeholders is useful for guiding the process of *Identifying Questions* for research that are relevant, usable, and useful.

The development of Action Plans based on factors identified in the SWOT analysis process encouraged continued *Relationships* and long-term commitments to work together on challenges impacting Arctic rivers and the people who depend on them. This process also fostered opportunities for *Empowerment*, encouraging and mobilizing stakeholders with tools and relationships to take action. The development and sharing of these Action Plans are a part of the *Communication* of Summit deliverables. These plans should be useful and usable to stakeholders, with diverse voices factored into the process of creating them.

Inform the Modeling: Climate

During the Inform the Modeling: Climate session, a brief presentation was given by western scientists on the Arctic Rivers research team regarding the climate, river, and fish modeling being conducted by research team members on the Arctic Rivers Project. The

presentation addressed background information on anthropogenic climate change, and outlined the goal of the project to provide more targeted climate, river ice, and fish models for the Yukon River basin than the current low-resolution models that currently exist for Alaska.

After this presentation, facilitators prompted discussion to ask community members about what information they hoped to learn from the models, how they would use the type of information, and how it could best be presented and provided to communities. The following questions were presented for discussion.

Table 9: Discussion questions for Inform the Modeling: Climate usefulness and communication data collection

Usefulness and Communication of Climate Data
How will you use estimates of future climate, river, and fish information?
Existing climate products are freely available on websites to view and for download. Is this the best way to provide data?
Is it helpful to have a range of possibilities, or is it best to have a single “best guess” or average?
What are your questions for the climate modelers?

This Inform the Modeling session was intended to define the information that communities wanted to learn from models generated by the Arctic Rivers Project. Thus, an emphasis of this session was focused on *Problem Definition* from the community, soliciting what type of information community members need and want for adaptation planning in a changing climate. Gathering information regarding how data from the project should be presented in order to be most useful for people living within the study region was an essential part of *Problem Definition*. This session also focused on *Reciprocity*, identifying information that would be most useful to communities and making sure that research products are informed by community needs.

Additionally, during this Inform the Modeling session, facilitators inquired about the type of *Communication* of model results that would be useful to communities. Asking how to communicate results in a way that communities understand is paramount to creating useful and usable knowledge for the future. While a wide array of climate data for Alaska and western Canada already exist, useful information communicated in ways that are understandable and accessible to managers and planners within communities is necessary for this information to be factored into management.

Closing Banquet and Post- Summit Survey

On the last day of the Summit, a closing banquet was held at the Lakefront Anchorage hotel. This closing event offered an opportunity for participants to share food, stories, and reflections on the Summit and all of its sessions, proceedings, and take-aways. Sharing a meal is a customary way of building *Relationships* in both western and Alaska Native cultures. One goal of bringing together a wide variety of stakeholders from different backgrounds and positionalities was creating an opportunity for continued connections and coalition-building. A closing banquet provided space to establish and build these connections and *Relationships*.

A post- Summit survey was distributed at the closing Banquet for participants to evaluate the Summit. This survey is included in Appendix F. It was also emailed in a digital version to participants at the close of the event. The post- Summit survey gave participants a space to provide feedback on the event as well as their understanding of knowledge co-production, free, prior, and informed consent in the context of the Summit (Appendix F). Other questions in this survey asked participants if they had a full understanding of how their knowledge would be protected, and then provided an opportunity to redact any knowledge shared at the Summit, in accordance with the Data-Sharing protocols shared prior to the event. Finally, the survey asked participants to indicate whether they wanted to contribute to any Fish, Ice, or Storyline project components in the future (Appendix F). Participants were also asked if they wanted to participate in the deliverables being produced from the Summit, including the Summit White Paper, Action Plans, and Modeling Reports.

The post-Summit survey gave participants an opportunity to redact information they shared according to the Data Sharing Protocols, ensuring that *Ethical* guidelines were followed. Additionally, the protocol ensured that participants would have the opportunity to provide feedback on the event, a form of *Reviewing Results* for the gathering.

Summit White Paper

Proceedings, take-aways, and knowledge exchanged during the Arctic Rivers Summit will be summarized in a Summit White Paper. This document will be available to all participants and the public in the year following the event. When the Arctic Rivers Summit White Paper is released, participants will be given the opportunity to *Review Results* shared in the document. Participants will also be given co-authorship credit if they wish, to ensure proper attribution for their knowledge (Arctic Rivers Summit, n.d.). This is a part of putting *Equity* at the forefront of the research process.

The publication of this White Paper is essential to ensuring that all knowledge generated during the Summit is useful, usable, and publicly available. To meet the goals set by the Indigenous Advisory Council for the Arctic Rivers Summit, good *Communication* of the event's proceedings is essential. Compiling and sharing the knowledge generated during the event is necessary in order to move the needle on the many challenges and threats to the rivers and communities who depend on them in the Yukon River basin.

While some knowledge generated during the Summit is specific to the Arctic Rivers Project study region, stakeholders from all across the state of Alaska and western Canada were present to voice their concerns and observations of changes in fish and rivers at the Summit. Thus, the knowledge generated at the event is widely applicable to co-production efforts between western researchers and Indigenous communities, and sharing this knowledge will be useful for future projects and collaborations.

Discussion

Co-Production of Knowledge and Collaboration on Multiple Scales

In this work, I sought to understand how co-production of knowledge principles and practices were applied and utilized in the planning, preparation, and execution of the Arctic Rivers Summit in Anchorage Alaska, December 6-8, 2022. To do this, I utilized Ellam Yua et. al 2022's framework for understanding the principles and practices necessary to co-produce knowledge with Indigenous communities in the Arctic region. To analyze the ways in which these principles and practices were applied at the Arctic Rivers Project's Arctic Rivers Summit, I outlined a narrative of the planning and preparation process for the event, and how and where these principles were demonstrated. I then wrote a narrative of the agenda and sessions at the Summit itself, and analyzed the ways in which these sessions exhibited principles of the framework. Finally, I looked at the actions taken post-event to see where co-production principles were applied. My findings were discussed in full, with finding summaries presented in Tables 4 and 5. While these tables are not exhaustive of all the ways that these principles and practices were applied at the Summit, they provide pertinent examples of how one might think about applying co-production principles in planning an event of this type.

I found that all of the co-production of knowledge principles and practices outlined in the Ellam Yua et al., 2022 framework were demonstrated in the planning, preparation, and execution of the Arctic Rivers Summit, with numerous examples of each principle and practice being applied. Breaking down how parts of Summit preparation and the event itself demonstrated principles and practices of the framework allowed me to answer my research question regarding how these principles and practices were applied. However, in efforts to dig deeper into understanding how these principles were applied, I wanted to understand the *extent* to which co-production of knowledge principles and practices were applied at the Summit. Extent, for the purposes of this work, is defined as the amount the project team engaged with co-production principles and practices throughout the process (Latulippe & Klenk, 2020).

Analyzing the extent to which co-production of knowledge principles were employed is essential to avoid an "extractive approach" to utilizing Indigenous Knowledge in research (Latulippe & Klenk, 2020, 8). Often, when Indigenous Knowledge Holders are consulted in western academic research projects, there is an expectation of either using Indigenous Knowledge to validate western science or treating Indigenous Knowledge as a resource as opposed to a whole knowledge system rooted in a community of people and a place (Latulippe & Klenk, 2020). This extractive approach to using Indigenous Knowledge reinforces colonial research regimes. I look at the extent to which co-production practices from the Ellam Yua et al.,

framework were utilized to avoid using the framework as a list of boxes to check as opposed to the iterative process knowledge co-production ought to be (Ellam Yua et al., 2022)

Thinking about the extent to which co-production of knowledge practices were employed is also necessary for distinguishing co-production from collaboration. In the introduction to this work, I outlined the difference between co-production and collaboration, according to Ellam Yua et. al (2022). Co-production of knowledge involves working together with understandings of reciprocity and equity, with project lifespan involvement of communities and researchers throughout the entirety of the knowledge production process. This cycle of community involvement begins with building *Relationships* and *Identifying Problems*, and ends with *Reciprocity* and opportunities to *Review Results*, cycling through as many iterations of the circular process as are necessary (Ellam Yua et al., 2022).

Co-Production of the Arctic Rivers Summit: the Indigenous Advisory Council, the Research Team, and the Institute for Tribal Environmental Professionals.

