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Arctic Research Collaborations among Agencies: A Case Study Analysis of Factors Leading to Success within the Interagency Arctic Research Policy Committee

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Arctic Research Collaborations among Agencies: A Case Study Analysis of Factors Leading to Success within the Interagency Arctic Research Policy Committee

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List of Acronyms

AAAS	American Association for the Advancement of Science
ACCT	Arctic Communities Collaboration Team
AESC	Arctic Executive Steering Committee
ARPIPC	Arctic Region Policy Interagency Policy Committee
ARPA	Arctic Research Policy Act
BOEM	Bureau of Ocean Energy Management
BLM	Bureau of Land Management
CBCT	Chukchi Beaufort Collaboration Team
CDC	Center for Disease Control
CENRS	Committee on Environment and Natural Resources
CoP	Community of Practice
CT	Collaboration Team
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DHS	Department of Homeland Security
DOI	Department of the Interior
DOS	Department of Safety
DOT	Department of Transportation
EPA	Environmental Protection Agency
FACA	Federal Advisory Committee Act
HHS	Department of Human Health Service
KM	Knowledge Management
NAS	National Academy of Sciences
NGO	Non-Governmental Organization
NIH	National Institute of Health
NPRB	North Pacific Research Board
NOC	National Ocean Council
NOP	National Ocean Policy
NSAR	National Strategy for the Arctic Region
NSF	National Science Foundation
NSPD-66	National Security Presidential Directive
NSTC	National Science and Technology Council
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
MMC	Marine Mammal Commission
IARPC	Interagency Arctic Research Policy Committee
IASC	International Arctic Science Committee
IPY	International Polar Year
OMB	Office of Management and Budget
ONR	Office of Naval Research
OSTP	Office of Science and Technology Policy
SEARCH	Study of Environmental Arctic Change
SNA	Social Network Analysis

SI	Smithsonian Institute
TAPS	Trans-Alaska Pipeline System
USARC	United States Arctic Research Commission
USCG	United States Coast Guard
USGS	United States Geological Services
USDA	United States Department of Agriculture
USGCRP	United States Global Change Research Program
USGEO	United States Group on Earth Observations

Abstract

The Arctic is changing rapidly as average temperatures rise. As an Arctic nation, the United States is directly affected by these changes. It is imperative that these changes be understood to make effective policy decisions. Since the research needs of the Arctic are large; 14 Federal agencies have Arctic research programs. As a result, the government regularly works to coordinate Federal Arctic research in order to reduce duplication of effort and costs, and to enhance the research's system perspective. The government's Interagency Arctic Research Policy Committee accomplishes this coordination through its Five-year Arctic Research Plans and Collaboration Teams, which are research topic-oriented teams tasked with implementing the plans. However, the Collaboration Teams operating during the years 2013-2017 achieved differing levels of success in building lasting collaborations among Federal agencies and Arctic research stakeholders. This thesis aims to understand what factors contributed to these differing outcomes. Using the frameworks of knowledge management (KM) and communities of practice (CoPs), two case studies of Collaboration Teams with varying success are analyzed. These case studies are built on interviews, archived data, meeting notes, and reports. Several factors are found to have contributed to the varying levels of success of these two teams: leadership, scope, centrality, disciplinary challenges to collaborations, and inclusivity. From the case studies, several recommendations emerge, including establishing appropriate agency leadership; determining focused and achievable scope of team goals; providing room for bottom-up, community-driven determination of goals; building relationships and creating an open team environment; and finally, completing of a social network analysis.

Executive Summary

The Arctic is changing rapidly as average temperatures rise. As an Arctic nation, the United States is directly affected by these changes. It is imperative that these changes be understood to make effective policy decisions. Since the research needs of the Arctic are large; 14 Federal agencies have Arctic research programs. As a result, the government regularly works to coordinate Federal Arctic research in order to reduce duplication of effort and costs, and to enhance the research's system perspective.

The Interagency Arctic Research Policy Committee

The United States' interests in Arctic research have coalesced at certain points in time around pieces of Federal policy which sought to direct Federal research initiatives and create a space for greater interagency collaboration. The Arctic Research Policy Act of 1984, which established the Interagency Arctic Research Policy Committee (IARPC), was intended to address the complexity of Federal agency Arctic research agendas and create structures through which United States Arctic research priorities could be communicated and interagency research collaborations could develop.

IARPC was created to advance research collaborations for Arctic science among a variety of Federal agencies, as well as State of Alaska organizations and officials, academia, non-governmental organizations (NGOs) and Alaskan stakeholders in order to reduce duplication and capitalize on areas of shared interest. Each of the Federal agencies that participate in IARPC has a unique mission that shapes its interests in the Arctic. However,

although each of these agencies has its own set of research interests, there are many areas where these interests overlap and collaborations can be built.

Although IARPC was created by Congress in 1984, it was not until around 2012 that it began to more fully meet its legal mandate through the publication of a robust five-year Arctic Research Plan. IARPC accomplishes it mission to coordinate Federal Arctic research through these Research Plans and through its Collaboration Teams (CTs), which are research topic-oriented teams tasked with implementing the plans. This thesis focuses on the implementation of IARPC's first robust plan, the Five-year Arctic Research Plan FY2013-2017. At the highest level, the Plan is organized into seven research areas, chosen because of their salience and potential for interagency collaboration. Objectives fall under these broad research areas that help to capture different interests in the topic. Beneath these objectives fall milestones, which are more specific and actionable steps towards achieving the objectives and the broader research areas.

Twelve Collaboration Teams, composed of a wide range of researchers, program managers, industry representatives, and policy makers, were formed to carry out the objectives and milestones set forth in the Plan. However, the CTs operating during the years 2013-2017 achieved differing levels of success in building lasting collaborations among Federal agencies and Arctic research stakeholders. This thesis aims to understand what factors contributed to these differing outcomes.

Shortly after the publication of the Plan and the formation of CTs, IARPC launched IARPC Collaborations, an innovative virtual meeting and web-based platform designed to help facilitate collaboration among Arctic researchers. IARPC Collaborations is both the structure through which teams carry out the implementation of the Plan and a social and knowledge sharing web platform. Each member of IARPC Collaborations brings a particular perspective as well as a wealth of experience and knowledge. Creating spaces for these perspectives to be shared is of the utmost importance for the health and value of IARPC Collaborations, and it takes time and strategic effort to enable those with vastly different experiences to share information effectively.

Frameworks of understanding

Using the frameworks of knowledge management (KM) and communities of practice (CoPs), this thesis analyses two case studies of variously successful IARPC Collaboration Teams. KM is the coordination of an organization's knowledge resources in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge (Dalkir, 2005). IARPC is broadly a knowledge management system through which relevant knowledge is captured, shared and applied, to the end of establishing collaborative efforts. Communities of Practice (CoPs) are structures through which knowledge can be shared. CoPs are defined as a group of people who share a common interest and learn how to be better practitioners in this interest through regular interaction with each other (Wegner, 2006). Several factors are thought to contribute to the success and longevity of CoPs, including leadership, focused goals, shared methodology and vocabulary, and continuous outreach. IARPC CTs fit many of the defining factors of CoPs. Social network analysis, which is a quantitative method of understanding connections between people, can also be used to understand the underlying networks of knowledge exchange within CoPs.

The Arctic Communities Collaboration Team and the Chukchi Beaufort Collaboration Team

This research explores the progress made towards the building of lasting collaborations in two Collaboration Teams through a combination of primary and secondary research. The case studies of the two CTs are based primarily on a set of semi-structured interviews conducted over a month-long period. Interviews are supplemented by data from a questionnaire distributed to both teams and the IARPC Collaborations website, as well as meeting notes and reports.

The two teams selected for in-depth analysis are the Arctic Communities Collaboration Team (ACCT) and the Chukchi Beaufort Collaboration Team (CBCT). Both teams functioned from 2013 to 2016. The ACCT was primarily composed of social scientists and tasked itself with working toward a broad range of 18 milestones related to adaption and community resilience. The CBCT focused on a narrower set of seven milestones designed increase understanding of the marine ecosystem processes of the Chukchi and Beaufort seas.

Several factors contributed to the varying levels of success of these two teams: leadership, scope, centrality, disciplinary challenges to collaborations, and inclusivity. The leadership between the two teams, for example, varied significantly at the agency level. While the ACCT was led by the Smithsonian Institute (SI), its proportionally small research budget and specific interests worked against the development of robust collaborations. In contrast, a wide variety of agencies were highly interested in the specific goals of the CBCT and were willing to lead by contributing funding toward collaborative research efforts. Perhaps the greatest contrast between the two teams was the scope of the two teams' goals. The ACCT's goals ranged widely, from topics of cultural and linguistic preservation to supporting predictive climate models. The CBCT was focused around a single goal, to build a conceptual model of the Chukchi and Beaufort seas. In addition, the ACCT's goals were established through a top-down process, while the CBCT left room for its team members to contribute to the establishment of high priority research themes within the overarching goal. For the ACCT, the lack of a pointed focus, combined with the fact that the team's members were spread out across a wide range of interests within the social sciences, prevented the establishment of strong collaborative efforts. Perhaps enhanced by its ties to social science, and therefore to the human dimension of the region, the ACCT needed to connect with local communities, but because of the primary location of its leadership in DC, the team was unable to do this consistently.

While there is certainly complexity within and between the teams that does not always allow for a direct comparison, in many instances, the same factors that led to the success of the CBCT influenced the mixed outcome of the ACCT. Each of these factors played a significant role in the unfolding of the teams and their relative ability to create lasting collaborations. By understanding these factors, we can gather lessons learned that will help improve the latest edition of IARPC Collaboration Teams and help lead to more and longer lasting collaborations on Arctic Research.

Policy Recommendations

From the case studies, several recommendations emerge, including establishing appropriate agency leadership; determining focused and achievable scope of team goals; providing room for bottom-up, community-driven determination of goals; building relationships and creating an open team environment; and finally, completing of a social network analysis.

First, IARPC needs to align the primary goals of the team with the missions of the agencies that will be taking leadership positions within the team. As was evidenced by the ACCT, when a leading agency's mission does not fit the majority of the team's goals, its leadership ability is compromised as it cannot support many of the goals through collaborative research efforts. In addition, it is helpful to have leading agencies that are willing and able to fund research initiatives that contribute towards at least some of the team's goals. Combined, these agency leadership roles contribute to the success of CTs through the alignment of goals, agency interests, and funding ability.

Second, **IARPC and team leaders should bind the scope of the team's goals during the Plan formulation process and implementation.** The questions facing Arctic research are quite large, and CTs cannot hope to answer all the research questions surrounding their topic in a five-year span. The scope of the CT's topic needs to be taken into consideration and a mechanism for channeling the team's energy should be established. This might not be a conceptual model like the CBCT's, but having a centering point to build cohesion and collaboration in teams that have wide-ranging goals and membership interests will help increase the team's ability to build strong and oriented collaborations.

Third**, team leaders should also leave room for community members to contribute to the direction and priorities of the team.** This bottom-up approach allows the membership to bring their expertise to bare and find areas of shared interest from multiple agencies, scientists, and stakeholders. This plays to a strength of communities of practice, their informality, which is necessary to foster spontaneous and creative knowledge. This can be accomplished through the wording of milestones/performance elements, which can leave space for team members to determine priorities.

Fourth, **actions can be taken by both IARPC and team leaders to strengthen the relationships between DC, Alaska, and Arctic communities.** IARPC deals primarily with Federally funded research, but the stakeholders and those most closely tied to the application of this research reside in Alaska and in Arctic communities. It is, therefore, important that efforts are made to bridge these divides. Both IARPC as well as CT leaders should make repeated efforts to engage these with these native organizations and networks. Increasing indigenous engagement with IARPC will likely take time and focused effort by both the Secretariat as well as team leaders, but it is a necessary step toward building better science policy that meets the needs of Arctic stakeholders.

Fifth, **team leaders should make outreach and engagement a concrete goal.** Because IARPC has strong ties to the Federal government, outsiders might feel excluded. Therefore, it is important for team leaders to consistently message that the team is open to anyone who is interested. The wider the perspectives are, the more well-rounded the team will become.

Finally, although a social network analysis was not able to be completed for this thesis, due to low questionnaire response rates, **SNA would be a valuable exercise for IARPC to undertake in order to understand the hidden nature of knowledge flows within and among the collaboration teams.** If IARPC strongly supported such an effort, higher response rates would be likely. With more data, teams could be assessed for key knowledge sharers and knowledge bottlenecks as well as sub-networks within the teams.

Conclusions

Given the complexity of the Arctic system, including its human dimension, policy makers argue that Arctic research is strengthened if research efforts are coordinated across government agencies and stakeholders and, in some cases, are interdisciplinary. Studying the Arctic system through isolated entities only captures part of the picture, while coordinated efforts have the advantage of pooling resources and information to create a more complete picture of the Arctic system and how this knowledge can be applied.

Although the current direction of Arctic research and IARPC is not certain due to the change of administration in 2017, Arctic research continues to be important and Arctic residents continue to face the challenges brought on by a changing climate. Federal agencies continue to need to collaborate with each other, as well as with academics, indigenous organizations, the state of Alaska, and NGOs in order to produce the best and most cost-effective research. Therefore, it is likely that IARPC will continue to be needed as a facilitator of these collaborations. IARPC has grown tremendously in its ability to fulfill its legal responsibilities over the last decade and will need to keep its flexible and open-minded approach in order to adapt to new challenges and continue to increase its effectiveness in building lasting collaborations.

I. Introduction

In the past several decades, the Arctic has experienced a set of dramatic events linked to climate change. These events include record-breaking warm air temperatures and end-of-summer minimum sea ice extent, extreme melting events on the Greenland ice sheet, and severe wildfire activity (Fetterer, Knowles, Meier & Savoie, 2002; Shepherd et al., 2012; Kasischke & Hoy, 2010). Changing long-term trends in the Arctic are also important. For example, annual minimum and maximum sea ice extents are decreasing at rates of 13.4% and 2.6% per decade, respectively (Serreze, Barrett, Stroeve, Kindig, & Holland, 2009), with implications for ecosystems, subsistence hunting, and commerce. These events have catalyzed United States policy makers and scientists at varying scales to assess research needs and potential areas for collaboration in Federally funded Arctic science initiatives (National Academy of Sciences, 2014; United States Arctic Research Commission, 2016; Alaska State Committee on Research, 2014). The United States is an Arctic nation and therefore has a vested interest in understanding the Arctic system. Not only is the changing Arctic effecting Arctic ecosystems and residents, but will increasingly effect the continental US through sea level rise, changing ecosystem regimes, and increasing ocean acidification (Vorosmarty & Hinzman, 2016)

Arctic research spans a wide range of topics from understanding sea ice dynamics to food security, and there are 14 Federal agencies that have programs with Arctic focus. While many of the Federal agencies have their own research goals that are in line with their respective missions, there are many areas of overlapping concern. Federal agencies themselves are large, complex organizations with a variety of goals and responsibilities, and finding areas for potential coordination takes effort, communication, and organizational capacity. What the factors are that lead to successful coordination and collaboration among Arctic researchers in these complex organizations is the fundamental focus of this thesis.

