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"We Never Get Stuck": A Collaborative Analysis of Change and Coastal Community Subsistence Practices in the Northern Bering and Chukchi Seas, Alaska

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ABSTRACT. The Indigenous communities of the northern Bering Sea and Chukchi Sea are experiencing extensive social, economic, and technological change. The region's marine ecosystem is also characterized by a high degree of variability and by rapid change. Residents of eight coastal communities from Savoonga to Utqiaġvik were involved in the Chukchi Coastal Communities Project, which used the results of a literature review together with the experiences of the community participants to co-analyze what is known about societal and environmental change in the region and what the communities' experiences have been in responding to those changes. Some of the observed changes are transient in duration and effect, such as the passage of an individual ship, whereas others, such as the creation of the Red Dog Mine Port Site, persist and may force coastal residents to make lasting changes in their activities. Some responses can use existing knowledge (e.g., hunting bowhead whales in fall as well as spring), whereas others may require learning and experimentation (e.g., harvesting new species such as the Hanasaki crab). Our findings show that the results of a change are more important than the source of the change. They also emphasize the continuing importance of traditional values and practices as well as attitudes conducive to persistence and innovation. Indigenous leadership is an essential component of continued resilience as the ecosystem continues to change. The resilient characteristics of coastal communities and their ability to determine their own responses to change need greater attention to match the research effort directed at understanding the ecosystem.

Key words: Chukchi Sea; Bering Sea; Iñupiaq; St. Lawrence Island Yupik; subsistence; response

RÉSUMÉ. Les collectivités autochtones du nord de la mer de Béring et de la mer des Tchouktches font face à d'importants changements sur les plans social, économique et technologique. L'écosystème marin de la région est également caractérisé par un grand degré de variabilité et de changement rapide. Les habitants de huit collectivités côtières, de Savoonga à Utqiaġvik, ont participé au projet des collectivités côtières des Tchouktches. S'appuyant sur l'examen de documentation et sur l'expérience des participants des collectivités, les responsables de ce projet ont co-analysé les faits connus au sujet du changement social et environnemental dans la région de même que l'expérience des collectivités en matière de réponse à ces changements. La durée et l'effet des changements observés sont parfois transitoires, comme le passage d'un navire, tandis que d'autres, comme l'aménagement du site portuaire de la mine de Red Dog, perdurent et risquent de forcer les habitants de la côte à modifier leurs activités en permanence. Certaines des réponses peuvent s'appuyer sur des connaissances déjà acquises (comme le fait de chasser la baleine boréale à l'automne ainsi qu'au printemps), tandis que d'autres pourraient nécessiter de l'apprentissage et de l'expérimentation (comme la récolte d'une nouvelle espèce comme le crabe Hanasaki). Nos constatations démontrent que les résultats d'un changement sont plus importants que la source du changement. Elles mettent également l'accent sur l'importance continuelle des valeurs et des pratiques traditionnelles ainsi que sur les attitudes propices à la persistance et à l'innovation. Le leadership autochtone est une composante essentielle de la résilience continue alors que l'écosystème évolue sans cesse. Les caractéristiques de résilience des collectivités côtières et leur capacité à déterminer leurs propres réponses au changement doivent faire l'objet d'une plus grande attention afin d'être à la hauteur de l'effort de recherche visant à comprendre l'écosystème.