Analyzing the extent of co-production of knowledge led me to a question that encircled all of my research: who, within this project, could be considered true co-producers? I found that the Arctic Rivers Summit was a co-produced event planned and executed by the Arctic Rivers research team, the Institute for Tribal Environmental Professionals, and the project Indigenous Advisory Council. Throughout the Summit's planning and execution, a wide array of co-production principles and practices were utilized to inform and build the event from the ground up. The research team, the Institute for Tribal Environmental Professionals, and Indigenous Advisory Council members were engaged in the beginning-to-end process of setting Summit goals and objectives. They were then involved in building an agenda to meet those goals and objectives informed by multiple knowledge systems and perspectives. They then brought these goals to life at the Arctic Rivers Summit, which many members from this group helped facilitate in Anchorage.

The Indigenous Advisory Council's role throughout the lifespan of the Summit was paramount to ensuring that co-production principles in the Tools and Concepts circle of the framework were employed throughout the process. With the root of long-term commitment to the project, the Council and research team had opportunities to build *Relationships* with *Deliberate and Intentional* dedication to the co-production of knowledge process. *Ethical* guidelines for co-production helped ensure that pre-established expectations were set between co-producing parties (Andre et al., n.d.). Good *Relationships* built between the research team and the Council emphasized *Equity*, *Sovereignty*, and *Decolonization* in interactions with one another and decision-making processes. These *Relationships* also allow for the development of *Trust and Respect* for one another's knowledge system. Building these *Relationships* also depended upon the *Capacity* of co-producing parties to commit to the project and to one another. *Capacity* included acknowledging and mitigating differences in *Means and Ability* between the research team and the Council. Finally, the *Empowerment* of the Indigenous Advisory Council as a key component of the Arctic Rivers Project is essential to their role as co-producers of knowledge.

The presence of all of these interconnected principles are rooted in *Relationships*. The same people involved in the planning and implementation of the Summit will be the same people involved in synthesizing, reflecting upon, and applying the knowledge generated at the event. Many of these people involved in planning the Summit will continue to be involved in the Arctic Rivers Project throughout its lifespan. These long-term commitments are an essential component of knowledge co-production because they allow the time to build the *Equity* and *Trust and Respect* required in *Relationships* from which co-production can occur.

Despite the Indigenous Advisory Council's key role in setting the priorities and agenda of the event, the idea of holding a Summit was planned by the research team during the National Science Foundation grant application process, not in Indigenous Advisory Council meetings. Because of this, before forming and involving the Indigenous Advisory Council in Summit planning, the event was envisioned with some predetermined sessions. This is an example of the ways in which academic funding structures limit the ability of western scientists to co-produce knowledge with Indigenous communities— grant applications inform priorities, often before building *Relationships* with Indigenous co-producers. The grant application process and time scales of academic funding structures are often at odds with building the *Relationships* necessary for co-production of knowledge. This is in part because grants for research activities are often applied for prior to community engagement, contrary to *Problem Identification* occurring at the ground level with all stakeholders in the room. Additionally, project time scales put timelines on *Relationship* building. These limitations to co-production induced by grant structures were present in the Arctic Rivers Project and the Summit event.

Another limitation to co-production of the Arctic Rivers Summit and knowledge produced during the event is that while the Indigenous Advisory Council is an essential part of the project team, the research team is composed primarily of western scientists, not Indigenous Knowledge holders. While the Council played a key role in the planning, preparation, and execution of the Arctic Rivers Summit, the Arctic Rivers research team is not Indigenous-led, but rather, advised and informed by Indigenous Knowledge holders. Co-production efforts from western science institutions should balance the idea of moving over and making room for Indigenous Knowledge holders with providing institutional *Capacity*, funding, and western science methods to aid in addressing multi-faceted problems (Latulippe & Klenk, 2020). This said, striking the balance, avoiding extractive research, meaningfully supporting Indigenous *Sovereignty*, and truly co-producing knowledge through *Equitable Relationships* is no simple task.

Collaboration at the Arctic Rivers Summit: Participant Engagement

The Arctic Rivers Summit brought together stakeholders from across Alaska and western Canada to provide useful research products informed by the needs of Indigenous people, managers, and scientists across the region. The focus of the Summit event was increasing collaboration and input from stakeholders, rather than co-production of knowledge with participants. The Summit facilitated successful collaboration across a wide range of Indigenous

Knowledge Holders, managers, and scientists to better inform the Arctic Rivers Project modeling and science communication. Individual Summit sessions were less focused on co-producing knowledge themselves, but informing the priorities and research questions established by the Arctic Rivers Project team. These sessions also contributed to redefining the *Problem* and asking the right *Questions* in the context of a broader array of stakeholders.

This process demonstrated the circular nature of *Problem Definition* and *Question Identification* in the context of co-produced research intended to be useful and usable to stakeholders. The Summit provided space to modify and revise these research questions to produce actionable research answering the questions of a wider audience. Asking the right questions, based in the needs of communities, is integral to co-production of knowledge. While the Indigenous Advisory Council had been essential to this *Problem Definition* and *Question Identification* process prior to the Summit, the event solicited opinions and observations from a wider range of stakeholders in the field who could share knowledge and experiences from their own communities and places of work.

The Summit also served as a venue to build *Relationships* for future co-production of knowledge projects. Opportunities to build *Relationships* across disciplines, agencies, and communities are often sparse as a result of disconnect between stakeholder groups. Multidisciplinary projects such as the Arctic Rivers Project can serve as a touchstone for collaboration between groups who may not otherwise have the chance to discuss their successes, challenges, and experiences in intersecting fields. Enhancing *Communication* between people who conduct river research, have vast, intergenerational knowledge of river systems, make decisions about the management of these systems, and enforce policies for them is vital for improving the management outcomes for river systems and the people who depend on them.

The Scalability of Knowledge Co-Production

In this research, I hoped to study the scale at which knowledge co-production is possible, and the challenges presented when working with numerous stakeholders from different backgrounds and knowledge systems. In order to do this, I analyzed why only the Indigenous Advisory Council, the Institute for Tribal Environmental Professionals, and the research team members working with them can be considered co-producers of the Summit event and other knowledge generated within the project, and why it would be most accurate to define participants at the Summit as collaborators. Application of the Ellam Yua, et al. (2022) framework indicates that Summit participants are indispensable collaborators, rather than co-producers. This said, these collaborators have opportunities to connect and co-produce with the Arctic Rivers Project and one another moving forward.

Co-production of knowledge is difficult to execute on a large scale because of the many preconditions and extensive time and *Relationship*-building needed to produce knowledge in concert. Building long-term *Relationships* between researchers and communities requires that all other aspects of the Tools and Concepts for Knowledge Co-Production are met: *Equity, Deliberate and Intentional, Trust and Respect, Means and Ability, Capacity, Ethical,*

Decolonization, Sovereignty, and Empowerment. These principles must then be applied to all of the action items within the framework's Action Circle: *Reciprocity, Communication, Control of Information, Problem Definition, Identify Question, Develop Methods, Gather Information, Information Analysis, and Review Results* (Ellam Yua et al. 2022).

For this reason, it is difficult to consider Summit participants without long-term involvement to be project co-producers. If they stay involved with the project, however, with commitment to the principles outlined above, they can certainly become co-producers. Opportunities to stay involved were presented in the Post-Summit Survey, and the participants who indicated interest in co-production will be contacted following the Summit.

Embedded in this idea of co-production scalability is a mismatch between the scale of the event, and the scale at which co-production can successfully occur. The difficulties of scaling up co-production of knowledge efforts has been observed in other co-production and usable science research. Dilling et al., describe the challenges associated with increasing the number of people involved in a co-production project as “time-intensive, costly, and difficult to scale up” (Dilling et al. 2021, 1). They also note that *Capacity* to engage is an important hindrance to scalability of knowledge co-production (Dilling et al., 2021).

While collaboration is feasible at the scale of Summit sessions, co-producing knowledge at the same scale, and in the context of new *Relationships* without an established basis of Tools and Concepts circle principles is significantly more difficult. If the aim was to co-produce knowledge with every participant at the Arctic Rivers Summit, this would mean that each participant would need to be intimately involved with every step of Action Circle project processes from start to finish. At the scale of nearly 90 Summit participants, two countries, a large multi-disciplinary research team, and a diverse array of Yukon River basin communities, involving all Summit participants in project decision-making from start to finish is nearly impossible.