Recently, there has been a rising focus on collaboration among Arctic agencies, researchers, academics, and local stakeholders (Arctic Research Consortium of the United States, 2016; Interagency Arctic Research Policy Committee, 2015; Jeffries, Starkweather & Stephenson, 2016). Congress acknowledged the value in coordinating different Federal agencies to work together on scientific research in order to more efficiently and effectively understand and manage this rapidly changing environment (Arctic Research Policy Act, 1984). The Arctic provides a unique stage that Federal agencies can collaborate on, not only because of the mounting evidence of the rapidly changing Arctic increases the urgency of action (Vorosmarty & Hinzman, 2016), but also because there is a vast and varied amount of research taking place. Arctic scientists are particularly aware of the importance of developing a systems approach to understanding the Arctic system and the changes happening there, and this awareness provides further impetus for interagency collaboration on research.

Coordinating research across Federal agencies is complex but increasingly important as the rate of Arctic change increases and budgets are limited. In order to do this Congress created the Interagency Arctic Research Policy Committee (IARPC) to advance interagency collaborations. IARPC functions as a knowledge sharing facilitator and gives agencies and other stakeholders a platform to build collaborations through topic oriented teams. These teams can be viewed as communities of practice, where researchers, policy-makers and other stakeholders that have common interests exchange knowledge. In studying two Federally organized teams, this thesis finds that a number of factors influenced the collaboration and knowledge sharing within these communities of practice and contributed to their varying levels of success at building lasting collaborations. These factors include leadership, scope, centrality, disciplinary challenges to collaborations, and inclusivity. Based on these conclusions, I argue that IARPC and Collaboration team leaders can take several steps that will help Collaboration Teams move from knowledge sharing spaces to spaces where collaborative action is taken. These steps include; securing strong and fitting agency leadership of teams, scoping the goals of the team appropriately to create achievable and measurable outcomes, creating a balance of top-down and bottom up approach by allowing community input on the team's goals, developing stronger ties between Federal agencies and researchers in DC, the state of Alaska, and Arctic communities through relationship building and staff location, fostering an inclusive team environment through continuous outreach, and further examining the structure of networks within Collaboration Teams through social network analysis.

In order to understand or indeed validate the varying degrees of success across IARPC Collaboration Teams, this research explores the progress made towards the building of lasting collaborations in two Collaboration Teams through a combination of primary and secondary research. Frameworks within the literature of knowledge management are described and used to assess the Collaboration Teams. The case studies of the two Collaboration Teams are based primarily on a set of semi-structured interviews conducted over a month-long period. Interviews are supplemented by data from both a questionnaire distributed to both the Arctic Communities Collaboration Team and the Chukchi Beaufort Seas Collaboration Team and the IARPC Collaborations website. The originally intended method was to use a questionnaire to receive data on social networks within the team in order to perform a Social Network Analysis, however, the response rate was too low to perform a robust analysis. Some of the multiple-choice questions asked in the questionnaire have been used to provide additional analysis. Finally, the IARPC Collaborations website was used for data that was relevant to the analysis of the two teams. Because the website is, in part, a social media platform, some of the data stored there speaks to the activity level and engagement of team members.

The Interagency Arctic Research Policy Committee

The Interagency Arctic Research Policy Committee (IARPC) is a body created by Congress to advance research collaborations for Arctic science among a variety of Federal agencies as well as State of Alaska organizations and officials, academia, non-governmental organizations (NGOs) and Alaskan stakeholders in order to reduce duplication and capitalize on areas of shared interest. IARPC was established by the Arctic Research Policy Act (ARPA) of 1984 to address the complexity of Federal agency Arctic research agendas. One tool IARPC uses to accomplish this task is the production and implementation of five-year Arctic Research Plans. While compilations of individual agency Arctic research plans were produced in the 1980s-2000s, they lacked cohesions or any articulation of how agencies would work together to accomplish broad goals (National Science Foundation, 2006). It was not until 2013, however, that IARPC began to meet the requirement mandated by ARPA when they published their first truly integrated 5-year Arctic Research Plan (2013-2017).

Collaboration among organizations and individuals requires that information flows efficiently among members (Asoh, Belardo & Neilson, 2002), and IARPC faces many challenges in this regard. They not only have to bring together disparate groups of people and entities at different scales, but also have to do so across wide distances. In order to overcome these challenges, IARPC established teams that members could funnel into based on their interests. They also created actionable milestones in their Five-Year Arctic Research Plan FY2013-2017 (hereafter called “the Plan”) around which teams collaborated. While some Collaboration Teams (CTs) were worked very effectively together, others had mixed success and did not build lasting collaborations.

Shortly after the publication of the Plan and the formation of CTs, IARPC launched IARPC Collaborations, an innovative, virtual meeting and web-based platform designed to help facilitate collaboration among Arctic researchers. IARPC Collaborations is both the structure through which teams carry out the implementation of the Plan and a social and knowledge sharing web platform. Each member of IARPC Collaborations brings a particular perspective as well as a wealth of experience and knowledge. Creating spaces for these perspectives to be shared is of the utmost importance for the health and value of IARPC Collaborations, and it takes time and strategic effort to enable those with vastly different experiences to share information effectively.

II. Background: The Context and Content of United States Arctic Research Policy to Date

IARPC is one organization within of a wide landscape of Arctic research policy bodies (e.g. Subcommittee on Ocean and Science Technology, US Group on Earth Observations, Arctic Executive Steering Committee, US Global Change Research Program). Arctic research covers a wide range of activities, from satellite observations to socio-economic studies and it spans both the public and private sectors, but the connecting thread is the need to better understand the Arctic region. Within the government, Arctic research and programs are spread across a range of Federal and state agencies. Important resources targeting the science community come from Federal organizations like the National Science Foundation (NSF) and play an important role in shaping the emerging field of Arctic research. This chapter lays out the United States' political and policy interests in the Arctic. Second, the chapter gives a brief overview of the foundational legislation on which IARPC is established. Next, other Arctic policies contributing to a more robust policy landscape are considered in both their own right and in their relation to IARPC. Finally, a brief history of IARPC activities to date is outlined.

United States Interests in the Arctic

The United States became an Arctic nation in 1959 when Alaska became a state. Since then, US political interests have ranged from Alaska's abundant natural resources, to security issues, and now climate change. Alaska, its continental shelf, and the adjacent waters, historically, contain large amounts of natural resources, most notably oil and natural gas, but also fishing, mining, and forestry. The 1970s oil crisis prompted the United States to develop oil resources in the Arctic via the Trans-Alaska Pipeline System (TAPS). In turn, this created a demand for environmental and technological research associated with the challenges of this massive infrastructure project (Starkweather, 2011).

During the Cold War, the Arctic became a place of important strategic significance for defense and security, as Russian waters are adjacent to the United States along a border in the Bearing Sea, also known as the Ice Curtain. Military bases in the Bearing Sea, like Adak, were built and used to track Russian submarines and provide aerial defense. Currently, the Artic serves as a center for renewed geo-political competition and tension as receding sea ice makes previously unreachable offshore energy sources available, and nations are starting to build up their Arctic military presence through new bases (Hutchison, 2017) and icebreakers (France-Presse, 2016).

In the 1990s, the United States interests began to shift and expand in the Arctic as concerns over climate change moved onto the national agenda. The United States identified a need to understand the Arctic's influence on sea level rise due to the diminishment of sea ice and how the changing Arctic would impact Arctic residents. These impacts range from permafrost loss to shifts in fire regimes and migratory patterns. Permafrost thaw threatens Arctic infrastructure such as roads and pipelines, which effects Arctic commerce. Arctic indigenous communities are particularly vulnerable because they often rely on the land to provide food that is becoming increasingly unpredictable. In addition to challenges for infrastructure and communities, the changing climate presents new opportunities potentially opening up the Northwest Passage for summer shipping and tourism.

In response, during the 1990s's the United States began to prepare for increasing Arctic development. In addition to research policy, the Arctic is also governed by a regional policy, first established in the Nixon administration, that focuses on the natural resource management and national security (Starkweather, 2011). Another part of United States preparation for increased Arctic activities, was United States participation in the expansion of the international Arctic regime with the creation of the Arctic Council (AC) in 1994. The AC, composed of the eight Arctic nations[1], six permanent participants[2], and observers, was formed, in part, to address the rapidly changing Arctic environment and its effects on Arctic residents as well as the projected increase in transportation, tourism, and energy drilling due to a longer periods of minimal ice coverage. The Arctic Council does much to facilitate international collaborations on Arctic research.

Each of these interests prompts research from a wide variety of Federal agencies, from the Department of Health and Human Services' focus on the health and well-being of Arctic residents from issues of contaminants to child abuse to the National Aeronautics and Space Administration's remote observations and modeling. Federal money also funds researchers at academic institutions. Rising academic interest in part stems from the drastic effects of climate change on the region and the understanding that Alaska was experiencing the changes more rapidly and to a greater degree than elsewhere in the United States.

As Arctic issues became more pressing and research was needed to address them, an Arctic field of research began to emerge in its own right. A field is defined as "a conceptual space where various regulatory/disciplinary regimes are pursued and negotiated among a host of players" (Shamir, 2004). The NSF, which was designated as the lead agency responsible for implementing Arctic research policy in 1984 by an Act discussed below, published the

[1] Canada, the Kingdom of Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden and the United States.

[2] The Aleut International Association, the Arctic Athabaskan Council, Gwich'in Council International, the Inuit Circumpolar Council, Russian Association of Indigenous Peoples of the North and the Saami Council.

journal Arctic Research of the United States from 1987-2007, which attempted to capture the Arctic research budget for each Federal agency with research in the region as well as a detailed overview of the Arctic research being conducted within each agency's programs. In addition, conferences and professional associations for Arctic scientists began to multiply[3]. The NSF, with its relatively large Arctic research budget and mandate to lead Arctic research efforts helped to support this area of scientific growth.

These rising trends in both policy and academic circles are reflected in the initial construction of the Federal Arctic network in the early 1980s and the acceleration of collaboration since the mid-2000s. Up through the 1980's the research being conducted by various Federal agencies in the Arctic was disconnected and little coordination was taking place (Arctic Research Policy Act, 1984). This can be especially detrimental to Arctic research, which, because of the remote location and harsh conditions, can be extremely expensive. Researchers were siloed in their respective disciplines, but by the end of the decade systems science had matured along with a rising awareness of the role of human activity in climate change that spurred interdisciplinary work (Interagency Arctic Research Policy Committee, 2012). Along with IARPC, interdisciplinary efforts like the Study of Environmental Arctic Change (SEARCH), an interagency effort focusing on the impacts of shrinking land and sea ice and degrading permafrost, and the International Polar Year (IPY), a large scientific program from 2008 to 2009 that supported over 200 projects in the Arctic and Antarctica. Importantly, the United States' interests in Arctic research coalesced at certain points in time around pieces of Federal policy which sought to direct Federal research initiatives and create a space for greater interagency collaboration (Figure 1).

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[3] International Arctic Research Committee created in 1990, Polar Research Board created in 2010, Alaska Ocean Observing System created in 2005, North Pacific Research Board created in 2001.

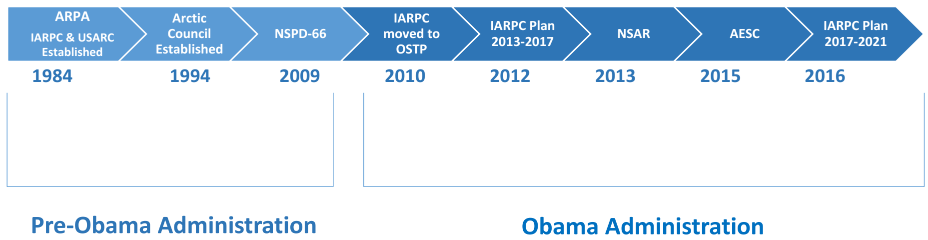

Figure 1: Timeline of Relevant Arctic Policy 1984-2016

Shaping Arctic Science and Policy: Arctic Research Policy Act

The Arctic poses an interesting challenge for those involved in science and technology policy, who need to not only coordinate a range of research across Federal agencies, but also across the continental U.S., Alaska, and international boundaries (Starkweather, 2011). To address these challenges, **The Arctic Research Policy Act (ARPA)** was passed by Congress in 1984 and amended in 1990 (Arctic Research Policy Act, 1984). ARPA was intended to address the complexity of Federal agency Arctic research agendas and create structures through which United States Arctic research priorities could be communicated and interagency research collaborations could be fostered. ARPA established both the United States Arctic Research Commission (USARC) and the Interagency Arctic Research Policy Committee (IARPC). USARC is designed as a rotating, seven-person, non-partisan advisory board of scientists, physicians, indigenous leaders and industry representatives who are appointed by the President in order to advise the President and Congress on Arctic research priorities through the publication of a bi-annual Report on the Goals and Objectives of Arctic Research.

Initially, IARPC was tasked with coordinating implementation of these research priorities within and among Federal agencies (Starkweather, 2011). IARPC is chaired by the Director of the NSF and includes senior ranking officials (called principals) from each of the participating agencies[4]. However, IARPC was not effective at meeting ARPA mandates during the first decade of its existence as its publications largely lacked strategic and forceful implementation. Due to the increased focus on the Arctic by the Obama administration, which, as discussed below, has led to more robust Arctic focused policies that increase the motivation and power behind implementation, IARPC has taken on a more active role in fulfilling its mandate.

Changing Political Environment and Policy Concerns

In 2010, the Obama Administration issued a **Presidential Memorandum** transferring the responsibility for implementing IARPCS's five-year research plan from NSF to the Office of Science and Technology Policy (OSTP) in the White House through the National Science and Technology Council's (NSTC) Committee on Environment and Natural Resources (CENRS) (Obama, 2010a). The Memorandum states that this move was driven by the rapid ecosystem changes in the Arctic, the advancing strategic importance of the region, and the increasingly interagency aspects of managing the vast Arctic research program plan (Starkweather, 2011).