Mots clés : mer des Tchouktches; mer de Béring; Iñupiaq; Yupik de l'île St. Lawrence; subsistance; réponse

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INTRODUCTION

Subsistence activities, which include traditional hunting, fishing, and gathering practices, provide vital cultural, nutritional, economic, social, and spiritual benefits to Indigenous residents of the northern Bering Sea and Chukchi Sea coast of western and northern Alaska (ICC-Alaska, 2015; Raymond-Yakoubian, 2019). In recent years, much attention has been given to the effects of climate change on subsistence and other aspects of Indigenous community life in Alaska and elsewhere (e.g., Fall et al., 2013; Gadamus, 2013; Pearce et al., 2015). At the same time, community members and researchers both recognize that subsistence practitioners have long dealt with considerable environmental variability on time scales from hours to decades (Kapsch et al., 2010; Huntington et al., 2013). In addition to environmental considerations, subsistence practices have been affected by social, economic, regulatory, technological, and other forms of change (Kersey, 2011; Moerlein and Carothers, 2012; Raymond-Yakoubian, 2013; Huntington and Eerkes-Medrano, 2017). These societal shifts have affected both the demand for subsistence foods and the ability to procure those foods (Fall et al., 2013). For example, modern hunting equipment facilitates access but requires money for its purchase, maintenance, and operation, which can limit participation for those with limited access to cash. While negative effects on subsistence get much attention and for good reason, the various changes communities have experienced have also had positive effects (e.g., Noongwook et al., 2007; Huntington et al., 2017a), in part due to the ability of communities to adjust where possible and to take advantage of opportunities.

That ability to adjust and to find and create opportunities is an essential attitude in an environment characterized by variability, as is the case for the northern Bering and Chukchi Sea marine ecosystem (e.g., Moore et al., 2018; Huntington et al., 2020). Weather and sea ice conditions can change within hours and can vary greatly from year to year. The harvest of marine mammals, seabirds, and fish in coastal communities also varies from year to year (e.g., Fall et al., 2013). If the Iñupiat and St. Lawrence Island Yupik of Alaska's western and northern coasts were unable to cope with that variability, their communities could not have persisted (e.g., Hovelsrud and Smit, 2010). This is not to say that such strategies are always effective. In both oral history and the archeological record, there is abundant evidence of the abandonment of settlements and shifts in subsistence patterns and technology (e.g., Mason and Gerlach, 1995). Nonetheless, the application of knowledge and skills to changing conditions, also described as adaptations to change, have been described in a number of papers. Thornton and Manasfi (2010), for example, define eight modes of adaptation, such as mobility and diversification. In addition, Walker and Salt (2012) describe societal characteristics or attitudes that promote adaptive responses, such as openness and diversity. Huntington et al. (2017a) examine how communities are able to respond to change, autonomously or in collaboration with others outside the community. Amid current concerns about the effects of climate change on the Arctic and its residents (e.g., Brinkman et al., 2016), the question of how coastal residents respond to change is ever more pertinent, deserving of detailed attention at the community level.

Our study started from the premise that much has already been documented about Indigenous observations of, experiences with, and responses to variability and change in this region. Rather than engage in another effort to interview community residents, we elected to engage community-identified experts in a co-analysis of the existing information. This approach is part of a shift in the role of community participants from providers of information to interpreters of information, and part of a wider movement towards meaningful collaborations, Indigenous leadership in research, and the co-production of knowledge, a paradigm emphasizing the need to work together from start to finish in research projects (Lemos and Morehouse, 2005; Bartlett et al., 2012; Meadow et al., 2015; Whyte, 2017; David-Chavez and Gavin, 2018; Peltier, 2018; Kirby et al., 2019). The aim of the study and of this paper therefore is not to generate or report new observations and basic information, but to take a new look at what is already on record, to better understand the meanings and implications of that existing information from the perspective of Indigenous communities.

Our project had two questions in mind. First, do different types of change manifest themselves in different ways, for example in the timescale on which they operate, and do they have demonstrable effects on subsistence outcomes? Climate change and other modes of change such as the effects of industrialization or commercial fishing are often regarded as major influences on subsistence practices (e.g., Cochran et al., 2013; Brinkman et al., 2016). We seek evidence to support that oft-repeated assertion.