Relationships are paramount to the Arctic Co-Production of Knowledge framework (Ellam Yua et al., 2022). Because *Relationships* take time to build and involve immense energy to grow and maintain, co-production scalability is limited, whereas the scalability of collaboration is not. While the Arctic Rivers Summit emphasized *Relationship* building, the depth to which relationships can be built in a three-day period is limited. The Summit, however, provided an opportunity to begin the co-production of knowledge process between stakeholders. The limited scalability of knowledge co-production is one of the many challenges of the process, and also poses important questions regarding who to co-produce with in order to increase the usability of research products.

Conclusion

While collaboration is built on input and consultation, co-production is a process of collaborating on all parts of Ellam Yua's Action Circle components of knowledge production, with all actions informed by the Tools and Concepts Circle (2022). This process requires intimate involvement between co-producers in every step of knowledge-production and

extremely high *Capacity* on the part of all co-producers. The process also involves constant *Communication*, equal voices in decision-making, and deep *Relationships* between co-producers. Especially on a large scale, co-production of knowledge is extremely difficult to practice. The most prominent challenges associated with the scalability of co-production of knowledge projects are related to the *Capacity* and *Means and Ability* of both researchers and Indigenous communities to fully invest in the process from start to finish. This challenge is amplified by funding structures and availability to support co-production of knowledge projects, and the inequities and injustices facing Indigenous people as a result of colonial impacts.

This said, the Arctic Rivers Summit serves as an example of how an event can be co-produced by Indigenous Knowledge holders and western scientists to inform a project dedicated to producing useful and usable science. I found that collaboration between the Indigenous Advisory Council, Institute for Tribal Environmental Professionals, and the Arctic Rivers Project research team in planning and executing the event demonstrated adherence to good practices in knowledge co-production. This co-produced event provided a venue for starting conversations and building meaningful connections between stakeholders, as well as informing project climate, ice, and fish modeling efforts.

Moving forward, I hope that documentation of the process of planning, preparing for, and executing the Arctic Rivers Summit according to co-production of knowledge principles and practices can be utilized to better engage Indigenous Knowledge and western science in producing knowledge, and planning more inclusive gatherings for co-production projects. To produce useful and usable knowledge, Dilling et al., suggest that “starting from a place of humility— asking communities what outcomes are most valued (NOT what science they need), asking how they have been affected by previous interventions, and listening to what is most wanted— [is] a good starting place” (2021, 2). Listening to the observations and needs of stakeholders, and their past experiences with researchers was an essential component of co-production of knowledge efforts at the Arctic Rivers Summit.

Co-production of knowledge is an intensive process that requires high investment from all parties involved. Working under a co-production framework will often be more complex, more involved, and require more time to work under than operating on the basis of a singular knowledge system. The benefits, however, include producing knowledge that is holistic, inclusive, and useful and usable to communities. If this is not the goal of conducting research, I ask— what is?

Works Cited

The Administration for Children and Families. (n.d.). *American Indians and Alaska Natives -*

What about Alaska? Administration for Native Americans. Retrieved April 5, 2023, from <https://www.acf.hhs.gov/ana/fact-sheet/american-indians-and-alaska-natives-what-about-alaska>

Alaska Department of Fish and Game, & US Fish and Wildlife Service. (2022). *2022 Yukon River Salmon Fishery Announcement #19: 2022 Yukon River Summer Season Summary*. <https://www.adfg.alaska.gov/static/applications/dcfnewsrelease/1445996671.pdf>

Andre, A., Buschman, V., Combs, E., Cozzetto, K., Fitka, S., Herman-Mercer, N., Murray, E., Musselman, K., Neakok, W., Prince, C., Salmon, P., Tlen, J., & Williams, M. (n.d.). *Knowledge Co-production Protocols*. Arctic Rivers. University of Colorado Boulder. (n.d.). Retrieved April 3, 2023, from <https://www.colorado.edu/research/arctic-rivers/>

Arctic Rivers Project Storymap. United States Geological Survey. (2022). Retrieved April 3, 2023, from <https://geonarrative.usgs.gov/arcticriversproject/>

Arctic Rivers Project. University of Colorado Boulder. (n.d.). Retrieved April 3, 2023, from <https://www.colorado.edu/research/arctic-rivers/>

Arctic Rivers Summit. National Science Foundation. (n.d.). Retrieved April 3, 2023, from <https://beta.nsf.gov/events/arctic-rivers-summit>

Arctic Rivers Summit. (n.d.). Arctic Rivers Project. Retrieved April 3, 2023, from <https://sites.google.com/view/arcticriverssummit/summit-goals-agenda?authuser=0>

Brabets, T., Wang, B., & Meade, R. (2000). *Environmental and hydrologic overview of the Yukon River basin, Alaska and Canada*. <https://doi.org/10.3133/wri994204>

Brown, D. R. N., Brinkman, T. J., Verbyla, D. L., Brown, C. L., Cold, H. S., & Hollingsworth, T.

- N. (2018). Changing River Ice Seasonality and Impacts on Interior Alaskan Communities. *Weather, Climate, and Society*, 10(4), 625–640.
<https://doi.org/10.1175/WCAS-D-17-0101.1>
- Dilling, L., Lemos, M. C., & Singh, N. (2021). Commentary: First, do no harm: Scaling usable knowledge for just and equitable outcomes. *Global Environmental Change*, 71, 102404.
<https://doi.org/10.1016/j.gloenvcha.2021.102404>
- Ellam Yua, Raymond-Yakoubian, J., Daniel, R. A., & Behe, C. (2022). A framework for co-production of knowledge in the context of Arctic research. *Ecology and Society*, 27(1), art34. <https://doi.org/10.5751/ES-12960-270134>
- Federal Waters of District 3 of the Yukon River Closed to Subsistence Salmon Fishing | U.S. Department of the Interior.* (n.d.). Retrieved April 3, 2023, from <https://www.doi.gov/subsistence/news/fishing/federal-waters-district-3-yukon-river-close-d-subsistence-salmon-fishing>
- Herman-Mercer, N., Andre, A., Buschman, V., Blaskey, D., Brooks, C., Cheng, Y., Combs, E., Cozzetto, K., Fitka, S., Koch, J., Lawlor, A., Moses, E., Murray, E., Mutter, E. A., Newman, A., Prince, C., Salmon, P., Tlen, J., Toohey, R. C., ... Musselman, K. (n.d.). The Arctic Rivers Project: Using an equitable co-production framework for integrating meaningful community engagement and science to understand climate impacts. *In Review*.
- Herman-Mercer, N. M. (2021). A Decade of Indigenous Knowledge Research in the Yukon River Basin: Reflection on “Indigenous Observations of Change in the Lower Yukon River Basin, Alaska.” *Human Organization*, 80(3), 234–245.

<https://doi.org/10.17730/1938-3525-80.3.234>

Herman-Mercer, N. M., Matkin, E., Laituri, M. J., Toohey, R. C., Massey, M., Elder, K., Schuster, P. F., & Mutter, E. A. (2016). Changing times, changing stories: Generational differences in climate change perspectives from four remote indigenous communities in Subarctic Alaska. *Ecology and Society*, 21(3), art28.

<https://doi.org/10.5751/ES-08463-210328>

Holton, G. (n.d.). *Alaska Native Languages Relationships and Family Trees*. Languages.

Retrieved April 4, 2023, from <https://www.uaf.edu/anlc/languages-move/languages.php>

Inuit Circumpolar Council-Alaska. 2015. Alaskan Inuit food security conceptual framework: How to assess the Arctic from an Inuit perspective, summary and recommendations report, 1-29.

Institute for Tribal Environmental Professionals. SWOT Protocol. (n.d)

Kenton, W. (2022, November 2). *SWOT analysis: How to with table and example*. Investopedia.

Retrieved April 4, 2023, from <https://www.investopedia.com/terms/s/swot.asp>

Languages | Alaska Native Language Center. (n.d.). Retrieved April 3, 2023, from

<https://www.uaf.edu/anlc/languages-move/languages.php>

Latulippe, N., & Klenk, N. (2020). Making room and moving over: knowledge co-production, Indigenous knowledge sovereignty and the politics of global environmental change decision-making Author links open overlay panel. *Current Opinion in Environmental*

Sustainability, 42, 7–14. <https://doi.org/https://doi.org/10.1016/j.cosust.2019.10.010>

Lawlor, A., & Herman-Mercer, N. (In Review). *The Promise, Power, and Peril of Knowledge Co-Production Research in an Alaskan Context*.