This move, which was facilitated by USARC, improved the status and power of IARPC. The direct White House leadership helped to legitimize IARPC (Starkweather,

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[4] National Science Foundation, Department of Agriculture, Department of Commerce, Department of Defense, Department of Energy, Department of Health and Human Services, Department of Homeland Security, Department of Interior, Department of State, Department of Transportation, Environmental Protection Agency, Marine Mammal Commission, National Aeronautics and Space Administration, Office of Management and Budget, Office of Science and Technology Policy, Smithsonian Institute.

2011). This reflected the increasing agenda salience of the Arctic for the Obama administration. With the support of the Obama White House, however, IARPC increased participation and coordination among its members by publishing and implementing a robust Arctic research plan.

One reason for this increased activity, is that by moving IARPC under the control of the White House, as opposed to the NSF, all participating agencies became peers and thus more willing to contribute to the effort (Starkweather, 2011). In addition, this move created more avenues for cooperation with other groups within the White House, such as the United States Global Change Research Program (USGCRP) and the United States Group on Earth Observations (USGEO) (Starkweather, 2011).

Other contributing Arctic policies

The Obama Administration continued to support the expansion and recognition of the Arctic and Arctic policy as an agenda item for the administration (Starkweather, 2011) (Figure 2) President George W. Bush signed the **National Security Presidential Directive (NSPD-66)** in January of 2009 that was later endorsed by the Obama Administration in 2010. This Directive lays out Arctic regional policy in relation to recent developments like, the formation of the Department of Homeland Security under the Bush administration, climate change, increasing Arctic development, a rising awareness of the need to involve indigenous communities in decision making, and the formation of the Arctic Council (National Security Presidential Directive and Homeland Security Presidential Directive, 2009). The policy also encourages international cooperation in research. Because ARPA was created before the rapid environmental change seen in the Arctic in recent years, the NSPD-66 was designed to modernize United States research priorities (Starkweather, 2011). The Arctic Region Policy Interagency Policy Committee (ARPIPC) was assigned responsibility for implementing this policy, and IARPC participates in the Working Groups that relate to research (Starkweather, 2011).

In 2013, the Obama Administration published the **National Strategy for the Arctic Region (NSAR)**, as a means of streamlining and implementing the priorities of the NSPD-66 and the Arctic Region Policy. The NSAR focused on security, stewardship, and international cooperation (National Strategy for the Arctic Region, 2013). These priorities are a statement of the United States' current policy goals in the Arctic and reflect the growing awareness of the Arctic as a critical stage for both national security and climate related issues (Arctic Executive Steering Committee, 2015)[5].

These policies contributed to IARPCs increased ability to fulfill its legislated mandate to facilitate interagency collaboration through the publication and implementation of five-year Arctic research plans. The Obama administration's focus on the Arctic increased activity across and among Federal agencies contributing to Arctic research, and drove the need for interagency bodies, lie IARPC, to coordinate the growing research efforts.

[5] The Arctic Executive Steering Committee, chaired by the OSTP, was established by Executive Order in 2015 to fulfill the policies of the NSAR.

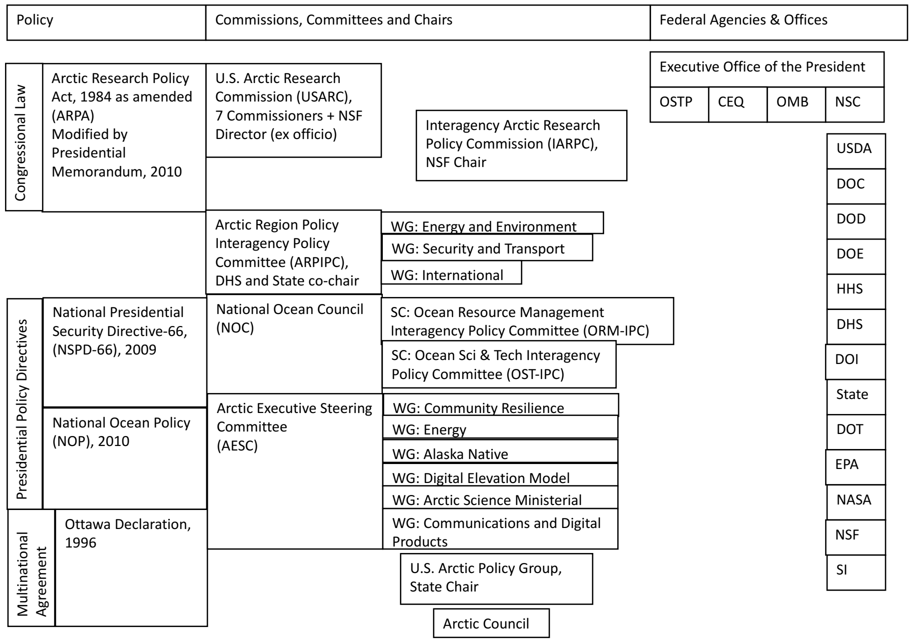

Figure 2: United States Arctic Policy Map. Source: Advancing Interagency Cooperation in a Restructured Arctic Planning Environment: Recommendations for SEARCH and the United States Arctic Observing Network, Starkweather, 2011. Adapted by Meredith LaValley

IARPC Revitalized

The Federal government uses IARPC and their activities to coordinate Arctic research in order to reduce duplication of efforts, build on existing projects, save money, and further align policy with research. Although IARPC was legally created by ARPA in 1984 with a mandate to produce an Interagency Arctic Research Plan every 5 years, it was not until 2012 that IARPC began fulfilling this requirement in a meaningful way. Prior to 2012, in lieu of the required plan from, IARPC, with support of NSF, would publish an Arctic Research Journal each year beginning in 1987. This journal functioned primarily as an inventory of Arctic research and budgets was by organized agency, but did not, in particular, support or encourage interagency collaboration.

The momentum of NSPD-66 in 2009, the Presidential Memorandum that moved IARPC under OSTP in 2012, and the NSAR in 2013 all contributed to the considerably more elaborative and robust Arctic Research Plan FY2013-2017.

The Arctic Research Plan FY2013-2017

Following the priorities of proceeding policies, the Plan, as outlined in its introduction summarized here, was intended to address the rapid changes affecting the region's biota and people through interagency collaboration. These changes included increasing access to the region for energy and mineral development, shipping, tourism, and military operations—human activities that carried both risks and opportunities for the Arctic region. Several Federal agencies conduct scientific research to understand those changes, risks, and opportunities. Policymakers increasing rely on the ensuing science to make decisions and form practical responses. The Plan aimed to support those decisions with enhanced interagency cooperation on Arctic research to address the most pressing science needs (Interagency Arctic Research Policy Committee, 2012).

IARPC Organizational Structure

There are 14 Federal agencies that have research interests in the Arctic and are part of IARPC (Figure 3). Each of these agencies contributes a Principle who all meet twice a year and represent their respective agency's interests in IARPC. There is also a Staff Group, populated by representatives from the 14 Federal agencies, which meets monthly to discuss timely issues and have discussions about budgets and action that need to take place in a

Federal only space. The Principles along with the Staff Group comprise the Federal component of IARPC.

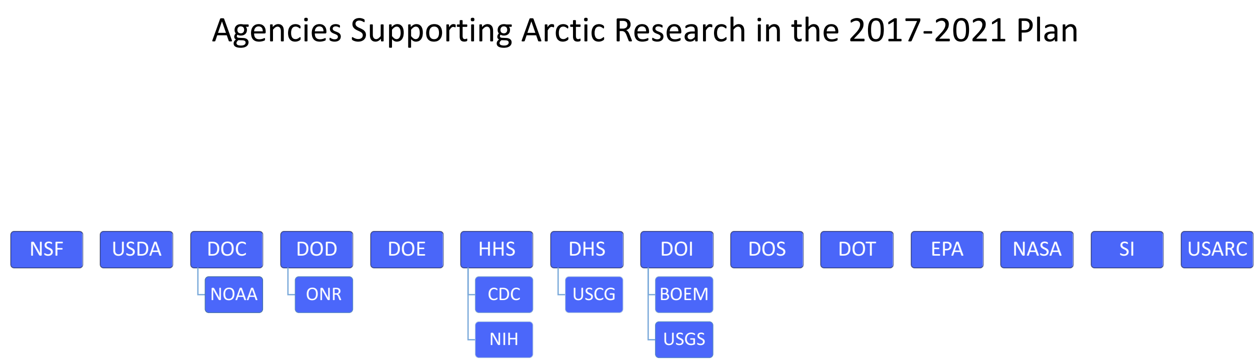

Figure 3: United States Federal Agencies and Offices that participated in the Arctic Research Plan FY2013-2017.

Each of the Federal agencies that participate in IARPC haa a unique mission that shapes their interests in the Arctic. However, although each of these agencies has its own set of research interests, there are many areas where these interests overlap and collaborations can be built. Because scientists are thinking of the Arctic as a system, the pieces of the Arctic relevant for each agency are connected and influence each other. The awareness of the interconnectedness of the component parts of the Arctic, as well as the Arctic's rapidly changing state, drives researchers and Federal agencies to collaborate and share knowledge around topics of concern.

IARPC is staffed by a small Secretariat that at the time implementation of the Plan began, consisted of the Executive Director, Brendan Kelly, and the executive Secretary, Sara Bowden. Shortly after the Plan was published, and Implementation Scientist, Sandy Starkweather, was brought on to help direct the Plan's implementation. It was through

Sandy's direction that IARPC created a website, IARPC Collaborations, to facilitate the Plan's implementation.

Plan Structure

The need to gather Federal agencies to collaborate around prescient issues helped to determine the structure and focus of the Plan. At the highest level, the Plan is organized around seven Research Areas, chosen because of their salience, potential for interagency collaboration, and relevance to the policy drivers outlined in the NPSD-66.

Table 1: Research Areas in the Arctic Research Plan 2013-2017

Research Areas
1. Sea ice and marine ecosystems
2. Terrestrial ice and ecosystems
3. Atmospheric studies of surface heat, energy, and mass balances
4. Observing systems
5. Regional climate models
6. Adaptation tools for sustaining communities
7. Human health

Objectives fall under these broad research areas that help to capture different interests in the topic. Beneath these objectives fall milestones, discussed in more detail later as they relate to the case studies, which are more specific and actionable steps towards achieving the Objectives and the broader Research Areas.

Collaboration Teams

Collaboration Team Formation

In order to implement the Plan and build interagency collaborations around the Research Areas, Implementation Teams were formed to correspond to each Research Area. At first, these teams were open to Federal employees only. However, it soon became apparent that the Implementation Teams needed to become open to other members of the Arctic research community to be truly robust. Varied expertise needed to be included in discussions and different perspectives needed to be brought to bear[6].

Although it was the intent of the Executive Director, Brendan Kelly, to open the teams up to non-Federal employees, there were several obstacles that needed to be overcome. Federal employees had concerns over collaborating with non-Federal employees because of the Federal Advisory Committee Act (FACA). FACA is designed to ensure that competitive advantages are not give out for Federal contracting[7]. For example, if NSF plans to do a study in the Chukchi sea, and NSF went to several meetings where only some of the potentially interested bidders were involved, unfair advantage would be given to the potential bidders that attended those meetings. Agencies were hesitant to participate in meetings where some but not all of the potential contractors for research projects were involved in the discussion. Realizing the source of agency resistance to opening up the teams, Kelly worked with OSTP counsel on a guidance letter that established clearer rules for open collaborative meetings that was signed off and sent out of the White House[8]. The letter stated that Federal employees should engage in teams with Federal and non-Federal scientists for the purposed of promoting good coordinated science, and they should use their professional judgement, as they do every day, to make sure not to tip the government's hand on funding or regulation[9].

[6] Interview with Brendan Kelly, March 28, 2017.
[7] Interview with Brendan Kelly, March 28, 2017.
[8] Interview with Brendan Kelly, March 28, 2017.
[9] Interview with Brendan Kelly, March 28, 2017.

Conversations surrounding funding and regulation needed to occur in a Federal-only space. With this obstacle surmounted, IARPC was able to open up team membership to include academics, Arctic residents, industry professionals, NGOs, state officials, and anyone who had an interest in Arctic research (Figure 4). Thus, within a year after the Plan's publication, the Federal-only Implementation Teams became inclusive Collaboration Teams open to all stakeholders in Arctic research.

Figure 4: Stakeholders in Arctic research.

Collaboration Team Operations

Each of the twelve Collaboration Teams (CTs) corresponds to a Research Area, or a sub-section of a Research Area, and is assigned the set of related Milestones upon which interagency collaborations are to be built (Figure 5). These CT are composed of, Federal agency representatives, scientists and officials of the Federal government, scientists and program managers from the private sector, academics, NGO representatives, Alaskan natives, representatives from international bodies, and state of Alaska officials. The variety of stakeholders represented in the CTs is key to the innovative success of IARPC, although it can be challenge as well. In order to take the necessary actions needed to fulfill their Milestones, CTs meet monthly. These meetings often consist of presentations to increase awareness around certain initiatives and follow-up discussion on how CT members can collaborate to support the initiative.

Figure 5: Collaboration Teams and member representation. Collaboration teams, designed around priority research areas, are composed of Federal and non-Federal members from a wide range of organizations and are supported in their collaborative efforts by the IARPC Collaborations website.

During the first year of implementation in 2013, CT meetings were conducted via conference call, but with the launch of the website, meetings shifted towards a webinar format. On this platform, people can communicate with one another by audio and camera connection. This means of interaction allows team members to share information both verbally and through slide presentations. Members can also exchange information through email, both personal and the regular email that is distributed to IARPC members with content that is specifically targeted to the member's interests, which are analyzed using an algorithm based on what web content they interact with. In addition, the Arctic research community is, in many ways, a small community, where people develop professional relationships through working in the same organization or through frequent interaction at workshops, conferences, research vessels, and meetings. These relationships allow for more knowledge exchange, which can take place through one or all of the previously mentioned means mentioned, or during phone or in-person conversations.

Through these means of communication, CT members inform each other on current research, relevant programs and initiatives, resources, events and many other types of knowledge. The assumption by IARCP is that through this information sharing, strong and lasting collaborations have a chance of growing.

IARPC Collaborations

The most innovative way in which the Plan was implemented and the collaborations within and between the CTs supported was through IARPC's website, IARPC Collaborations. IARPC Collaborations, launched alongside the publication of the 2013-2017 Plan, is a web-based platform designed to help facilitate collaborations among Arctic researchers. The website is, in part, a social media site where people from Federal agencies, labs, academic institutions and the broader community can connect and contribute to the conversation. The website also functions as a mechanism to keep the community updated on current research, reports, events and funding opportunities. In addition, the website is designed to track the progress made on the Plan in a publically accessible venue.

IARPC Collaborations currently has just over 1,100 members and is a key aspect of the success of the 2013-2017 Plan. The open environment of a social website allows researchers outside of the Federal government to become involved in collaboration teams and contribute to the community, and in return these members get access to Federal contacts who sometimes have means for funding promising research ventures in their area of expertise.