Second, what strategies are used by Iñupiaq and St. Lawrence Island Yupik residents of Alaska's northern Bering Sea and Chukchi Sea coasts? If the strategies being used are likely to be effective in light of continued change to the ecosystem, it will be important to support the use of those strategies. If the strategies are unlikely to continue to be effective, it will be important to recognize their shortcomings and for coastal communities to develop alternatives. We conclude by considering the context in which environmental change affects the region's communities and its implications for the future well-being of those communities.

The study area for this project extends from St. Lawrence Island in the northern Bering Sea to Utqiaġvik at the edge of the Chukchi and Beaufort Seas (Fig. 1). There are over a dozen Alaska Native communities along the coast or close enough to the coast to use the marine environment for subsistence. Of these, we invited nine communities to join the project based on their connections to the sea, their participation in previous collaborative research efforts of

FIG. 1. Map of the region showing the communities with experts on the project team.

this type, and their willingness to take part. Eight were able to accept: Savoonga (2020 population est. 712; Alaska Department of Labor and Workforce Development, 2021), Diomede (84), Buckland (465), Kotzebue (3064), Kivalina (423), Point Hope (687), Point Lay (248), and Utqiaġvik (4436; formerly known as Barrow). The participant chosen by the ninth community was unable to attend because of schedule conflicts and no substitute could be arranged. The communities are Iñupiaq and St. Lawrence Island Yupik, referred to collectively here as the "Chukchi coastal communities."

METHODS

The Chukchi Coastal Communities Project is part of the North Pacific Research Board's Arctic Integrated Ecosystem Research Program (Arctic IERP; http://www.nprb.org/arctic-program/about-the-program/). The Arctic IERP includes several projects spanning physical oceanography to social science in an effort to consider the Chukchi Sea ecosystem and the implications of the environmental changes taking place in the region. The scope of the Arctic IERP was shaped in part by previous

efforts to engage coastal communities in the planning and conduct of Arctic research (Grebmeier, 2014). The Chukchi Coastal Communities Project examines the ways environmental changes affect the Iñupiaq and St. Lawrence Island Yupik communities along the Chukchi Sea coast of Alaska and also seeks to make available their observations of change in order to contribute to the program's collective understanding of what is happening in the region's marine environment.

Recognizing that Alaska Native communities have been the subject of extensive research concerning subsistence and environmental change (among many other topics; see, e.g., Cochran et al., 2013 and references therein; Raymond-Yakoubian and Raymond-Yakoubian, 2017), the Chukchi Coastal Communities Project does not include primary research, such as interviews, in the communities. We instead conducted a literature review of publications relevant to Chukchi coastal communities and their role in the marine ecosystem. We found 248 publications, including articles in scientific journals, books, reports, and other materials. The review began with papers known to the project team and by reviewing the reference lists of the publications already in the collection. We expanded through Internet searches using key words such as "Bering, Chukchi, Bering Strait, North Slope, Northwest Arctic, subsistence, Indigenous, Alaska Native, hunting, climate change, adaptation, resilience," and other terms and combinations found in the works already in our collection. The bibliographic details of the publications and a short list of key points or topics for each one were compiled into a document archived in the Arctic IERP data collection. This material is summarized below and constitutes the starting point for our co-analysis discussions.

In parallel to the literature review, members of the eight participating communities along the coast were identified as experts and selected by the project leads in cooperation with tribal and community leaders to take part in meetings to review and co-analyze what is known about societal and environmental change in the region and what these data tell us concerning the communities' experiences and well-being. By "co-analysis," we mean an effort to work together, not simply for academically trained researchers to ask questions of community experts and take notes, but for all involved to discuss observations and implications of changes, effects, and responses, based on each person's experiences and understanding.

The meeting discussions were organized around the questions mentioned in the Introduction. In March 2017, the project team met in Anchorage, Alaska, with 12 residents of the coastal communities (including two of the project leads) and two project leaders who live in the greater Anchorage area. In March 2018, the project team met again in Anchorage, this time with 11 residents of coastal communities (including two project leads and one project staff person) and the two project leaders from the Anchorage area. In both years, notes were taken of the discussions, circulated to participants for review and correction, and archived as part of the Arctic IERP data collection.