Loring, P. A., & Gerlach, C. (2010). Food Security and Conservation of Yukon River Salmon: Are We Asking Too Much of the Yukon River? *Sustainability*, 2(9), 2965–2987.

<https://doi.org/10.3390/su2092965>

Rantanen, M., Karpechko, A. Yu., Lipponen, A., Nordling, K., Hyvärinen, O., Ruosteenoja, K., Vihma, T., & Laaksonen, A. (2022). The Arctic has warmed nearly four times faster than the globe since 1979. *Communications Earth & Environment*, 3(1), 168.

<https://doi.org/10.1038/s43247-022-00498-3>

Untangling colonialism: virtual training. Native Movement. (n.d.). Retrieved April 4, 2023,

from <https://native-movement.teachable.com/p/untangling-colonialism>

Ellam Yua, Raymond-Yakoubian, J., Daniel, R. A., & Behe, C. (2022). A framework for co-production of knowledge in the context of Arctic research. *Ecology and Society*, 27(1), art34. <https://doi.org/10.5751/ES-12960-270134>

Appendix A: Arctic Rivers Summit Schedule

Arctic Rivers Summit

December 6-8, 2022

Alaska Native Heritage Center, Anchorage, Alaska

Tuesday, December 6

7:30-8:30 am	Registration <i>Lobby</i>		
8:30-10:00 am	Welcome Alaska Native Heritage Center Welcome and Land Acknowledgement Opening Blessing Remembrance Project Welcome and Summit Objectives Indigenous Advisory Council Welcome <i>Large group, Gathering Room</i>		
<i>Break 10:00-10:15</i>			
10:15-10:45 am	Icebreaker		
10:45-12:00 pm	Knowledge Exchange: Elders Share Harold Gatensby (Carcross/Tagish First Nation, co-founder Yukon River Inter-Tribal Watershed Council) Mike Williams (Kuskokwim River Inter-Tribal Fish Commission) Reverend Anna Frank (Fairbanks Native Association) <i>Facilitator: Theresa Clark (Yukon River Inter-Tribal Watershed Council)</i> <i>Large group, Gathering Room</i>		
<i>Lunch 12:00-1:00 pm</i>			
1:00-1:20 pm	Knowledge exchange: Arctic Rivers Project Overview Keith Musselman (University of Colorado – Boulder) Nicole Herman-Mercer (U.S. Geological Survey) <i>Large group, Gathering Room</i>		
1:20-1:30 pm	Introduction to the afternoon Nicole Herman-Mercer (U.S. Geological Survey) <i>Large group, Gathering Room</i>		
	<i>Track 1 (Groups 1-3)</i>	<i>Track 2 (Groups 4-6)</i>	<i>Track 3 (Groups 7-9)</i>
1:45-5:00 pm <i>(There are 15-minute breaks between sessions.)</i>	Inform the Modeling: River Transport Through the Seasons 1:45-2:45 pm Inform the Modeling: Fish Through the Seasons 3:00-3:45 pm	Inform the Modeling: Fish Through the Seasons 1:45-2:45 pm Tour: Alaska Native Heritage Center 3:00-3:45 pm	Tour: Alaska Native Heritage Center 1:45-2:45 pm Inform the Modeling: Fish Through the Seasons 3:00-3:45 pm

	<p>Tour: Alaska Native Heritage Center 4:00-4:45 pm</p>	<p>Inform the Modeling: Fish Through the Seasons 4:00-4:45 pm</p>	<p>Inform the Modeling: River Transport Through the Seasons 4:00-4:45 pm</p>
<p>5:00-5:30 pm</p>	<p>Report back - reconvene as a large group to review the day and discuss what's next <i>Facilitator:</i> Ryan Toohey (U.S. Geological Survey) Large group, Gathering Room</p>		
<p>Adjourn for the day</p>			

Wednesday, December 7

8:30-10:00 am **Knowledge Exchange: State of Arctic Rivers**
 Ben Stevens (Tanana Chiefs Conference)
 Craig Chythlook (Food Security Working Group, International Arctic Research Center)
 Dr. Jessica Black (University of Alaska - Fairbanks)
 Stanley Njootli, Sr. (Yukon River Panel)

Facilitator: Nikki Cooley (Institute for Tribal Environmental Professionals)
Large group, Gathering Room

Break 10:00-10:30

10:30-11:45 pm **Knowledge Exchange: Weaving Together Indigenous Knowledge and Western Science & Management**
 Esther Ashton-Reese (Southeast Alaska Indigenous Transboundary Commission)
 Serena Fitka (Yukon River Drainage Fisheries Association)
 Kevin Whitworth (Kuskokwim River Inter-Tribal Fish Commission)

Facilitator: Danielle Stickman (The Wilderness Society)
Large group, Gathering Room

Lunch 11:45-12:45 pm

	Track 1 (Groups A-C)	Track 2 (Groups D-F)	Track 3 (Groups G-I)
12:45-4:40 pm	Taking Action: SWOT Analysis, Topic 1 12:45-2:45 pm	Taking Action: SWOT Analysis, Topic 1 12:45-2:45 pm	Taking Action: SWOT Analysis, Topic 1 12:45-2:45 pm
Break 2:45-3:00 pm			
	Taking Action: SWOT Analysis, Topic 2 3:00-4:40 pm	Taking Action: SWOT Analysis, Topic 2 3:00-4:40 pm	Taking Action: SWOT Analysis, Topic 2 3:00-4:40 pm

4:50-5:30 pm **Report back** - reconvene as a large group to review the day and discuss what’s next
 Working group members will report back on any key themes and ideas emerging from their group discussions, and we’ll discuss what’s next.
Large group, Gathering Room

Adjourn for the day

Please note

There are four action plan working group topics:

- State of Salmon
- State of Rivers
- Partnering Indigenous Knowledge with Western Science for Management
- Youth and Elders: Building a Bridge of Traditional Knowledge

Everyone will be part of the working groups for two topics. We have done our best to match each person with their top two topic choices as indicated when registering.

SWOT analyses will examine strengths, weaknesses, opportunities, and threats for a particular topic.

Thursday, December 8

	<i>Track 1 (Groups A-C)</i>	<i>Track 2 (Groups D-F)</i>	<i>Track 3 (Groups G-I)</i>
8:30-12:00 pm <i>(There are 10 or 15-minute breaks between sessions.)</i>	Inform the Modeling: Climate 8:30 - 9:15 am, Athabasca Ceremonial House	Taking Action: Translating SWOT analyses to Actions, Topic 1 8:30 - 9:40 am	Taking Action: Translating SWOT analyses to Actions, Topic 1 8:30 - 9:40 am
	Taking Action: Translating SWOT analyses to Actions, Topic 1 9:30 - 10:40 am	Inform the Modeling: Climate 9:55 - 10:40 am, Athabasca Ceremonial House	Taking Action: Translating SWOT analyses to Actions, Topic 2 9:50 - 11:00 am
	Taking Action: Translating SWOT analyses to Actions, Topic 2 10:50 - 12:00 pm	Taking Action: Translating SWOT analyses to Actions, Topic 2 10:50 - 12:00 pm	Inform the Modeling: Climate 11:15 - 12:00 pm, Athabasca Ceremonial House
Lunch 12:00-1:00			
1:00-2:15 pm	Report back and discussion about actions and action plans		
2:15-2:45 pm	Break/gallery walk during which people can add notes to the action plans and vote		
2:45-3:00 pm	Closing blessing		
Break 3:00-6:30			
Banquet 6:30-9:00 pm at the Lakefront Anchorage			
Adjourn the summit			

We wanted to give a huge thank you to our Summit sponsors!



Appendix B: Informed Consent Form for Data Collection at the Arctic Rivers Summit**Permission to Take Part in a Human Research Study**Page **1 of 95**

Title of research study: Arctic Rivers Summit: Co-Developing an understanding of climate impacts on fish and river ice

IRB Protocol Number: 21-0536

Investigator: Keith Musselman

Purpose of the Study

The purpose of the study is to understand how climate change will impact fish, river ice, and communities in parts of Alaska and Canada. Climate change is having profound impacts on communities in the arctic and subarctic. Our study will estimate what the future might look like for fish habitat and river ice transportation using models, local and Indigenous knowledge, and other scientific approaches such as water quality monitoring. The goal is to provide data and information to communities to assist with adaptation efforts.

We expect that you will be in this research study for one year. The data will be collected from you and other Arctic Rivers Summit attendees over two days, December 6, 2022, and December 7, 2022. Data analysis will take several months to complete, and we may contact you to clarify any questions about the information you have given us. Once data analysis is complete, we will provide you with a copy of the results. We anticipate this will be approximately one year from the date of the Arctic Rivers Summit.