III. Literature Review

Over the past thirty years, knowledge management (KM) as a field has received increasing attention (McGraw & Harrison-Briggs, 1989; Wiig, 1993; Riege & Lindsay, 2006; Virtanen, 2010) and offers insight and practical strategies to large organizations seeking to manage knowledge assets more efficiently and improve organizational learning. Defined here briefly, and in more detail below, KM is a process through which information is turned into actionable knowledge and made easily available (Dalkir, 2005).

Starting in the 1980s, KM became a critical tool for private sector and large scale multilateral agencies to strengthen the channels of information flow between widespread groups within the larger organization. However, one can argue that knowledge management has been around far longer than the term itself. People have long used knowledge management to build on experiences, reduce redundancies, and avoid repeating mistakes (Dalkir, 2005). Dalkir (2005) demonstrated that knowledge sharing can be found in apprenticeships, trade guilds, town meetings, and seminars, where people themselves functioned as the means or “technology” for transferring knowledge.

This chapter first examines the emergence of KM and its relevance for the public sector then briefly considers the foundational aspects of knowledge management, followed by a closer look into one structure thought to create more efficient knowledge flow, communities of practice (CoPs). These theories play out partially in the real-world example of the IARPC Collaboration Teams, and this thesis will examine why this might be.

Issue Emergence

The evolution of knowledge management can be viewed as a natural response to the development of modern technology (Wiig, 1997). As computer use increased and information technology developed, experts began to see the value in capturing and disseminating organizational knowledge to extend organizational memory. The advent of the World Wide Web change the distance and scale that knowledge sharing networks could operate at, and inspired communities to form and share knowledge around shared areas of interest. By the 1990s books were being written on knowledge management by practitioners and the mid-1990s saw a proliferation of KM conferences as the field began to mature (Dalkir, 2005). According to Dalkir (2005) academia added their perspective to KM in the 2000s and worked towards transforming it into an academic discipline in which more formalized theories and trainings were developed (Dalkir, 2005).

In knowledge management's present iteration and focus towards making large organizations more efficient and competitive, organizational and individual knowledge is valued for a variety of reasons. The knowledge of an employee can be encapsulated in a skill or skill set, knowledge can be stored and retrieved in the future thus reducing the need to reinvent the wheel, knowledge can be shared to build the overall intellectual capital, and knowledge can lead to innovation (Wiig, 1997). These reasons make knowledge management useful for policy makers who aim to reduce redundancy across agencies and create synergies that capitalize on existing intellectual capital.

Although the majority of the literature around knowledge management focuses on the private sector, there is a strong need for knowledge management in the public sector. The public sector differs from the private sector in two main ways. First, the public sector focuses on information and service delivery, while the private sector is characterized by its highly competitive environment. Second, the public sector is responsible for a range of stakeholders and their perspectives on issues, thus involving multiple parties, while the private sector is often concerned solely with the benefit of its shareholders (Cong & Pandya, 2003).

Knowledge management has played a role in the public sector through strategy, planning, consultation, and implementation, although it is not always identified as such (Riege & Lindsay, 2006). The role of the public sector is to work towards the common good, however, competition exists both within the public sector from the international to individual level (Cong & Panda, 2003), although perhaps not to the same degree as in the private sector. While at the same time the government is pressed to do more with fewer resources, which makes effective KM essential (Wiig, 2002; McAdam & Reid, 2000). Governments can benefit from consciously initiating KM practices and some government agencies, like the armed forces, already do (Asoh, Belardo & Neilson, 2002). In addition, the public sphere is increasingly working to foster partnerships with stakeholders in an attempt to create transparency, and this engagement across scales and organizations turns the public sector into dynamic and knowledge intensive organizations (Riege & Lindsay, 2006). Public policy benefits from government relationships with stakeholders because the knowledge the stakeholders possess can be transferred to the government to aid in the policy making process, and the results of this policy are communicated back to the government via these same relationships (Bridgman & Davis, 2004). Summarizing from an article by Riege and Lindsay (2006), stakeholder participation is often central to the government's objectives. This can be difficult to achieve however, due to the diversity of stakeholder perspectives as well as their varying ability to participate in the public sector. The latter point can be seen indigenous and remote communities, which are often marginalized. In addition, governments themselves are not homogenous entities and the various entities that comprise them may have significantly different missions and goals.

If governments can overcome these barriers, they can engage stakeholders in exchanging information or full collaboration based on shared resources (Riege & Lindsay, 2006). These ideas of public sector knowledge management and stakeholder engagement are central to the mission of IARPC.

Knowledge Management

The importance of understanding knowledge and what it means to know something has deep philosophical roots. Knowledge management also has pragmatic roots, as it has always been necessary for humans to share information with each other. As the world began to globalize, advance rapidly in terms of technology, and, in the industrialized world, move away from making things to providing services, the importance of knowledge management began to rise (Wiig, 1999). KM can benefit individuals through an increased ability to save time during decision making and problem solving processes, as well as communities through facilitating effective networking and collaborations (Dalkir, 2005).

KM developed in several arenas, and spans many disciplines including; organizational science, cognitive science, linguistics, communication studies, and collaboration technologies (Dalkir, 2005). A well-rounded definition of KM is as follows:

> "the deliberate and systematic coordination of an organization's people, technology, processes, and organizational structure in order to add value through reuse and innovation. This coordination is achieved through creating, sharing, and applying knowledge as well as through feeding the valuable lessons learned and best practices into corporate memory in order to foster continued organizational learning" (Dalkir, 2005).

This definition includes reference to the structure and infrastructure of knowledge management, the knowledge cycle (to be discussed in detail below), and the potential for KM to build on itself.

What is knowledge?

Knowledge itself has many different definitions and a long history of epistemologies that seek to define it. In the field of KM, knowledge is often thought of as data/information that is contextualized through expert opinion, skills, and experience and thus is made useful and is readily applied. This value-added information, or knowledge, is understood to come in two forms: tacit and explicit knowledge. Explicit knowledge, often well documented and accessible, is objective, rational and technical. Explicit knowledge can be articulated in language and mathematical expressions (Nonaka & Takeuchi, 1995). Examples of explicit knowledge include a set of directions or a written report. Explicit knowledge can be transferred through presentations, emails, books, and manuals (Panahi, Watson & Partridge 2013).

Tacit knowledge, on the other hand, is subjective, cognitive and experiential (Gupta, Iyer & Aronson 2000). Tacit knowledge is hard to express through formal language (Virtanen, 2010), and resides within people and can be embedded in social processes (Quintas, Lefrere & Jones 1997). A person can know something tacitly acts and makes decisions based on this knowledge, but have great difficulty putting their process in words (Dalkir, 2005). Tacit knowledge can take a technical form in certain types of skill and "know-how," or a cognitive form in beliefs and paradigms (Nonaka, 1994), and is often transferred through face-to-face contact, mentorships, observing, experience or demonstration (Panahi, Watson & Partridge 2013). Roughly 80% of knowledge is in tacit form and of that only about 20% is has been made explicit in some fashion, often through books, databases, video recordings graphs etc. (Dalkir, 2005)

Both types of knowledge are essential for organizations to capture and manage, and the aim of knowledge management often is to convert tacit knowledge into explicit knowledge that can be codified and thus captured, stored and transmitted (Gupta, Iyer & Aronson, 2000). The purpose of KM is then to harness knowledge for the benefit of an organization, often by converting tacit knowledge to explicit knowledge in order to make it usable to others and to spread it efficiently throughout the organization. IARPC attempts to make this conversion of tacit to explicit knowledge through hosting web conferences, administrative services like note taking, and their web-platform which acts as a storehouse for the information exchanged at meetings and over the website itself.

Importance of knowledge

Knowledge is a high-value form of information that is ready to apply to decisions and actions (Davenport, De Long & Beers 1997). In modern organizations, knowledge often equates to power. Because much of a worker's worth to the organization is determined by the knowledge they have and share, the more knowledge a worker has, the more power the worker has within the organization (Dalkir, 2005). This principle scales to the organizations level: the more knowledge an organization possesses and the better their ability to manage this knowledge is, the more competitive the organization will be (Halawi, Arnoson & McCarthy, 2005). In some organizational cultures, the value of knowledge can lead individuals and organizations to guard it in order to give the individual a competitive edge.

Theoretically, this competition would not be present in governmental organizations, which are meant to help each other. However, while competition might not be as dramatic in government agencies as it is in corporations, Agencies might have valid reasons for not sharing information that is either relating to a "pre-decisional" government action or would jeopardize their future ability to secure resources for their organization. This is also true for scientists (of which this thesis takes particular interest) who want to guard the data and sometimes even the methodology behind their practices in order to keep ahead of other scientists.

However, although knowledge is a valuable resource, the sharing of knowledge can benefit both individuals and organizations by leading to innovation. Herkema (2003) define innovation as occurring when new knowledge or knowledge processes are created to develop a viable solution to a challenge. Innovation happens when knowledge exchange is encouraged and facilitated through knowledge management practices. Companies and organizations can benefit from the innovations inspired through the KM process. However, this knowledge exchange can be difficult because individuals and organizations often guard their knowledge and also because knowledge can be challenging to capture, transfer, and apply.

Capturing and exchanging knowledge is complex and is further complicated in cases where knowledge is transferred between organizations. Companies and governments increasingly use information and communication technologies, and with this increased use often comes a need to cooperate across organizational and disciplinary boundaries to enable innovation (Quintas, Lefrere & Jones 1997). Tacit knowledge is particularly hard to transfer across organizations because it is often intimately linked with social processes inside the organization. In addition, cross-organizational information transfer can be hampered by the reality that knowledge is valuable and organizations are often in competition with each other. For knowledge transfer to be successful an organization's borders need to be open to both formal and informal flows of information, while also protecting the organization's intellectual capital (Quintas, Lefrere & Jones 1997).

Knowledge Management Cycle

In order to understand what knowledge management looks like in more detail, we will now examine the KM cycle, which, broadly, is the process through which knowledge is converted from pieces of disconnected information to usable knowledge. There are several models for the KM cycle, and, in his textbook "Knowledge Management Theory and Practice," Dalkir (2005), distilled several of the major models posited into three major stages:

1. Knowledge capture and/or creation
2. Knowledge sharing and dissemination
3. Knowledge acquisition and application

Knowledge capture refers to the identification and then codification of existing knowledge, and knowledge creation is the development of new knowledge. Knowledge capture can be seen in knowledge repositories that many organizations have developed that have systems of for labeling, indexing, linking, and cross-referencing the pieces of information stored within it. Once this captured/created knowledge is deemed valuable the knowledge is shared within the networks of an organization. Finally, if understood by the knowledge consumers, this knowledge is applied to make decisions or fulfill the goals of the organization. For example, knowledge about the best practices of a project might be captured in a document or a recording of a presentation, this document/recording may be shared with other program managers working on similar projects. If they are able to understand the context of the best practices and how they might translate the knowledge to their own projects they will absorb the knowledge and apply it to their situation. However, only a conscious and organized method for implementing this knowledge cycle will allow organizations to leverage their knowledge assets (Dalkir, 2005). The case studies of this thesis focus on the movement from the second stage of knowledge sharing to the third stage of knowledge applying.

Communities of Practice

Given the often-acknowledged importance of social relations in knowledge transfer, it is useful to look at ways of social organization that supports the transfer of explicit and tacit knowledge. One promising type of social organization gaining accolades for its ability to encourage knowledge transfer is the community of practice (CoP). Knowledge sharing defines communities of practice. Communities of practice seek to capture and disseminate knowledge through the social environment of a community, often in virtual spaces (Wenger & Snyder 2000; Dalkir, 2005).

Broadly defined, a community of practice is a group of people who share a common interest and learn how to be better practitioners in this interest through regular interaction with each other (Wegner, 2006). This definition implies that (1) members of these communities share a domain of interest and thus a shared competence in the specific domain, (2) members engage in joint activities and discussions, help each other, and share information. From these actions, relationships are built between members that facilitate shared knowledge and learning, and (3) the members of the community are practitioners and not merely interested in a shared topic of conversation (Wenger, 2006). Members of such communities are often passionate about their topic and are willing to put in extra time to learn from and share with others. This passion can provide important social and intellectual leadership (Wenger & Snyder, 2000).

Perhaps the most unique characteristic of a community of practice is its freedom of form. Communities of practice are often not tied by agendas, formalized meetings, direct supervision or management, or rigid structures. Instead, communities of practice are places for informal, free-flowing, and creative knowledge transfer unrestricted by formalized hierarchies. While freedom of form continues to be a vital part of CoPs, recent scholarship has shifted to allow CoPs to include communities where the leadership is determined by the organization (Bourhis, Dube & Jacob, 2005). CoPs spring up around a shared interest and members will regularly meet to share information. This is the strength of communities of practice, but the informality necessary to foster spontaneous and creative knowledge transfer makes them hard to institutionalize. As communities of practice generate knowledge they renew and reinforce themselves (Wenger & Snyder, 2000). Successful management or cultivation of communities of practice often involves bringing the right people together, providing an infrastructure for them to communicate, and measuring their value in creative ways (Wenger & Snyder, 2000).

Communities of practice can exist within an organization or they can span across organizations. For example, communities of practice can be a group of nurses who regularly eat lunch together and share information about the best way to care for patients, a network of technical oil rig engineers dispersed across the globe but connected by regular email communication about engineering challenges.

Some have argued that community of practice is too broad a term for all of these different types of groups, and a more nuanced label was developed to categorize what was dubbed a “network of practice” (Brown & Duguid, 2001). Wasko and Faraj (2005) argue that a community of practices is a tightknit group, formed between people in a localized area, and built on face-to-face interactions, whereas a network of practice is dispersed and comprised of individuals who don’t necessarily know each other and may never meet. Networks of practice can be facilitated through conferences, professional associations or, of particular interest to this thesis, computer-based communication. In an electronic network of practice, the sharing of practice-related-knowledge occurs primarily through computer-based technologies like webinars and discussion threads.

Within the literature, there are those who argue that web-based communication cannot facilitate the transfer of tacit knowledge in which social interaction is understood to be foundational (Panahi, Watson & Partridge, 2013). It is argued that sharing tacit knowledge electronically might prove particularly challenging because tacit knowledge is often dense and contextualized and needs face-to-face communication to be transferred effectively (Brown & Duguid 2000). Others, however, admit that tacit knowledge sharing might not be as rich in electronic communications, but some degree of tacit knowledge transfer is still possible (Panahi, Watson & Partridge, 2013). Electronic communication, and in particular, web-based social platforms, can facilitate tactic knowledge sharing by providing a space where people can express their perspectives, where a dialog among experts can be established, and by making information more available (Alavi and Leidner, 2001). While KM often focuses on knowledge capture, web based social platforms might be better used to encourage experts to communicate and sustain social interactions, thus allowing both explicit and tacit knowledge to flow with more ease (Panahi, Watson & Partridge, 2013).

The literature suggests the better the technology and applications become at supporting real-time synchronous interactions and a community space on social web platforms the more tacit knowledge will be able to be transferred across them (Panahi, Watson & Partridge, 2013). Websites and social media are becoming critical platform from which knowledge can be managed and communities of practice can be formed. These platforms can be a key contributor to the success of CoPs, especially those that are geographically dispersed. For example, in the public sector, the Federal Highway Administration created a CoP called Re:NEPA, after the National Environmental Policy Act, which is a virtual network of people interested and responsible for highway-related environmental issues. In the CoP members discuss the development of NEPA guidance and other timely issues (Asoh, Belardo & Neilson, 2002).

Factors contributing to success of CoPs

Studies on CoPs have identified several factors that can play a role in their success. The first is the important role of leadership. Leadership can play a key role in the success of a community of practice for many reasons. Active and consistently engaged leadership can help to build a sustainable CoP (Stucky & Smith, 2004). Leadership can help encourage participation, direct attention on important issues and bring new and energizing ideas to the CoP (Bourhis, Dube & Jacob, 2005). In addition, strong leadership can contribute to a CoPs cohesion as the membership broadens and its sense of purpose, discussed below. In many way leadership is the foundation on which all the other factors that lead to CoP success are built. Bourhis, Dube and Jacob (2005) find that CoPs that had full-time leaders were more likely to be successful than those that did not. Without engaged and focused leadership, the other factors cannot be established. A leader need to create strong practices of outreach to the community, while remaining a central figure (Stuckey & Brown, 2002). However, there can be a downside to a large and ever-growing membership if CoP leaders do not work to maintain the communities focus while bringing in perspectives from both the center and the periphery of the community (Stuckey & Brown, 2002). Some leaders manage this through the creation of sub-groups. The discipline or disciplines involved in a CoP can be a potential barrier (Fontainha & Gannon-Leary, 2008). It may be difficult to disseminate specialized knowledge among large groups with varying disciplines or levels of expertise (Fontainha & Gannon-Leary, 2008). Each discipline has its own methodology and vocabulary that can make knowledge transfer difficult. As discussed, many CoPs operate virtually and the capabilities and usability of the communication technology can be a critical success factor (Fontainha & Gannon-Leary, 2008). When CoP members are geographically dispersed, and must communicate virtually, messages can be misinterpreted and non-verbal cues can be missing. Thus, the better the technology is at overcoming these difficulties, the richer the knowledge exchanged can be. It is also important for the technology to be easily usable and accessible to CoP members (Wegner, 1998). Another critical success factor is a CoPs sense of purpose (Dube, Bourhis & Jacob, 2005). A sense of purpose, if realistically achievable, leads to direction and action (Fontainha & Gannon-Leary, 2008). Leaders can help to establish the scope by sticking to a clear focus and discussion topics (Stuckey & Brown, 2002). Other factors to CoP success include; membership stability, cultural diversity, availability of technical help, size, and geographic dispersion (Bourhis, Dube & Jacob, 2005).

Communities of practice are of particular importance in the context of this thesis, because their informal structure makes the social interactions between community members vital. In communities of practice information doesn't necessarily flow up and down the chain of command, instead, it flows along the social connections among community members. These connections can be measured through the framework of social network analysis discussed next. In addition, IARPC Collaboration Teams fit the framework of CoPs through their topic oriented structure; members from a wide-range of organizations coalesce around shared interests and share knowledge with each other through IARPC's web-based platform and web-conferences. IARPC plays a supportive role for these CoPs, but largely leaves the leadership of the CTs to the team leaders. The primarily web-based and dispersed activities of CTs reflect characteristics of Brown and DuGuid's (2001) networks of practice, and the extent to which knowledge, especially knowledge of the tacit nature is shared and made useful among team members is a point of interest. The connectedness of the members and overall level of participation is another potentially problematic area when considering CTs CoPs, and social network analysis could play a role in understanding the underlying networks of CTs.

Social Network Analysis

Social network analysis (SNA) is a set of theories and methodologies that seek to understand and measure the structure, patterns, and characteristics of connections between actors (individuals, organizations, other networks etc.). SNA is a useful tool for understanding the underlying and often hidden structure of the connections within an organization. In the last couple of decades, knowledge management practitioners are increasingly starting to see the use of performing an SNA within their organization to bring to light issues of communication disconnects and the transference of knowledge among organization members. Social networks are critical to understanding the varying levels of successful knowledge sharing and collaboration building among CTs that are built on the collaboration of community members from a wide range of backgrounds.

SNA began as a relatively non-technical approach to understand, the structure of human communities. In the early twentieth century, social scientists from fields as varied as psychology, education and community studies contributed to the foundation of social network analysis through ideas like how to visually represent networks through diagrams and how to capture network data in matrices (Scott, 2011). During the 1950s, a more formalized and technical approach to social network analysis was developed to measure network connectivity (Scott, 2013). Increasingly, social network analysis has been applied outside of the strictly social science realm in areas like corporate power, community structure, organizational management and, of course, social web-based activities.

IARPC Collaborations is broadly a knowledge management system through which relevant knowledge is captured, shared and applied to the establishment of collaborative efforts. The concept of CoPs is relevant among KM systems because of their success in facilitating efficient knowledge flow among their members as well as their organic nature. Social network analysis can be a valuable tool for examining the underlying networks that influence CoP success.

IV. Collaboration Team Case Studies

In this chapter, I conduct a comparative case study of two Collaboration Teams created by the 2013-17 Plan. As discussed in chapter two, the purpose of the collaborative teams was to implement the plan through making progress on well-defined milestones which sought to reduce duplication of efforts, build on existing projects, save money, share resources like research infrastructure, and further align policy with research through building collaborations among Federal agencies as well as a host of other actors and entities such as state institutions, indigenous organizations, universities, and NGOs. Of the 12 teams established to implement the Plan, these teams stood out to IARPC leadership as presenting a strong contrast in the strength of collaboration they had established by the end of Plan implementation period. They are the Arctic Communities Collaboration Team (ACCT) and the Chukchi Beaufort Collaboration Team (CBCT). Both teams function from 2013 to 2016. The ACCT was primarily composed of social scientists with a broad range of 18 milestones related to adaption and community resilience. In contrast, The CBCT focused on a narrower set of seven milestones designed to increase understanding of the marine ecosystem processes of the Chukchi and Beaufort seas. In considering the differing levels of success achieved by the teams, this analysis will consider the relative roles of: leadership, scope, disciplinary challenges to collaboration, centrality, and inclusivity.

Success

There are several elements to success as it is used within the framework of this thesis. First, success for Collaboration Teams is accomplished when teams move from knowledge sharing communities to communities where lasting research collaborations are built among participating agencies. Next, successful CTs accomplish the goals and milestones they are responsible for in the Plan through interagency efforts. The success of CTs can also be seen in their longevity, i.e. did they continue on through successive Arctic Research Plans, or do they dissolve? Finally, success can be defined through the engagement and participation of CT members. Here, success is measured through the perspectives of interviewees, milestone reports, which are the recorded actions teams took towards completing their milestones, and data from the IARPC Collaborations website. Successful and efficient knowledge flow could also be measured by SNA, which is an area for further research.

Arctic Communities Collaboration Team

Formation

The Arctic Communities Collaboration Team (ACCT) was created in 2013 in the wake of the 2013-2017 Arctic Research Plan. The team's purpose was to assess vulnerabilities and adaptation strategies for communities in the United States Arctic and to use this information to enhance Arctic residents' well-being in the face of climate change. Many Arctic residents are indigenous peoples that live a subsistence lifestyle that is becoming more challenging because of the dynamic changes happening in the region. In addition, many Arctic communities are facing coastal erosion due to sea level rise and new and increasing diseases because of the changing climate. Arctic communities also face issues that may be impacted by climate change where the Federal government has a role in helping, like water sanitation, family abuse, and mental health; all areas where the Federal government may have a role.

To address these issues that span both the physical and social worlds, the team was heavily weighted toward social science in both the nature of the milestones and the make-up of the team. The strong role of social scientists in the ACCT team reflected a growing acknowledgement among scientists and policy makers that the social and cultural sciences were an important component of ongoing Arctic science effort (National Science Foundation, 1999; National Academy of Sciences, 2014) In addition, there was a recognition that increasing collaboration among the agencies involved in social and cultural sciences would help to reduce duplication of research efforts[10]. This is especially important in the social sciences where research can be burdensome for the human subjects and local stakeholders, especially in small communities that are bound to tight schedules for subsistence hunting[11]

Goals

The overarching goal of the ACCT was, as stated in the Plan, to

> "Assess strengths and vulnerabilities of Arctic communities facing the impacts of climate change and assist in developing adaptation strategies and tools to maximize sustainability, well-being, and cultural linguistic heritage."
> – Arctic Research Plan FY2013-2017

During the time that the Plan was written, Arctic communities were on the front lines of climate change and the government recognized that further research was needed to assess vulnerabilities to help these communities adapt. This meant different things to different team members, however. depending on where they sat in government agencies. The lead agency of the ACCT, the Smithsonian Institute (SI), was interested in cultural and linguistic preservation in the face of climate change, while many of the other agencies had more pragmatic concerns like ensuring that communities would have access to clean water or

[10] Interview with Chris Campbell (BOEM), March 16, 2017.
[11] Interview with Chris Campbell (BOEM), March 16, 2017.

sustainable infrastructure. The ACCT hoped to address all of these concerns by facilitating collaborations around more specific and actionable milestones.

The milestones clustered around a set of primary objectives (Table 1):

Table 2: Arctic Communities Collaboration Team Objectives and Milestones from the Arctic Research Plan FY2013-2017.

Objective 1	**Conduct socio-economic research to understand ecosystem services as increased warming changes the Arctic tundra**	DOI, NIH, NSF, SI
1.a	Support the outcomes and recommendations of the Arctic Social Indicators Project within the U.S.	
Objective 2	**Assess local-resident priorities for addressing change**	DHS, DOE, DOI, EPA, NASA, NOAA, NSF, ONR
2.a	Assess local-resident priorities for addressing change	
2.b	Engage indigenous observers and communities in monitoring environmental parameters	
Objective 3	**In collaboration with local communities, develop methods for assessing community sustainability and resilience and determine the efficiency of current adaptation strategies**	DOS
3.a	Identify and develop a database on past and current adaptation strategies used by Arctic communities to combat climate change impacts	
3.b	Determine which strategies have been most successful	
3.c	Document unintended consequences of previous strategies and responses to change	
3.d	All will be explored by the Adaptation Actions for a Changing Arctic Report	
Objective 4	**Identify the current vulnerabilities of Arctic communities and ecosystems to climate change and explore their interactions with socio-economic and other stressors**	BOEM, DOS, EPA, NSF, USFW, USGS, French science funding agencies
4.a	Establish research and community collaborations aligned with local priorities and needs, including in planning, data collection, conceptualization, and interpretation of research results and recommendations	
4.b	Assess vulnerability of Arctic communities and ecosystems to climate change and socio-economic stressors	
4.c	In collaboration with other Arctic nations develop a standardized set of quantifiable socio-economic indicators of vulnerability: Arctic Social Indicators II Study	
Objective 5	**Develop projections of future climate scenarios and demographic conditions to forecast potential strengths and weaknesses of human and ecological systems in the Arctic**	BOEM, DOE, DOS, NOAA,USFW
5.a	In collaboration with other Arctic nations, develop a standardized set of socio-economic indicators to measure future community resilience (2020 and 2030 projections), including input of local resources, population fluctuations and migration, communication networks, and capacity to adapt via the Arctic Council's Arctic Social Indicators II Study 2012 and Arctic Resilience Report	
5.b	Link climate models with projections of ecological and socio-economic change that include community dependence on harvesting local food sources	
5.c	Test existing scenarios of the status of certain wildlife species of value to local consumers, according to available climate change models	
Objective 6	**Assist Arctic communities in documenting, revitalizing, and strengthening indigenous languages and cultural heritage**	DOE, DOI, NEH, NPS, NSF, SI
6.a	In concert with local communities, strengthen partnerships between researchers, Alaska Native organizations, Federal, state, and NGO entities through strategic projects, workshops, and conferences	
6.b	Develop tools that Arctic communities can use to more effectively support indigenous languages, traditional ecological knowledge, and natural resource harvesting activities - Native language restoration and Native language immersion programs	
6.c	Create community profiles that highlight continuity of indigenous languages and knowledge systems	
6.d	Identify and strengthen Federal, state, and local efforts related to indigenous languages, traditional knowledge, and cultural heritage	
6.e	Develop research programs to monitor the status of indigenous languages and knowledge systems and to better understand factors affecting language and cultural resilience	

For example, milestone 4.*a* seeks to establish collaborations based on local priorities. While milestone 4.*c* that fell under this objective sought to collaborate internationally on developing a standardized set of quantifiable indicators of vulnerability. Each milestone, therefore, required coordination across a varying set of Federal agencies.

Milestone 5.a assigns the DOS, in collaboration with other Arctic nations, to develop a standardized set of socio-economic indicators to measure future community resilience. While milestone *b* sought to link climate models with projections of ecological and socio-economic change that include dependence on the harvesting of local food sources. The final milestone, *c*, aimed for the United States Fish and Wildlife service to test existing scenarios of certain wildlife species of value to local consumers, according to available climate change models. Although these milestones fall under the same objective, they are very different.

Many of the studies that fell under the responsibility of the ACCT took place in remote Arctic communities in Alaska. The assumption was that the communities would be at the center of each of these objectives and incorporated into the operationalization of these goals through the milestones.

As can be seen in these examples, the objectives and milestones of the ACCT were wide-ranging and required collaboration across many Federal agencies. The ACCT had mixed success in accomplishing these objectives and milestones through collaborations. Although IARPC reported that many of the ACCT's milestones had been met in the milestone log which is the accumulation of all of the actions taken towards completing milestones, the report reveals that many of the Milestones show no actions taken by all of the agencies that were published as collaborators in the Plan. To answer the question of why was there such a mixed outcome, this chapter argues that 4 key factors, including; leadership, scope, disciplinary challenges to collaboration, and centralization, contributed to the ACCT's mixed success in building lasting collaborations.