We expect about 100 people will be in this research study including participants from the United States and Canada.

Explanation of Procedures

The research will take place during the Arctic Rivers Summit in the form of 3 breakout sessions that will be held during the event. Each breakout session will last 45 minutes, and each Summit attendee is invited to participate in all 3 breakout sessions for a total of 135 minutes.

Each breakout session will be led by a trained facilitator that is part of our research staff and a note-taker that is a member of the Arctic Rivers Project team. Each breakout

session will have a focused discussion on a different topic. The topics are, 1) subsistence fish; 2) river ice; 3) usefulness of climate information and data. For the focused discussion the facilitator will guide the group through a series of questions and discussion topics. The discussion will be recorded on large flip charts for everyone to see as well as by handwritten or typed notes taken by the notetaker. There will be no audio or video recording.

In addition to a short discussion Topic 1 (subsistence fish) and 2 (river ice) will also include a mapping activity. During this activity you will be asked to form a small group (4 individuals total) within your breakout session group to locate critical fish habitat locations (breakout group topic 1) or critical river ice transportation locations (breakout group topic 2) on a map of the region or community that you are from or are representing at the Summit. Locations will be identified on the map by drawing directly onto a paper map with permanent markers.

As part of this research the information you provided when registering to attend the Arctic Rivers Summit will be collected.

This will include:

- First and Last Name
- email address
- mailing address
- Name of Tribe or First Nation (if applicable)
- Name of institutional or agency affiliation (if applicable)

Optional information will include

- phone number

This information will be used to place you in the appropriate breakout groups with other Summit attendees from, or representing, the same region as you. It will also be used to follow up with you if there are questions later about the information you provided and to share the summary results from this research with you.

Voluntary Participation and Withdrawal

Whether or not you take part in this research while you attend the Arctic Rivers Summit is your choice. If you choose to participate in a breakout session you can change your mind and leave the breakout sessions where the research will take place at any time, and it will not be held against you.

At the end of the Summit, you will be asked to complete an evaluation survey. If you decide that you would like to have the information you provided removed, you can tell us that as part of the survey and we will remove it. A few months after the Summit we will send you a summary of the information you provided at the Summit and give you the opportunity to correct or withdrawal any information you previously provided.

The person in charge of the research study can remove you from the research study without your approval. Possible reasons for removal include being disruptive during the breakout sessions or refusing to follow the instructions of the facilitator.

Risks and Discomforts

This research will take place indoors at an event venue and we do not anticipate any risks or discomforts to individuals as part of participation in this study. There can be risks involved in sharing Indigenous knowledge. Because Indigenous knowledge is linked to a place and a culture there are risks that it can be misinterpreted or misrepresented if taken out of its original context. We will strive to keep Indigenous knowledge that is shared with us whole and describe the context of the Indigenous knowledge in any products or publications that result from this work. We will also give each research participant an opportunity to review reports and publications prior to publication to ensure there has been no misinterpretation or misrepresentation.

We cannot control the use of all information and knowledge learned as part of this research. Information and knowledge provided by participants will be summarized and published. Once information is published it becomes part of the public domain. Once in the public domain there is potential for this information to be used by private corporations or others for profit or for uses not anticipated by, or under control of, the research team.

Finally, due to the nature of this event in which data will be collected in a structured way as part of breakout sessions at the same time that organic conversations are occurring outside of structured data collection, there is a risk that summit participants will share Indigenous knowledge with individuals outside the research team. This could result in Indigenous knowledge being shared further without proper attribution. The risk of this happening is low as all Summit attendees will be provided with data sharing protocols and will be made aware of their responsibilities to protect data and information shared with them throughout the event.

Potential Benefits

We cannot promise any benefits to you or others from your taking part in this research. However, possible benefits to communities within parts of Alaska and Canada include an increase in knowledge of climate change impacts and estimates of future impacts on fish species of interest, river ice transportation corridors of interest, and how to make climate data and information useful and usable for Indigenous communities.

Confidentiality

Information obtained about you for this study will be kept confidential to the extent allowed by law. Research information that identifies you may be shared with the University of Colorado Boulder Institutional Review Board (IRB) and others who are responsible for ensuring compliance with laws and regulations related to research, including people on behalf of the Office for Human Research Protections. The information from this research may be published for scientific purposes; however, your identity will not be given out.

Consent forms and any information collected on paper will be stored in locked cabinets and electronic data in password-protected secure computer files. Data will be kept for at least 5 years after the funding period ends. It may be kept longer, but all protections of the data will stay in place. Data will be completely destroyed when it is no longer needed.

Government staff sometimes review studies such as this one to make sure they are being done safely and legally. If a review of this study takes place, your records may be examined. The reviewers will protect your privacy.

Questions

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the Principal Investigator Keith Musselman at keith.musselman@colorado.edu, 303-735-7235

This research has been reviewed and approved by an IRB. You may talk to them at 303-735-3702 or irbadmin@colorado.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

Signatures

Your signature documents your permission to take part in this research.

Signature of subject

Date

Printed name of subject

Signature of person obtaining consent

Date

Printed name of person obtaining consent

Appendix C: Arctic Rivers Summit Data Sharing Protocols

Data Protocols for the Arctic Rivers Summit

Attendees of the Arctic Rivers Summit and the agencies, institutions, and organizations hosting the Summit including: The University of Colorado Boulder, the U. S. Geological Survey, and the National Center for Atmospheric Research

This document serves as a protocol for the use, management, storage, and sharing of data collected at the Arctic Rivers Summit, a three-day in-person summit planned for December 6-8, 2022. This data protocol is based upon the CARE Principles for Indigenous Data Governance and the FAIR principles for scientific data management and stewardship.

CARE stands for data life cycles that support Indigenous self-determination through:

Collective benefit
 Authority to control
 Responsibility
 Ethics

FAIR stands for managing data to create datasets that are:

Findable
 Accessible
 Interoperable
 Reusable

This document is comprised of three sections. Section 1 lists the types of data that will be collected at the Arctic Rivers Summit, how the Arctic Rivers Project will use that data, and how the Arctic Rivers Project will share data with individuals and the communities they represent. Section 2 describes the CARE principles for Indigenous data governance that the Arctic Rivers Project team will strive to uphold for data collected during the Arctic Rivers Summit. Section 3 describes how the Arctic Rivers Project will follow FAIR guidelines to ensure the accessibility of datasets created from data collected during the Arctic Rivers Summit.

1. Data types, Data use, Data Sharing

Types of data to be collected at the Arctic Rivers Summit:

- Key points from Plenary Talks, Questions and Answers, and Discussions.
- Locations of fish habitat and fish species
- Locations of river ice transportation corridors
- Locations concern for fish and ice
- Narrative data regarding decision-making processes in Indigenous communities, use of climate models and climate data to support decision making
- Textual data produced by summit participants in the form of a Strengths, Weaknesses, Opportunities, Threats activity

How data collected at the Arctic Rivers Summit will be used:

- Data collection activities that occur at the Summit will be described in a white paper. All Summit attendees will be invited to be listed as authors or contributors on this white paper.
- Location data will be summarized (maps created by small groups within the breakout sessions of specific regions, villages, or communities will be combined with all identifying information removed) and shared with the Arctic Rivers Project modeling team to identify specific locations to focus the development of river ice and fish models. The fish species identified in the breakout sessions will also be used to select the fish species to model.
- Information related to how Indigenous decision-makers use climate information and climate models and will be summarized. This synthesized information will be used by the project team to make preliminary decisions on the types of climate data and information to develop for communities.
- Scientific journal articles will also be written based on the data collected at the Arctic Rivers Summit. For example, a scientific journal article describing a breakout session mapping workshop, the regional locations of river ice identified by workshop participants, and the results of the river ice model are likely products. All data will be shared with the individuals and communities that provided the data for their consent before a journal article is published. Importantly, Indigenous Knowledge holders will be invited to contribute to the scientific journal articles as authors or internal reviewers.

How will we protect and share data with individuals that provided it and the communities they represent?