Membership Composition

The ACCT membership was composed largely of social scientists drawn from a variety of Federal agencies, academic institutions, and Alaskan organizations. The team leader of the ACCT, was William Fitzhugh, a Senior Archaeologist, and Director of the Arctic Studies Center in the Department of Anthropology at the Smithsonian Institution's National Museum of Natural History. Initially this team had a team co-lead from DOI, but after one year he retired and was never replaced. Fitzhugh has been involved in IARPC, as the principle from the Smithsonian Institute (SI), since IARPC was created by ARPA in 1984. Fitzhugh, along with Igor Krupnik, a curator for the SI, and two others from the NSF and NOAA authored the Plan's chapter which laid out the milestones to be supported by the ACCT. At the time, the SI was among the few agencies with longstanding histories of Arctic research that had a concerted interest in social sciences and cultural research[12]. Although the SI was an important actor in Arctic research, it has little funding for research initiatives and much of the research it does conduct occupies a narrow and unique niche.

The National Science Foundation (NSF), has a well-funded Arctic Social Sciences Program and played an important role in fostering the ACCT and their progress towards collaborative efforts. The Department of the Interior's (DOI) interest in the ACCT spanned from regional to international research issues. DOI's representative from the Office of Policy Analysis was responsible for several of the milestones tasked to DOI having to do with the Arctic Council. DOI also funds a significant amount of social science research in the Arctic

[12] Interview with William Fitzhugh (SI), March 8, 2017.

and based directly in Alaska, largely through the Bureau of Ocean Energy Management (BOEM) and the Bureau of Land Management (BLM). Several other agencies, with smaller interest in Arctic social and cultural sciences, were involved in the ACCT through member participation[13]. In addition, there were participants from universities and interested non-governmental organizations[14] and several members from universities[15]. International interests were also represented through an International Arctic Sciences Committee (IASC) representative to the human and social working group. Other agencies and institutions were represented sporadically. The members of the ACCT were located across a broad geographic range. However, most of the members, including the leadership, were located in the lower 48.

The interviews conducted for this case study aimed to be representative of the spread of team membership and captured the thoughts of the team leader, and two team members one of which was a Federal employee and the other not. However, this small sample will necessarily miss some perspectives. Because both of the team members were based in Alaska, it would have been beneficial to receive insight from an ACCT member working in DC. In addition, the perspective from university based academia is missing.

Information Sharing in the ACCT

There were several types of information that were successfully exchanged within the ACCT. ACCT members learned of research their colleagues were producing through presentations by both team members and others in the research community during monthly meetings.

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[13] NASA, NOAA, CDC, DOS.
[14] ICC-Alaska, ANTHC, the Eskimo Walrus Commission.
[15] University of Alaska Fairbanks, University of Alaska Anchorage, University of New Hampshire.

> " [W]e pretty much took our role as being an information sharing network, not so much conducting research, but trying to make people aware" – William Fitzhugh (SI)

This facilitated increased understanding of how other researchers were thinking about particular issues[16]. ACCT members were also able to gain insight into the way that policy makers and government officials in Washington were viewing community-related issues in the Arctic and the drivers behind the Federal government's policy priorities and decisions[17]. Because of the wide-range of ACCT members research interests, the ACCT helped to educate members on the value of multidisciplinary work[18]. Through the information shared within the ACCT, members increased their awareness of the variety of research taking place related to Arctic communities.

While information sharing occurred in the ACCT, using this information to build lasting collaborative happened infrequently. This section will explore the key factors preventing interagency collaborations from forming.

Factors

During the four-year lifespan of the team, the ACCT collaborated through papers, workshops, and webinars[19]. On the surface, it looks like they completed most of their milestones[20], however, many of the actions were taken by individual agencies, with little interagency collaboration recorded. Based on interviews with team members, this section unpacks some of the factors that lead to the team's mixed success. While the ACCT succeeded in creating a space where members could share information, several key factors

[16] Interview with Chris Campbell (BOEM), March 16, 2017
[17] Interview with Chris Campbell (BOEM), March 16, 2017
[18] Interview with Carolina Behe (ICC-Alaska) March 14, 2017
[19] ACCT Meeting Notes.
[20] Arctic Communities Milestone Log 2016, http://www.iarpccollaborations.org/members/documents/7173.

contributed to the ACCT's inability to consistently build interagency collaborations from this pool of shared information including (1) agency leadership (2) scope (3) the nature of social science research and (4) centralization.

Leadership

The SI was nominally responsible for leading the ACCT, as its team leader, William Fitzhugh, holds a position at the SI. Fitzhugh has represented the SI's interests in IARPC since around the time it was established by law in 1984. The SI, however, has rather unique interests among Federal agencies in the Arctic. The SI produces only a small amount of research, and the research it does produce is mostly focused on cultural and linguistic heritage preservation and revitalization.

Other Federal agencies funding social science research in the Arctic at the time were more interested in research that increased understanding of community resilience and ways to enhance community adaptive ability to the changing physical, social, and cultural Arctic landscape. And even so, there was not a great deal of interest by agencies in research directed at Arctic communities compared to agency interest in physical science research. In addition to the SI's specific and unique interests in social science research in the Arctic, their funding was also relatively small in comparison to other Federal agencies. The SI's leadership in the ACCT was therefore outside of its traditional 'wheelhouse', and this impacted its ability to lead the team[21].

The NSF has a well-funded Arctic Social Sciences Program, and, as the designated leader for Arctic research by ARPA, the NSF had the potential to play an important leadership role within the ACCT, but never co-lead the team. The NSF has a history of

[21] Interview with Sara Bowden (IARPC), March 31, 2017.

supporting community engagement in the Arctic, but, within the context of the ACCT, the NSF did not utilize IARPC to foster interagency research collaborations in a significant way. The NSF was involved in the ACCT largely through the participation of two American Association for the Advancement of Science (AAAS) fellows, but the team meetings were not on the agenda of the program manager of NSF's Arctic Social Sciences Program.[22]. Much of the NSF's Arctic Social Sciences Program is captured in the actions taken on the ACCT milestones, but these projects were largely within the sole purview of NSF and were not leveraged with projects funded by other agencies[23].

> "A lot of the stuff that we reported was from the NSF because they were one of the few places that had money that could be dolled out" – William Fitzhugh (SI)

One of the AAAS fellows left her position at NSF by 2014, and the other took on the role of unofficial team leader of the ACCT and also the main representative of NSF but were never official co-leads. However, because he was not in a program manager position, he had a limited ability to instigate interagency collaborations.

These two components of agency leadership within the ACCT, the misfit of the SI as well as a lack of senior program manager engagement from NSF, combined to play a key role in the team's struggle to build interagency collaborations. Because the SI lacked the funding to put money down to jump start a collaboration and lacked a program to pull other agencies into already existing or planned research this left a void in the team's leadership. The NSF was positioned to fill this void with their robust Arctic Social Sciences Program and role as the chair of IARPC. However, the NSF was detached, at the program manager level, from the ACCT and therefore lacked the leadership to pull in other agencies for

[22] ACCT Meeting Notes.
[23] Interview with Sara Bowden (IARPC), March 31, 2017.

collaborative research (Figure 6). It is important to note that NSF, in general, has a culture of sensitivity to top-down management of its researchers, which makes strong leadership antithetical to NSF protocol.

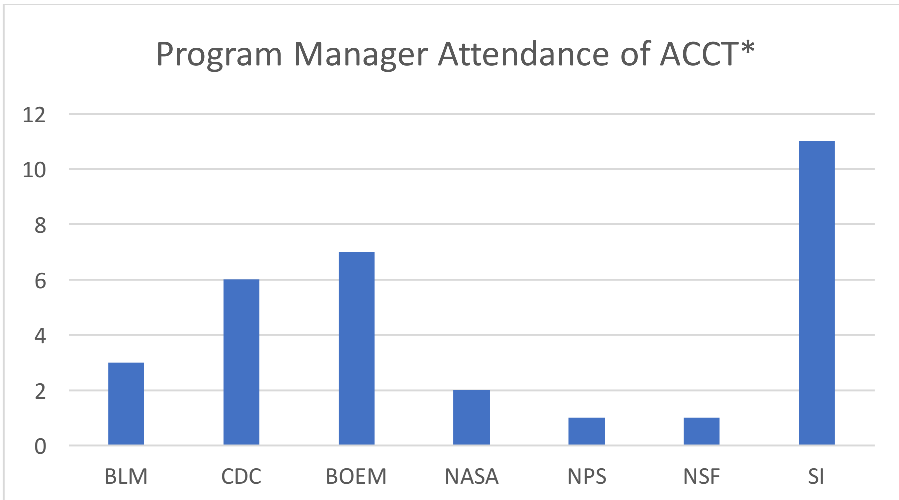

*Figure 6: Program Manager attendance of the ACCT. *Based on incomplete meeting notes.*

Scope of goals and membership

When the 2013-2017 Arctic Research Plan was written, IARPC was a more dormant body. Therefore, its plans and policy goals were high level (meant to set tone/long-run priorities rather than practical implementation). Therefore, it is understandable that those involved in IARPC for many years did not expect the 2013-2017 Plan to be different. When read with this in mind, the milestones associated with the ACCT may be viewed as what the authors would like to accomplish, but not realistically what could be accomplished in the five-year time frame of the Plan. This created a challenge because the scope of the ACCT's goals was too broad. It covered too many topics and contained too many milestones. For example, the ACCT was responsible for 18 milestones ranging on topics from indigenous observation and monitoring of change to adaptation strategies to Native language restoration. In addition, the

ACCT membership's interests varied widely as the team was made up of social scientists with different specialties. Specifically, one team member worked on the impacts of climate change on reindeer husbandry, while another focused on increasing development's effects on subsistence hunting, another team member studies infectious diseases in the Arctic, while others focused on linguistic heritage.

In order to deal with its challenges of the scope of the goals and the differing interests of team members, the ACCT sought to accomplish its milestones by forming self-populating sub-teams. On the one hand, the sub-team were cited by one interviewee as a successful aspect of the ACCT.

> "Another successful aspect was that we would have breakout groups that weren't formally listed on the IARPC webpage, but they were people with mutual interests that would collaborate. I was never involved directly with these communities of practice, but I was certainly aware of them, and I thought that they were generating some very interesting types of research questions that they were exploring." – Chris Campbell (BOEM)

The sub-teams were focused around 1) local-resident priorities and adaptation strategies, 2) Forecast climate scenarios and food security, and 3) language and cultural heritage. These groups were designed to allow people to organize a conversation, or an exchange of knowledge, around a specific issue with other team members who had similar interests. This structure, like the structure of the larger team, is in line with the framework of a community of practice. On the other hand, while the entire ACCT might be considered in this light, it was not, as revealed through the interview process, a group of practitioners with a cohesive area of interest or methodological toolkit, and this understanding of the varied nature of membership interest helped to prompt the formation of smaller groups. Like the ACCT as a whole, these sub-teams lacked leadership. They aimed to host a series of webinars pertaining to each of their topics, but a food security focused webinar was the only one that occurred. These sub-teams dissolved by 2014. Some of the other CTs also formed sub-teams that were more successful, and when developed with very active leadership, could be considered a best practice of IARPC.

Because of the diversity of ACCT membership that in some ways, functioned as the catch all team for social scientists, interests within the team varied greatly. This is not unique in IARPC teams, many of which have members from a wide range of scientific disciplines. The term scientific discipline is often used to mean multiple specialties of the same discipline. Discipline here means a branch of scientific knowledge, although both used experience the challenge of unintegrated knowledge. The diverse membership, in combination with the lack of focus of the team's goals after the dissolution of the sub-teams, created confusion within the team, and there was no centering force on which members could gather collaborate.

Disciplinary Challenges to Collaboration

The most agreed upon challenge, among those interviewed, faced by the ACCT was the nature of its social-science-oriented membership. There are several issues that surround social science collaboration in general, and other issues that are more specific to social science research in the Arctic.

The social sciences are very broad ranging, and bringing a group of social scientists together does not always assure there will be a common foundational knowledge, vocabulary, or methodological toolkit shared among them. In addition, it can be argued, that social scientists do not have the same tendency physical scientists often do of working together in large groups around data or infrastructure[24]. In addition, the various agencies have different perspectives on the kind of social science research that needs to be accomplished in the Arctic. This entails that the way the participant viewed both the problems and solutions was shaped by their respective agency.

Another dimension deterring collaboration within social science research is the lack of funding coming from Federal agencies[25]. This means that not only were there fewer researchers to connect with but also that there is strong competition among the existing researchers for limited funds. This competition, in turn, leads to less collaboration[26].

On top of the challenge of getting social scientists to collaborate with each other is the challenge of getting both physical and social scientists to work together. This interdisciplinary work is needed in Arctic communities that face issues that affect both the people living there and their environment. The ACCT, with its almost exclusively social scientist membership, did not build interdisciplinary effort in pursuit of its milestones. The barriers of a shared knowledge base and methodology that prevent social scientists from collaborating are present in a greater degree in interdisciplinary collaborations, and significant effort is needed to overcome this challenge.

<u>Centralization</u>

Structurally, there were several interrelated factors that led to challenges within the ACCT. One challenge was a misalignment of interests between the different levels of government as well as the individuals represented in the ACCT. For example, some team members based in Alaska felt that the milestones designed by the Federal government did not align with the

[24] Interview with William Fitzhugh (SI), March 8, 2017.
[25] Interview with Chris Campbell (BOEM), March 16, 2017.
[26] Interview with Chris Campbell (BOEM), March 16, 2017.

interests of the team members[27]. This is also true another level down; the communities of the Arctic were often detached from the conversation about scientific priorities and milestones. The ACCT was challenged with balancing the different priorities of the team and its membership.

> "You know the Arctic is such an interesting place… and it has captured the imagination of science on an international basis. So, we have people in headquarters that are so busy, they are going to all these meetings and they are discussing science, and they are going abroad to these conferences and they are talking about Arctic science and social science in the Arctic, and traditional knowledge in the Arctic and when we find out, often what is being said, we think that that is not exactly how I would prioritize that, or I don't really think that that is on mark, and we are in Anchorage. And when you get out to the Arctic communities they will probably inform you that, 'Well BOEM has this big studies program, and they do all these studies, but they just don't get it.' I think that the closer that you get to the area that is the area of consideration and concern, you are going to find out that the needs identified at that level are going to be very different than the needs identified internationally and then nationally at the Federal level and then the regional level." – Chris Campbell (BOEM)

The ACCT's team leader acknowledged that this challenge of separation from the stakeholders applied to him as he was working from Washington and was not directly connected to the communities.

> "I am not connected directly with those communities by nature anyway. I didn't feel really connected with the communities, it is not my bread and butter. I have to say I wasn't a very aggressive leader of the group. I pretty much just tried to steer the ship down the middle and offer the opportunities that we could." –William Fitzhugh (SI)

Additionally, only three or four of the ACCT members had direct working relationships with community members or Native organizations[28]. Thus, there was a divide between the Federal Government's priorities and those of team members working for agencies in Alaska, as well as a disconnectedness between both of these groups and Arctic communities.

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[27] Interview with Chris Campbell (BOEM), March 16, 2017.
[28] Interview with William Fitzhugh (SI), March 8, 2017.

> "I can only say that their success would be so much more if communities were directly involved and engaged in actually identifying what the performance elements should be, where focus should be, and also at the same time, how to improve them" – Carolina Behe (ICC-Alaska)

This disconnection was amplified by the nature of the Plan, which, was focused on building from initiatives funded by the Federal government that were currently in progress, aligned with the milestones, and that could support interagency collaboration. Members felt that research that was important to the community was being overlooked because it did not fit within these criteria[29] [30].

These factors led to the ACCT being largely a space for information sharing. Members exchanged information on projects and initiatives related to ACCT milestones and awareness of research that was taking place in the field was increased among community members. However, the information that was shared did not consistently lead to collaborative efforts. In terms of knowledge management: the information was shared but the next level, its application or benefit, was not fully realized. As ACCT members began to recognize this, participation fell and members left or participated sporadically. A lack of strong agency leadership prevented a robust collaborative environment. Confusion over the focus of the team, due, in part, to the wide range of topics covered in the milestones led to further disjunction and lack of collaboration. The ACCT also did not reflect clearly the priorities of both Alaskan and community stakeholders. The team was thus divided within itself and was unable to build strong and lasting collaborative efforts. The interviews revealed general agreement on the challenges the ACCT faced and its varied success at building lasting collaborative efforts.

[29] Interview with Chris Campbell (BOEM), March 16, 2017.
[30] Interview with Carolina Behe (ICC-Alaska) March 14, 2017.

Chukchi Beaufort Collaboration Team

Formation

The Chukchi Beaufort Collaboration Team (CBCT), formed in 2013 after the publication of the 2013-2017 Arctic Research Plan, sought to develop integrated ecosystems processes research in the Beaufort and Chukchi seas located directly North of Alaska. At the time the Plan was written, there was a growing interest in the region from a range of stakeholders within both the Federal government and industry[31] [32] due to the region's potential for offshore energy drilling. It became evident to Brendan Kelly, IARPC's Executive Director and the first team leader of the CBCT, that there needed to be a forum to bring those entities together. Collaborating across public and private lines could take advantage of those interests and corresponding efforts, but in order to do so research need to be planned [33]. All of the interested entities wanted to understand an aspect of the Chukchi and Beaufort Sea, but each had a different set of mandates that directed its specific research focus[34]. Therefore, at what scale in time and space each of these entities conducted studies, and to what end, depended on the mandate of each particular entity[35].

The CBCT aimed to leverage these differing foci to create a holistic understanding of the marine ecosystem of the Chukchi Beaufort region. Specifically, the CBCT was envisioned to be a place where stakeholders could look for ways that funders with more flexibility could complement the work of funders with more fixed mandates [36]. In addition, the CBCT was envisioned by the team leaders as a space where these collaborative efforts

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[31] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[32] Including BLM, NSF, the North Pacific Research Board, Shell, and Conoco Phillips.
[33] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[34] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[35] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[36] Interview with Brendan Kelly (SEARCH), March 28, 2017.

could be coordinated to assure that the methods were similar and the data gathered about the region's ecosystem processes was compatible.

Goals

The CBCT had only one objective to:

> "Develop integrated ecosystem processes research in the Beaufort and Chukchi Seas region"
> – Arctic Research Plan FY2013-2017

This objective fell under a larger chapter within the Plan that included understanding sea-ice and climate processes in the same region. From this single chapter, three IARPC teams were formed: the Chukchi Beaufort, The Distributed Biological Observatory, and the Sea Ice Collaboration Teams. The objective tasked to the CBCT, within the larger chapter, were operationalized into seven milestones as seen below.

Table 3: Chukchi Beaufort Collaboration Team Objectives and Milestones from the Arctic Research Plan FY2013-2017.

Objective 1	**Develop integrated ecosystem processes research in the Beaufort and Chukchi seas region**	
1.a	Conduct interagency and international workshops and consultations during 2012 to identify high priority research themes and objectives and coordinate funding and logistic plans	Selected Agencies as Appropriate
1.b	Perform synthesis and assessment during 2013-2014 on existing data and information to provide foundation for new research activities	Selected Agencies as Appropriate
1.c	Initiate 3-5 year research activities starting in 2013 with interagency/international results integration mechanisms	Selected Agencies as Appropriate
1.d	Demonstrate new and updated cyberinfrastructure tools to enhance data integration and application and identify opportunities for sharing of technology and tools among interagency partners	All Agencies
1.e	Conduct initial science integration conference in 2016	Selected Agencies as Appropriate
1.f	Conduct environmental and integrated risk assessments to evaluate the potential impacts of oil/natural gas production on ecosystems in the Beaufort Sea	DOE
1.g	Evaluate ecosystem impacts of oil and gas development and the potential for oil spills and especially the effects of oil, dispersants used in response to an oil spill, and to a mixture of oil and dispersants on the early life history stages of Arctic cod	NOAA

Interestingly, the Plan singled out only a few agencies as potential collaborators. Instead, all but two of the milestones had “selected agencies as appropriate” or “all agencies” written in. However, in the report published at the conclusion of the Plan, each milestone had at least two and as many as six collaborating agencies listed with it. In addition, there was a lead agency designated for each milestone. For example, on milestone 1.b NOAA was designated the lead agency responsible for making sure the milestone was met, and DOI and NSF were listed as supporting collaborators.

Following this tendency in the text of the CBCT milestones towards leaving room for the team to make decisions, there is space written into the milestones for the team to decide what its top priorities were. In milestone 1.a the milestone states “conduct interagency and international workshops and consultations during 2012 to identify high priority research themes and objectives”. This allowed for a more bottom-up design where the research community could give its perspective. This freedom worked well for the CBCT because of both the team’s strong leadership and focus.

As can be seen, each of the milestones is an ordered step towards completion of the main objective. Many of the milestones also emphasize that coordination must be achieved through interagency collaboration, signaling that interagency collaboration was a strong focus for the CBCT in addition to the goal to understand the ecosystem processes of the Chukchi and Beaufort seas region.

Membership Composition

Team membership of the CBCT included a range of physical and social scientists, including physical oceanographers, biologists, and anthropologists from both Federal and non-Federal spheres, as well as Arctic marine policy and managers from companies like Conoco Phillips and The Arctic Slope Regional Corporation. The first team leader of the CBCT, Brendan Kelly, was also the Executive Director of IARPC and Assistant Director for Polar Science in the White House OSTP at the time. When Brendan took another position, Guillermo Auad from BOEM and Danielle Dickson from NPRB, took his place. They were both strong participant in the team and had funding to support collaborative efforts. There were several agencies that had a strong presence in the team including, DOI, NOAA, NSF, and USARC. NASA and the DOD were also involved.

The team leadership made a concerted effort to not only to draw in members from Federal agencies with interests in the region but also to increase participation of the non-Federal employees[37]. This outreach took perpetual surveying, networking, and advertising by the team leaders in order to extend membership to places not in the regular network in order to bring in new perspectives[38]. Regularly attending members from industry represented Shell,

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[37] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[38] Interview with Brendan Kelly (SEARCH), March 28, 2017.

Conoco Phillips, and Santec. Combination Public/Private Research funders included the North Pacific Research Board (NPRB) and Alaska Ocean Observing System. Academics represented the University of Maryland, the University of Washington, and The University of Alaska Fairbanks among others.

The interviews of CBCT members aimed to be representative, and perspectives of two team leaders from Federal agencies and a team member who works with industry interests, but, because of the small sample size, not all perspectives are represented. The interviews would be more well-rounded if a team member from a Federal agency and an academic institution were included.

Factors

The CBCT, which began after the Plan was published in 2013 and transformed into the Marine Ecosystems Collaboration Team in 2017 after the latest Arctic Research plan was published, collaborated through two workshops that progressed toward developing a conceptual model of the marine ecosystems of the Chukchi and Beaufort seas region, the development of a Gantt chart to map out agency research in the region, the development of a framework document intended to outline a course of action for the CBCT, and by supporting collaborative research among agencies. The CBCT supported a number of collaborative efforts that are still ongoing, including the development of a pan-Arctic conceptual model, described below.

This section will examine several factors that contributed to the CBCT's success at forming lasting collaborations including; (1) leadership, (2) scope, and (3) inclusivity.

Leadership

On the agency level, leadership within the CBCT was dispersed among the DOI, NSF, and NOAA. Because of the resource potential, a great deal of interest from a range of stakeholders focused on the region. This strong focus brought funds with it. Therefore, many agencies could step forward to contribute to ecosystem research.

At the level of the team leaders, several of those interviewed stated that the team's leadership was strong[39 40 41]. The team leaders, first Kelly, then Dickinson and Auad, were dedicated to the team's mission. They used the focused mission to keep the team together.

> "Leadership was incredibly organized and concise around a directed message"
> – Sheyna Wisdom (Fairweather Science)

The team leaders were able to make the team useful to their varied membership by organizing them around a common purpose, the development of a conceptual model and testable hypothesis, described in detail below. Their ability to incorporate wide interests was enhanced by the co-leads status, one, Auad, was a Federal employee at BOEM, while Dickinson was a non-Federal employee of the NPRB; both had programmatic funding. This combination of Federal and non-Federal status helped to bring various perspectives to the team.

The strong leadership, both at the agency and team leader level, helped establish a wide-ranging and highly invested membership. This led to the formation of lasting collaborations among many of the entities represented by team members.

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[39] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[40] Interview with Guillermo Auad (BOEM), March 31, 2017.
[41] Interview with Sheyna Wisdom (Fairweather Science).

Scope

The CBCT had goals designed specifically to be completed within the time frame of 3-5 years. These goals focused on a particular region, the Chukchi and Beaufort seas. These boundaries narrowed the scope of what the CBCT wanted to accomplish enough that the goals of the team and the steps to achieve these goals were clear to the leadership as well as the team members.

The leadership recognized early in the life of the team that, while team members understood the value of collaboration, their differing objectives pulled the team in many directions[42]. To address this and synchronize the team, the team leadership looked for models of collaboration that worked well, in particular, the Bearing Ecosystem Study and its companion program the Bearing Sea Integrative Ecosystem Research Program. Like these programs, the CBCT worked to develop a common hypothesis, or conceptual model for the region, that the variety of participating scientists on the team contributed to and agreed upon.

> "So, we came up with this idea for the Chukchi Beaufort is that what really need then is this sort of common touchpoint or common hypothesis that everybody is building their work around. So what we ultimately came up with is that we needed a conceptual model of how the system worked and responded to change." – Brendan Kelly (SEARCH)

This conceptual model was developed over the course of two workshops[43] and is currently in the final stages of development. The conceptual model focused on key components of the region such as the water column and food webs as well as primary processes that acted as a system like sea ice extent and the northward flowing current. The conceptual model, in concert with a testable hypothesis about the future state of the system, was designed by the

[42] Interview with Brendan Kelly (SEARCH), March 28, 2017.
[43] ACCT Meeting Notes.

CBCT to provide an intellectual framework for the coordination of research in the Arctic marine environment (Developing a Conceptual Model of the Arctic Marine Ecosystem Workshop Report, 2013).

The focused scope of the CBCT along with the conceptual model, which functioned as a centralizing point for team members helped the team to synchronize the range of perspectives on the team and build collaborations in which member's interests complemented each other and contributed towards a more holistic perspective.

Inclusivity

The leadership of the CBCT intentionally worked to bring in team members with a wide range of perspectives. Because of the interest in the Chukchi and Beaufort Sea at the time, there were many people excited by the topic of the team alone, and even more interested because it was a space designed to facilitate collaboration[44]. People were searching for something that would be useful to their own research as well as something they could do that would make them better known to others in the field[45].

> "First of all, marine ecosystems, there are a lot of people working on that in the Chukchi and Beaufort and Bearing. So, by itself, the topic has when you mention that, the interest of many people. Second, when you mention that there is a team for exchanging information and hopefully for building collaboration, they will like it even more. They will naturally come to a team searching for something that will be useful to them and something that they can do that will make them better known to others."- Guillermo Auad (BOEM)

However, it took some time early on for potential members to understand that the team wanted to create an inclusive space that could be joined by anyone who was interested.

[44] Interview with Guillermo Auad (BOEM), March 31, 2017.
[45] Interview with Guillermo Auad (BOEM), March 31, 2017.

The team's leadership consistently repeated messaging that the team was open to everyone and worked to reach out beyond the regular network of players to relative outsiders who might have valuable contributions[46]. IARPC's website was utilized as a platform to facilitate these open interactions and to allow anyone who wanted to sign up for the team and participate.

> "The people, this group had some really good communicators. You didn't need to have a specific title necessarily to chime in, they were really inclusive of anyone coming in and asking questions. Some of the other teams could be a little exclusive, and are kept smaller, which I understand, it makes it easier for decisions to be made, but I think it is good for people to know of things that aren't necessarily in your box to make sure all the information is out there." – Sheyna Wisdom (Fairweather Science)

The strong focus of the team and its common touchstone, the conceptual model, helped to synchronize a wide variety of perspectives. The CBCT was able to have a broad membership and use their various perspectives towards a common purpose.

These factors lead to the CBCT's ability to build lasting collaborations among agencies and stakeholders. Not only did the CBCT build lasting collaborations, but they worked towards developing a product, the conceptual model, that was unique among Collaboration Teams. The CBCT was joined with the Distributed Biological Observatory Team to form the Marine Ecosystems Collaboration Team in the new structure under the 2017-2021 Plan, and much of the membership of the CBCT remains active.

[46] Interview with Brendan Kelly (SEARCH), March 28, 2017.

Discussion

The two Collaboration Teams analyzed above show very different outcomes in terms of the establishment of lasting collaborations. Although the teams shared the same administrative support, the same access to use the website capabilities, and the same auspices of a foundational plan published through the White House, they differed significantly in their ability to transition from a space for knowledge sharing to a place where strong collaborative efforts across agencies, universities, native organizations, industry, and other interested entities are built and maintained. This difference can be attributed to a number of factors, some shared, that played out in different ways across the two teams.