- The Arctic Rivers Summit white paper will be distributed to all Summit attendees. It will also be freely available on the Arctic Rivers Project website. The contents of the white paper will also be presented as a webinar. The webinar will be advertised to all Summit attendees using the email address provided at registration, on the Arctic Rivers Project listserv, through Arctic Rivers Project social media channels including Instagram and Twitter, and through listservs of our collaborators (YRITWC, ITEP) and networks (Rising Voices, ARCUS, IAPRC, etc.). This webinar will be recorded, the recording will be freely available and similarly shared.
- Digital data (locations of fish habitat and river ice) will be stored on a US government computer secured with two factor authentication. Paper copies of data (hand-drawn maps) will be stored in a locked US Government Office in a secured US Government access-controlled facility. Copies of digital data will be transferred to USB flash drives and mailed via FedEx to communities that provided information and data during the Arctic Rivers Summit. These data will include: digital maps of locations of fish habitat and river ice transportation corridors, summaries of information shared related to decision-making processes and use of climate data and information. Paper copies of maps and summaries of narrative data will be available to be mailed to communities if requested.

2. CARE principles for Indigenous data governance

To respect Indigenous data sovereignty and best practices of Indigenous Data Governance, and to ensure constructive collaboration among participants, all parties strive to adhere to the following¹:

COLLECTIVE BENEFIT

The data cycle for the Arctic Rivers Summit will be designed and function to enable the Summit attendees and breakout session participants including the Tribal and First Nation communities that they represent to derive benefit from the data.

For inclusive development and innovation

The outside institutions and organizations – the University of Colorado Boulder, the United States Geological Survey, and the National Center for Atmospheric Research – will actively support the use and reuse of data by the Summit attendees and breakout session participants including the Tribal and First Nation communities that they represent. Such data access support may facilitate the establishment of the foundations for Indigenous innovation, value generation, and the promotion of local self-determined development processes.

For improved governance and citizen engagement

Data collected at the Arctic Rivers Summit and related breakout sessions will be shared with Summit attendees and breakout session participants including the Tribal and First Nation communities that they represent, with participant permission. This data sharing effort is aimed to enrich and facilitate the planning, implementation, and evaluation processes to support the service and policy needs of the Summit attendees and breakout session participants including the Tribal and First Nation communities that they represent. The data sharing effort is also aimed to enable better engagement between the Summit Attendees and outside institutions and governments to improve decision-making. The open data will be used ethically in ways that are known to improve transparency and decision-making by providing the Indigenous communities represented by Summit attendees with a better understanding of their peoples, territories, and resources, as well as provide greater insight into third-party policies and programs affecting the Indigenous communities represented by attendees.

For equitable outcomes

Any value created from the Indigenous data, shared or collected, during the Arctic Rivers Summit, which are grounded in community values and extend to society at large, should benefit the Indigenous communities represented by Summit attendees in an equitable manner and should contribute to their aspirations for wellbeing.

¹ Raw aggregated data will be made publicly available – the Arctic Rivers Project team cannot make guarantees about the use of data by outside entities after publication.

AUTHORITY TO CONTROL

The rights and interests of Indigenous communities as it relates to their data will be recognized and their authority to control such data be empowered. Indigenous data governance enables Indigenous communities to determine how their People, as well as their lands, territories, resources, knowledges and geographical indicators, are represented and identified within the data.

Recognizing rights and interests

Indigenous Peoples have rights and interests in both their Indigenous Knowledge and Indigenous data. Indigenous Peoples have collective and individual rights to free, prior, and informed consent in the collection and use of such data, including the development of data policies and protocols for collection.

Data for governance

Indigenous Peoples have the right to data that are relevant to their world views and empower self-determination and effective self-governance. Indigenous data will be made available and accessible to the Summit attendees and the Indigenous communities they represent to support Indigenous governance.

Governance of data

Indigenous Peoples have the right to develop cultural governance protocols for Indigenous data and be active leaders in the stewardship of, and access to, Indigenous data – especially in the context of Indigenous Knowledge. The Arctic Rivers Project will support and facilitate stewardship of and access to data collected at the Arctic Rivers Summit.

RESPONSIBILITY

The outside organizations and institutions working with Indigenous data for collection at the Arctic Rivers Summit have a responsibility to share how those data are used to support the participating Indigenous Peoples' self-determination and collective benefit. Accountability requires meaningful and openly available evidence of these efforts and the benefits accruing to Indigenous Peoples.

For positive relationships

Indigenous data use is unviable unless linked to relationships built on respect, reciprocity, trust, and mutual understanding, as defined by the Indigenous Peoples to whom those data relate. The Arctic Rivers Project team working with Indigenous data are responsible for ensuring that the creation, interpretation, and use of those data uphold, and/or are respectful of, the dignity of the Summit attendees and the Indigenous communities they represent.

For expanding capability and capacity

Use of Indigenous data invokes a reciprocal responsibility to enhance data literacy within Indigenous communities and to support the development of an Indigenous data workforce and digital infrastructure to enable the creation, collection, management, security, governance, and application of data.

For Indigenous languages and worldviews

Effort will be made to ensure data generated and collected at the Arctic Rivers Summit are grounded in the languages, worldviews, and lived experiences (including values and principles) of the Summit attendees and the Indigenous communities they represent.

ETHICS

Indigenous Peoples' rights and wellbeing will be the primary concern at all stages of the life cycle and ecosystem of data collected at the Arctic Rivers Summit.

For minimizing harm and maximizing benefit

The data will be ethical and not stigmatize or portray the Indigenous Peoples, cultures, or knowledges in terms of deficit. The data will be collected and used in ways that align with the ethical frameworks of the Indigenous communities represented by Summit attendees and with rights affirmed in the United Nations Declaration on the Rights of Indigenous Peoples. Assessing ethical benefits and harms will be done from the perspective of the Indigenous Peoples to whom the data relate.

For justice

The processes of the Arctic Rivers Summit are designed to address imbalances in power and resources, and how these affect the expression of Indigenous rights and human rights. These processes will include representation from the Indigenous communities leading this work in their homelands.

For future use

Data governance will create processes that account for potential future use and future harm based on ethical frameworks grounded in the values and principles of the Indigenous communities represented by Summit Attendees. Metadata will acknowledge the provenance and purpose and any limitations or obligations in secondary use inclusive of issues of consent.

3. FAIR principles for scientific data management and stewardship. The Arctic Rivers Project team will adhere to following the **'FAIR Guiding Principles for scientific data management and stewardship'**:²

² <https://www.go-fair.org/fair-principles/>. FAIR is Findability, Accessibility, Interoperability, and Reuse of digital assets.

Findable

Data (digital object) and metadata (information about the digital object) will be made easy to find for both humans and computers. Machine-readable metadata are essential for automatic discovery of datasets and services, so this is an essential component of the FAIRification process.

- F1. (Meta)data will be assigned a globally unique and persistent identifier
- F2. Data will be described with rich metadata (defined by R1 below)
- F3. Metadata will clearly and explicitly include the identifier of the data they describe
- F4. (Meta)data will be registered or indexed in a searchable resource (infrastructure component)

Accessible

Once the user finds the required data, they need to know how the data can be accessed, possibly including authentication and authorization.

- A1. (Meta)data will be retrievable by their identifier using a standardized communications protocol
 - A1.1 The protocol will be open, free, and universally implementable
 - A1.2 The protocol will allow for an authentication and authorization procedure, where necessary
- A2. Metadata will be accessible, even when the data are no longer available

Interoperable

The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing.

- I1. (Meta)data will use a formal, accessible, shared, and broadly applicable language for knowledge representation.
- I2. (Meta)data will use vocabularies that follow FAIR principles
- I3. (Meta)data will include qualified references to other (meta)data

Reusable

The goal of FAIR is to optimize the reuse of data. To achieve this, metadata and data will be well-described so that they can be replicated and/or combined in different settings.

- R1. (Meta)data will be richly described with a plurality of accurate and relevant attributes
 - R1.1. (Meta)data will be released with a clear and accessible data usage license
 - R1.2. (Meta)data will be associated with detailed provenance
 - R1.3. (Meta)data will meet domain-relevant community standards

Above all, the Arctic Rivers Project team will work to ensure that all data collected at the Arctic Rivers Summit respect oral traditions and practices, and the sovereignty of Indigenous communities represented by Summit Attendees, including data sovereignty, rights, and self-determination.