The leadership at both the agency and personnel level varied in interesting ways between the two teams. The mission of the ACCT's leading agency, the SI, did not fit completely with the stated goals of the ACCT. The SI's interests in the Arctic were largely unique among the agencies involved in the ACCT, and this created confusion over the main goals of the team. In addition, the budget for research at the SI is small and thus the agency was not able to lead through research funding. Because the NSF did not actively advance the team's interagency efforts, there was a void in the team's leadership. In contrast, a wide variety of agencies were highly interested in the specific goals of the CBCT, had a vested interest in their success, and were willing to lead by contributing funding towards collaborative research efforts. This helped to channel the focus of the CBCT and push its goals forward. The CBCT leaders' agency or organization were highly interested in the team's goals, and this coupled with the leader's own dedication to fulfilling their objectives created a sense of strong direction within the team.

Perhaps the greatest contrast between the two teams can be seen in the scope of the two team's goals. Looking only at the numbers, the ACCT had six objectives with eighteen milestones under them. The CBCT had one objective with seven milestones under it. Not only was the number of goals to be achieved very different, but the broadness of the goals as well as the range of topics covered also stands in contrast. The ACCT's goals ranged widely, from topics of cultural and linguistic preservation to supporting predictive climate models. The CBCT was focused around a single goal, to build a conceptual model of the Chukchi and Beaufort seas. Their milestones were time oriented steps towards this goal.

In addition, the ACCT's goals were established through more of a top-down process, while the CBCT left room for its team members to contribute to the establishment of high priority research themes within the overarching goal. The CBCT team leaders strongly supported inclusivity in the membership were able to orchestrate the wide range of professional and disciplinary interests of its team members by having a strong and focused purpose. In contrast, the ACCT's broad membership interest added to the confusion of the team's goals, pulling the team in different directions, because they did not have a central objective, or research question of high interest to all the members to collaborate around. This difference in scope played a pivotal role in the relative collaborative culture, or lack of it, in the two teams.

For the ACCT, the lack of a pointed focus combined with the fact that the team's members were spread out across a wide range of interests within the social sciences, prevented the establishment of strong collaborative efforts. Because the team functioned, in some ways, as a catch-all for all Arctic social scientists, there was naturally a wide range of interests and disciplines within social science represented in the team that pulled it in different directions. This was intensified by the SI's rather unique interests in the Arctic compared to other agencies, which lead to a sense of confusion over the main purpose of the team. On top of these dynamics within the team, is the broader dynamic of social science research. The social sciences are broad ranging and individuals do not necessarily share a methodology or a foundational knowledge base. In addition, unlike physical scientists, who often have infrastructure like ships or satellites or data sets to collaborate around, social scientists do not, as often, share this natural coalescing structure. This is combined with the lack of funding for social science research within agencies that leads to fewer social scientists to collaborate with as well as increased competition. All of these aspects of social science may have played out in one way or another as deterrents to the ACCT's ability to create lasting collaborations among the entities represented in its membership.

Perhaps enhanced by its ties to social science, and therefore the human dimension of the region, the ACCT needed to connect with local communities, but because of the primary location of its leadership in DC, the team was unable to do this consistently.

Intertwined with both teams is the mechanisms through which they shared information and attempted to build collaborations. Team members collaborated through teleconference, webinar, email, phone, in person, and through the IARPC website. In particular, the website is a largely unique space that is designed to help foster these collaborative efforts and it was accessible to both teams for utilization. Differences in the use of the website between the two teams, however, indicate that the teams did, in fact, take advantage of the website to differing amounts (Figure 6; Figure 7).

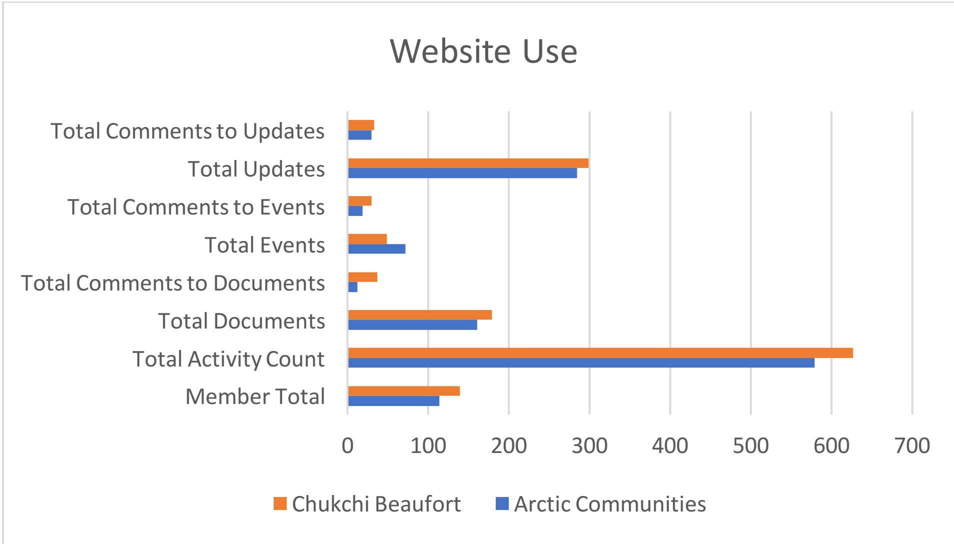

Figure 6: IARPC website use of the ACCT and CBCT. Data from IARPCCollaborations.org

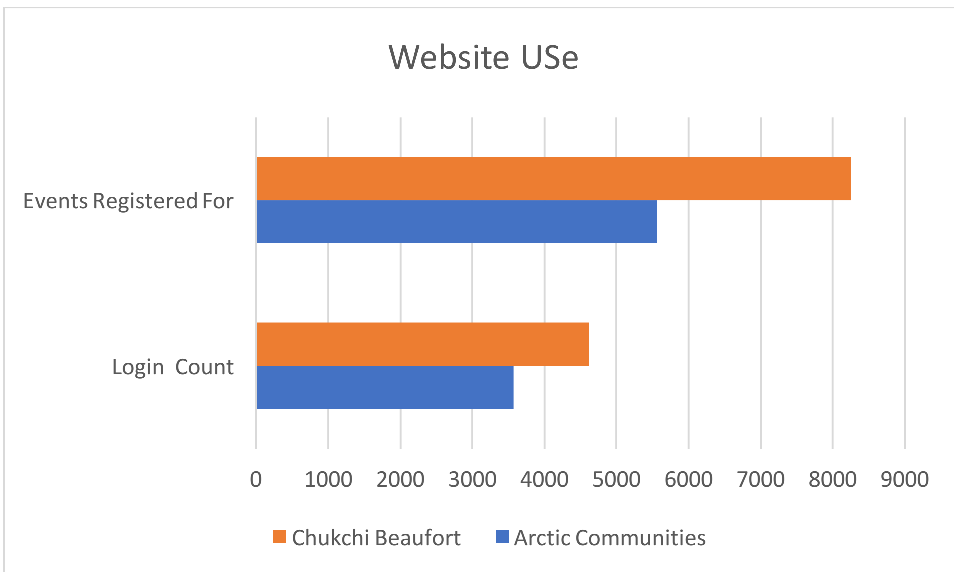

Figure 7: IARPC website use of the ACCT and CBCT. Data from IARPCCollaborations.org

Although the CBCT has 24 more members than the ACCT, the CBCT was still proportionally higher across many types of website activity. It should be noted that people can join multiple teams and this information is captured on the graph. For example, the data in the graph focuses on the CBCT and ACCT, if an ACCT team member was also a member of the Sea Ice team, the Sea Ice events they registered for are also captured in the graph. The graph, therefore, is an indicator of the level of engagement of the two team's members to both their team, but also IARPC as a whole. This data indicates varying levels of engagement between the two team's memberships.

While there is certainly complexity within and between the teams that does not always allow for a direct comparison, in many instances, the same factors that led to the success of the CBCT influenced the mixed outcome of the ACCT. Each of these factors played a significant role in the unfolding of the teams and their relative ability to create lasting collaborations. By understanding these factors, we can gather lessons learned that will help improve the latest edition of IARPC Collaboration Teams and help lead to more and longer lasting collaborations on Arctic Research.

IV. Policy Recommendations

The importance of understanding the Arctic region as a system continues to become more pressing as changes increase and the effects impact the planet. IARPC holds a unique position in the United States' policy landscape to bring together agencies and shareholders across organizations and scales to build collaborations on priority research areas of the Federal government. IARPC released their latest plan, Arctic Research Plan FY2017-2021 in December of 2016. This new Plan and the revised structure for implementation reflect the ability if IARPC to learn from its past efforts.

However, there are areas where IARPC can continue to make improvements. As the Collaboration Teams are structured as Communities of Practice and therefore able to determine to some extent their focus and means of achieving their goals, the decision-making process is distributed and IARPC has limited power in determining the directions the Collaboration Teams take. Therefore, it is important that not only IARPC learn from the lessons of the 2013-2017 Plan, but that teams and team leaders do as well. There are several team leaders who carried over from the last plan cycle, but the majority of them are new to the position, and some are also new to IARPC. The following policy recommendations are written to be considered both by IARPC as well as Collaboration Team leaders.

From the start, **IARPC needs to align the primary goals of the team with the missions of the agencies that will be taking leadership positions within the team.** As was evidenced by the ACCT, when a leading agencies mission does not fit with the bulk of the team's goals, their leadership ability is compromised as they cannot support many of the goals through collaborative research efforts. In addition, it is helpful to have leading agencies that are willing and able to fund research initiatives that contribute towards at least some of the team's goals. Combined, these leadership roles that can be taken by agencies will contribute to the success of Collaboration Teams through the alignment of goals, agency interests, and funding ability.

Next, **IARPC and team leaders should bind the scope of the team's goals during the Plan formulation process and implementation.** The questions facing Arctic research are quite large, and Collaboration Teams cannot hope to answer all the research questions surrounding their topic in a five-year span. The scope of the CT's topic needs to be taken into consideration. If the topic can be bounded in some way, like that of the CBCT, which was restricted by a particular region and focused objective, this will help increase the team's focus and ability to make significant progress. In many of the new CTs, the topics are still quite large. For example, the new Health and Well-being Collaboration Team has 22 performance elements (the updated name for milestones), which span goals for improving indoor air quality to improving occupational safety. The hope is that those participating in the meetings who have as wide a variety of interests as the goals will find areas of shared concern. However, this will only come to pass if there is some mechanism for channeling the team's energy. This might not be a conceptual model like the CBCT worked towards, but having a centering point to build cohesion and collaboration in teams, like sub-team CoPs with strong leadership, that have wide-ranging goals and membership interests will help increase the team's ability to build strong and oriented collaborations.

Although Collaboration Teams benefit from a centralizing focus**, team leaders should also leave room for community members to contribute to the direction and priorities of the team.** This bottom-up approach allows the membership to bring their expertise to bare and find areas of shared interest from multiple agencies, scientists, and stakeholders. This plays to a strength of communities of practice, their informality, which is necessary to foster spontaneous and creative knowledge. This can be accomplished through the wording of milestones/performance elements, which can leave space for team members to determine priorities.

Next, **actions can be taken by both IARPC and team leaders to strengthen the relationships between DC, Alaska, and Arctic communities.** IARPC deals primarily with Federally funded research, but the stakeholders and those most closely tied to the application of this research reside in Alaska and in Arctic communities. It is, therefore, important that efforts are made to bridge these divides. IARPC has made progress in this direction by choosing many team leaders who are based in Alaska. In addition, there is a growing recognition among IARPC members, team leaders, and Arctic researchers, that Arctic communities need to be involved in science, policy, decision-making processes. Currently, involvement by indigenous peoples in Collaboration Teams is quite low. This is, in part, due to the fact that indigenous individuals and groups have often been marginalized and don't have the same baseline access to things like communication infrastructure, and education about policy making processes to become involved as easily. Many Arctic communities are incredibly remote and connecting with them takes considerable effort and money. In addition, there are often challenges to building trust that must be overcome before working relationships can be established. However, these communities are most affected by the information being gathered through scientific research and thus it is the responsibility of the Federal government to make every effort to engage them in the science policy process. IARPC can do this by increasing its efforts to engage indigenous organizations. Many agencies and programs already have networks established that IARPC can tap into. IARPC should also base at least one of contractors in Alaska. This will allow the challenge of distance to be decreased. This IARPC representative in Alaska could work on building connections among state and native organizations. Both IARPC as well as CT leaders should make repeated efforts to engage these with these native organizations and networks. Increasing indigenous engagement with IARPC will likely take time and focused effort by both the Secretariat as well as team leaders, but it is a necessary step towards building better science policy that meets the needs of Arctic stakeholders.

The next recommendation, increased inclusivity, links to the previous one. **Team leaders should make outreach and engagement a concrete goal.** Some of the new teams are attempting to do this through creating an attendance tracker that captures how many indigenous peoples and early career scientists attend meetings. Because IARPC has strong ties to the Federal government, outsiders might feel excluded. Therefore, it is important for team leaders to consistently message that the team is open to anyone who is interested and the wider the perspectives are, the more well-rounded the team will become.

Finally, although a social network analysis was not able to be completed for this thesis, due to low response rates, **SNA would be a valuable exercise for IARPC to undertake in order to understand the hidden nature of knowledge flows within and among the collaboration teams.** If IARPC strongly supported such an effort, higher response rates would be likely. With more data, teams could be assessed for key knowledge sharers and knowledge bottlenecks as well as sub-networks within the teams. There are some obstacles to a study like this. For example, it is against protocol for Federal employees to ask other Federal employees to complete surveys. However, there are ways to structure such a survey to overcome these obstacles and it would be worth the effort.

Through these recommendations, IARPC and team leaders can begin to move from teams that share knowledge with each other to teams that use this sharing of knowledge to build lasting collaborations.

Conclusions

Given the complexity of the Arctic system, including the human dimension, policy makers argue that Arctic research is strengthened if research efforts are coordinated across government agencies and stakeholders and, in some cases, interdisciplinary. Studying the Arctic system through isolated entities will only capture part of the picture, while coordinated efforts have the advantage of pooling resources and information to create a more complete picture of the Arctic system and how this knowledge can be applied.

Although the current direction of Arctic research and IARPC is not certain due to the change of administration in 2017, Arctic research continues to be important and Arctic residents continue to face the challenges brought on by a changing climate. Federal agencies continue to need to to collaborate with each other, academics, indigenous organizations, the state of Alaska, and with NGOs in order to produce the best and most cost-effective research. One could argue that now, more than ever, we need IARPC. As the challenges in the Arctic increase, while at the same time many agency budgets are tightened, the need rises for new knowledge to be shared efficiently with decision-makers. Therefore, it is likely that IARPC will continue to be needed as a facilitator of these collaborations. IARPC has grown tremendously in its ability to fulfill its legal responsibilities over the last decade and will need to keep its flexible and open-minded approach in order to adapt to new challenges and continue to increase its effectiveness in building lasting collaborations.

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