Appendix D: Participatory Mapping Protocols Used by Facilitators in Inform the Modeling: Ice Through the Seasons and Fish Through the Seasons Sessions at the Arctic Rivers Summit

ICE

Winter Trails – this is priority information

- What percentage of your community do you think travels over river ice?
- Tell me about how people in your community travel over river ice.
 - Prompt: what types of vehicles used, e.g., cars, snow machines, atvs, dog sled, etc.
- Where are people going when they travel over river ice?
 - [this information should be mapped, trails for specific purposes]
 - Prompt: hunting, fishing, gathering, logging locations? Festivals, Potlatches, basketball games, visiting friends and family, etc.
- What are the typical months that one can travel over river ice?
 - Prompt: have there been changes to this time frame?
 - Prompt: when did those changes start (looking for a year e.g., 1995, 2002, etc)
- How are the trails over ice established or determined each year?
 - Prompt: is it the same trail each year?
 - Prompt: Does the winter trail avoid any non-ice areas?
 - Prompt: are trail markers set?

Now let's talk a little bit about the ice itself.

Ice quality – this is priority information

- Have you observed any changes in river ice?
 - Prompt: onset of ice, quality of ice, ice thickness, anything else
- Are there any places where the river never freezes, or the ice is thinner than other areas?
- Are there other obstacles that you encounter when traveling over ice?
- Are there places that freeze later, or melt earlier?
 - Prompt: has the timing or seasonality of freezing or melting changed?
 - Prompt: do these places change the route or trail?
- Have there been years that the ice was particularly thin or years where there is more open water than others?
 - Prompt: What years were these?
- What are the indicators that river ice will be unsafe for travel?
- How is information about river ice safety communicated throughout your community and between communities?
 - Prompt: word of mouth, facebook, radio, etc

Secondary priorities – if time allows, these questions focus on impacts of thin ice, more detailed quality questions, and more detailed questions about travel. □ save 25 minutes for mapping.

- What are the consequences of not being able to travel over river ice?
- What other ways can people travel if they can't travel over the ice?

- Have you observed any unusual ice features?
- For example, air pockets, double ice layers (with water and slush sandwiched between the layers), and/or open water leads?
- How many miles (or time estimate i.e., hours) do you travel on these trips?
- How frequent is travel over river ice?
 - Prompt: Provide a time frame – daily, weekly, monthly, something else

FISH

Fish species and timing – This is priority information

- Which fish species are harvested in your community?
 - [make a list of these on the white board]
 - Prompt - If no one mentions non-salmon species ask: What about non-salmon species?
- What time of year do you typically harvest these fish?
 - Tip: use the species listed on the white board as a prompt □ *let's start with white fish, what time of year do you typically harvest whitefish?*
 - [Fill in inner wheel on subsistence wheel]
 - Tip: make sure you are getting timing by species
- Has the timing of when you harvest any of these species changed?
 - [Fill in outermost wheel to indicate changes]
 - Tip: use the species listed on the white board as a prompt
- Do you harvest any of these fish based on age or size?
 - [make note of this on white board next to species name]

Next, let's talk a little bit about habitat before we move on to mapping locations

Fish locations and habitat – This is priority information

- What type of rivers do you find particular species?
 - [note responses on whiteboard – these responses should be mapped]
 - Prompt: Large rivers like the Yukon or Kuskokwim? Tributaries of large rivers? Smaller streams and slough?
 - Prompt: for specific species are they usually found in fast moving water, stagnant water?
- Are certain river reaches, streams, creeks, etc. important for different life stages growth and survival like for spawning, eggs, juveniles, near your community?
 - [note on whiteboard – this should be mapped]
- What makes these locations better for fish survival?
 - [note on whiteboard]
- Have you noticed any changes in timing of spawning, migration of adults or juveniles?
 - [note on whiteboard]
- Do you find certain fish species together in specific locations?
 - [note on white board – this should be mapped]
- Have you noticed any changes in the fish species that are found together?

- Have you observed changes in when fish are found in certain river reaches?

Changes in health – get this information if time allows **save 25 minutes for mapping.**

- What indicators do you use to know if fish are healthy?
 - Are there different indicators for different species?
 - Are there different indicators for different life stages?
- Have you noticed changes to the health or condition of any fish species near your community?
- Have you noticed changes in nest abundance or the abundance of juveniles?
- Have you noticed changes in the location of nests or juveniles?
- Have you noticed differences in age or size in species that you are harvesting?
 - Do you typically find fish of specific size or age together?

Appendix E: Pre-Summit Survey Distributed at the Arctic Rivers Summit

Arctic Rivers Summit – Pre-summit Survey

We are so excited to have you here at the Arctic Rivers Summit! This survey will help us understand who the Summit attendees are and what their goals for the Summit are. Please take a few minutes to complete this survey on Tuesday December 6th and return it to one of the Arctic Rivers Project team members at the end of the day.

Thank you!

There are instructions for completing the survey throughout. *Instructions are italicized like this text.*

1. Are you attending the summit as a representative of any of the following (please select all that apply)?

- Alaska Native Village
- First Nation Community
- State or Provincial agency
- Federal Agency
- Academic Institution
- Tribal or Aboriginal Non-Profit Organization
- Non-Profit Organization
- Other (Please fill in)

If you selected: “Alaska Native Village” or “First Nation Community” please proceed to questions 1a and 1b.

If you selected any other choices proceed to question 1c.

1.a. What community are you representing at the Summit?

1.b. What role do you have in that community? (*Please choose all that apply*)

- Community member
- Tribal Council or First Nation Government member
- Employee of a First Nation or Tribal Government
- Elder
- Youth
- City employee
- Alaska Village corporation employee
- Alaska Regional corporation employee
- Indigenous organization employee
- Other (please fill in)

1.c. Please describe your role at the organization you are representing at the Summit.

2. What are your goals for attending the summit?

(Please select all that apply)

- Learn more about climate science
- Learn about adaptation strategies from other communities
- Learn about climate impacts from other communities
- Learn about funding opportunities from other communities
- Learn how to be involved in the Arctic Rivers Project
- Guide the science of the Arctic Rivers Project
- Network with other communities and scientists
- Share my knowledge and experiences
- Identify actions and strategies to adapt to climate change
- Other (please describe on the next page)

3. Did you review the Arctic Rivers Summit website before attending the summit?

- Yes
- No
- Unsure

If you selected “yes” please answer questions 4a -c.

If you selected “no” or “unsure” please proceed to question 5 (next page)

4.a. What parts of the Summit website did you find useful?

4.b. What was missing from the Summit website?

4.c. How could the Summit website be improved?

5. Have you heard of the term knowledge co-production?

- Yes
- No
- Unsure

*If you selected "yes" or "unsure" please answer question 5.
If you selected "no" please proceed to question 6 (next page)*

Appendix F: Post-Summit Evaluation Survey Distributed at the Arctic Rivers Summit

1. Do you agree with any of the following statements as a result of attending the Summit?

(Please select all that apply)

- I learned more about climate science
- I learned from other communities about adaptation strategies
- I learned about climate impacts from other communities
- I learned about funding opportunities from other communities
- I learned how to be involved in the Arctic Rivers Project
- I provided guidance for the science in the Arctic Rivers Project
- I networked with other communities and scientists
- I shared my knowledge and experiences
- Worked with others to identify actions and strategies to adapt to climate change
- I shared my knowledge on how to best communicate results and products of the Arctic Rivers Project
- Other (please describe)

2. Are there other topics you would have liked to hear more about at the Summit?

Open Response

3. If we were to have a future meeting, how would you like that meeting structured?

- Similar to this meeting
- Opportunity to submit abstracts and present research
- Opportunity to host or attend workgroup sessions
- Opportunity to host or attend training sessions
- Opportunity to submit session ideas
- Opportunity to brainstorm other research/project ideas
- Other ideas (please describe)

4. What parts of the Arctic Rivers Summit did you think worked well? (Please select all that apply)

- Participatory mapping – ice (yes/no/ unsure)
- Participatory mapping – fish
- Inform the modeling: Climate
- Strengths Weaknesses Opportunities Threats (SWOT) breakout session
- Tour of the Native Villages at the Alaska Native Heritage Center

- Elders share Session
- Weaving together Indigenous Knowledge and Western Science for Management Session
- Status of Arctic Rivers Session
- Arctic Rivers Project Overview Session
- Networking with other communities
- Networking with scientists
- Other?

4a. Please describe what you liked about the above activities. Please feel free to provide any other feedback on what you think worked well

5. What parts of the Arctic Rivers Summit needed extra attention or could have been improved? (Please select all that apply)

- Participatory mapping – ice (yes/no/unsure)
- Participatory mapping – fish
- Inform the modeling: Climate
- Strengths Weaknesses Opportunities Threats breakout session
- Tour of the Native Villages
- Elders share Session
- Weaving together Indigenous Knowledge and Western Science for Management Session
- Status of Arctic Rivers Session
- Arctic Rivers Project Overview Session
- Networking with other communities
- Networking with scientists
- Other?

5a. Please describe how we could improve the above activities and please feel free to provide any other feedback on ways the Summit could have been improved

6. What did you learn from other summit attendees? (Please select all that apply)
Can you identify from whom you learned? No/Yes: Community member, Agency representative, Project member, Scientist, other)

- Climate science

9. Do you feel that you were adequately informed ahead of time about the knowledge you were asked to share during the Summit?

- Yes
- No
- Unsure

If you selected "No" or "unsure" please go to question 9a
If you selected "yes" please go to question 10

9a. How could we have better informed you of how you would be asked to share knowledge?

10. Do you feel that you fully understand how the knowledge you shared will be used?

- Yes
- No
- Unsure

If you selected “No” or “unsure” please go to question 10a

If you selected “yes” please go to question 11

10a. How could we improve your understanding of how your knowledge will be used?

12. Which of the following would you or your community like to participate in? (Please select all that apply)

- Fish
- Ice
- Storylines
- None of the above
- Not sure

13. Would you like to remove any information or knowledge that you shared with us at the Summit?

- Yes
- No
- Unsure

14. Would you like to contribute to any of the products coming out of the summit?

- Arctic Rivers Summit Proceedings (Yes/No/Unsure)
- Arctic Rivers Project Inform the Modeling Report
- Arctic Rivers Summit Action Plan
- Other (please describe)

15. Would you please provide your contact information so that we can discuss further opportunities referenced in the previous question or to discuss removing your information?

- Name
- Phone number
- Email address

Please provide your contact information

- Name

Thank you so much!!!!

Appendix G: Goals developed by Indigenous Advisory Council for the Arctic Rivers Summit

Arctic Rivers Summit Goals

Goals: broad general statements of what we hope to accomplish at the Summit

Objectives: more specific results associated with each goal

Agenda: methods for achieving our goals and objectives

<p>Goal #1: Facilitate discussions on the current state of knowledge of Arctic Rivers considering Indigenous and western science perspectives and including climate change impacts</p> <p>Identify: • Current research being done • Key information sources • Knowledge and/or data gaps</p>	
<p><i>Climate & weather observations</i></p>	<p>Summer vs. winter temperatures</p>
	<p>Increasing and severe weather conditions Rainfall - heavy rains/floods Dry conditions/wildfires, withered plants</p>
	<p>Incoming invasive plants/animals - land and water How hot weather could affect insect infestations</p>
	<p>How are climate impacts affecting culture? Knowledge transmission? Subsistence activities? Traveling on the land and waterways Campsites Social gatherings?</p>
<p><i>River bank erosion</i></p>	<p>Moving houses</p>
	<p>Moving entire communities</p>
	<p>Erosion-caused increases in sediments makes river waters more silty affecting fish species, water and shore birds and animals living along rivers.</p>
	<p>Impacts to spawning grounds and rest areas</p>
	<p>Impacts of river bank erosion to community infrastructure</p>
<p><i>Fish</i></p>	<p>Health of fish - including texture taste and recent observations of this kind</p>
	<p>Species numbers/populations - decline of fish in rivers</p>
	<p>Observations of early or late runs</p>
	<p>Commercial fisheries</p>
	<p>Past Indigenous fish management</p>
	<p>How hot weather could affect fish and dead animals along the rivers, along the shoreline</p>
<p><i>Fish riverine habitats</i></p>	<p>Climate change-induced changes and how they vary among watersheds</p> <ul style="list-style-type: none"> • Increasing water temperatures • Increased water availability vs. drying up
	<p>Spawning ground health</p>
	<p>Rest areas</p>

	<p>Pollution – natural or manmade</p> <ul style="list-style-type: none"> ● Mining threats and impacts to runoff <p>Beaver dams</p> <ul style="list-style-type: none"> ● Beaver dams affect water distribution and also beavers eat fish as well the otters that try to steal beaver dams <p>Past Indigenous management to encourage healthy creeks and rivers</p> <p>Impacts of glacial sediment flow into river habitats</p>
<i>Ocean habitats for fish whose life cycles include both freshwater & oceans</i>	WHAT MIGHT BE INCLUDED IN THESE DISCUSSIONS?
<i>Food security/ insecurity</i>	<p>Impact of government regulations during times of food shortage (e.g., not hunting or fishing on certain days)</p> <p>How to deal with food insecurity</p> <p>Sharing TK about what makes a food animal healthy (i.e. ways to tell if rabbits, geese, ducks, moose, caribou are healthy depending on the animal’s body fat.</p> <p>Access to subsistence areas due to lack of snow or ice to get around in the winter</p> <p>ICC Food security and food sovereignty technical reports -</p>
<i>Indigenous indicators of ecosystem health</i>	<p><i>Note: This came up during the discussion of Knowledge Co-Production Protocols. One example provided was fish texture and quality.</i></p> <p>WHAT MIGHT BE INCLUDED IN THESE DISCUSSIONS?</p> <p>Beaver dams could also have something to do with fish trapping if that happen on the Yukon? In Greenland, man-made dams help funnel salmon and trout into traditional fish traps</p> <p>Also for Beaver dams I don't remember what was said , but beaver dams affect water distribution and also beavers eat fish as well as the otters that try do steal beaver dams</p>
<i>River ice</i>	<p>Dates of river ice freeze up and break up</p> <p>Conditions of winter ice roads</p> <p>Summer barge issues</p>
<i>Sea ice</i>	WHAT MIGHT BE INCLUDED IN THESE DISCUSSIONS WITHIN THE CONTEXT OF THE CURRENT PROJECT?
<i>Alaska Native water rights and how they are changing; water law and policy; state of monitoring</i>	Alaska Native Water rights but if a mining company comes in then they have the right to use the water and some of the cases in line with water - familiarize ourselves
<i>Wildlife</i>	<p>How loss of species affects other species (e.g., decline of fish and having to hunt for other animals)</p> <p>temporal mismatches in salmon spawning/bear fishing and hibernation cycles? or other species</p>

Goal #2: Identify important areas of concern with respect to Indigenous livelihoods, river transportation, and fish species shifts and survival. This will inform the project modeling.	
Climate	What kinds of climate data formats would be most useful for planning?
	OTHER?
Rivers	What characteristics of riverine habitats are important for communities and/or fish?
	What river ice corridors are critical for communities?
	Considering the above two questions, what river reaches should we focus on for flow and ice modeling?
	What kinds of flow and river ice information would be most useful for planning?
	OTHER?
Fish	What fish play key roles culturally, ecologically or both that people might like us to model?
	What kinds of fish output would be most useful for planning?
	OTHER?
People	How is climate change affecting subsistence, livelihoods, and cultures?
	How can we increase the resilience of communities and non-human relatives to climate change both now and in the future? (This relates to Goal #3 as well in terms of developing action plans)
	OTHER?

Goal #3: Brainstorm and exchange information on solutions for communities and species to survive and thrive?	
Strengthen relationships	Strengthen relationships among the members of the Indigenous Advisory Council so they can become a stronger group
	Build a stronger network between Indigenous Knowledge holders and Western scientists and managers
	Strengthen relationships among IAC members, scientists, and managers by linking several small groups, 3-4 people, via a Zoom meet and greet several times outside IAC monthly calls.
	OTHER? Identify strengths where community has identified impacts and need to do something; impacts from coastal erosion or traffic in general and fish populations; weaknesses - lack of funding and prioritization by policy makers like looking for alternative water sources because of increased ocean influence on water sources. Opportunities for applications of traditional knowledge and management of resources for Tribal vision - including funding opportunities. Threats would state politics and industrial development. consider what we have control over versus what we don't have control over. Provide opportunities to get funding for mitigation for moving houses, etc. Be realistic about we can and can't do.

	<p>Also maybe some communities are already doing good adaptive things that we can discuss and learn from during the relationships/actions plans sections.</p>
<p><i>Develop action plans</i></p>	<p>Identify 2-3 goals at the Summit, how to accomplish them, and a timeline for doing so</p> <p>How to find out what is going on in our communities and make use of that information to develop solutions</p> <p>How to move forward with incorporating IK into management decisions – what does that look like and who is going to be taking action (e.g., our Council, this project, other organizations)</p> <p>OTHER?</p>