The authors of this paper include the project leads as well as community experts who were interested in contributing to the paper, beyond the meeting discussions. The overall project lead (H.P. Huntington) is a non-Indigenous scholar living near Anchorage, Alaska. Project co-leads include a non-Indigenous scholar living in the Anchorage area (J. Raymond-Yakoubian) and working for Kawerak, Inc., a regional non-profit organization based in Nome; an Iñupiaq from Kotzebue who at the time of the research was the planning and science director for the Northwest Arctic Borough (N. Naylor); and an Iñupiaq from Utqiaġvik who at the time of the research was a subsistence research specialist with the North Slope Borough Department of Wildlife Management (Q. Harcharek). The three remaining co-authors are a St. Lawrence Island Yupik whaling captain and local leader from Savoonga (G. Noongwook), an Iñupiaq provider of social services in Kotzebue who grew up on the land away from the community (C. Harris), and an Iñupiaq employee of the North Slope Borough Department of Wildlife Management from Utqiaġvik (B. Adams). All five of the Indigenous co-authors are active and experienced subsistence practitioners with additional extensive experience as members of formal scientific research efforts.

CAUSES, EFFECTS, AND RESPONSES TO CHANGE

The literature review provided numerous examples of changes that have occurred in Chukchi coastal communities and their surroundings over the past years and decades, the resulting effects of these changes on subsistence practices and outcomes, and the range of ways that individuals and communities have responded. These documented examples were complemented by observations of project team members during the co-analysis meetings. The list is not exhaustive. Instead, we have selected examples that community experts identified as representative of common experiences and trends and that illustrate a range of factors driving those changes.

We found dozens of examples of effects on subsistence practices. Fewer studies documented clear changes in outcomes, such as reduced (or increased) harvest levels. The causes of effects on subsistence can be divided first into societal and environmental categories and then further into subcategories. Environmental changes include changing weather, changing sea ice, changing abundance or distribution of harvested species, and the availability of new species to harvest. Societal changes include industrial activity such as shipping or offshore oil and gas activity, technological change, social or cultural change, economic change, and regulatory change. We considered both the short-term effects, lasting a season or less, and long-term effects, lasting for years or decades. A summary of examples of changes and effects is presented in Table 1.

TABLE 1. Examples of changes experienced by Chukchi coastal communities and their short- and long-term effects on subsistence. These examples were documented in the literature included in our project bibliography and complemented by additional observations shared in our project meetings.

Examples of change	Short-term (days to seasons) effects on subsistence	Long-term (years to decades) effects on subsistence	References
More strong winds and storms Rapid breakup of ice leading to short duration of good hunting conditions Marine mammals migrating farther from some communities	Temporary poor hunting season	Reduced hunting opportunities	Huntington et al., 1999, 2013, 2017a; Ashjian et al., 2010; Hanson et al., 2013; Oceana and Kawerak, 2014; March 2017, 2018 discussions
Earlier breakup and later freeze-up of sea ice	Earlier and later access for hunting from boats	More hunting opportunities from boats in Buckland, Utqiaġvik Fall whaling season in Savoonga	Noongwook et al., 2007; Oceana and Kawerak, 2014; March 2017 discussions
Less reliable shorefast ice	Harder to find places to haul whales out for butchering	No bowhead whales taken in Kivalina since 1994	Huntington et al., 2017a; Slats et al., 2019
More rain in summer	Spoilage of drying meat and fish	Need to switch to other methods of preservation	Raymond-Yakoubian, 2013; Raymond-Yakoubian and Raymond-Yakoubian, 2015
Warmer weather	Flooding of ice cellars and loss of stored food	Thawing ice cellars and need to find other methods of preservation	Christie et al., 2018
Hanasaki crabs arriving near St. Lawrence Island Increased salmon near Utqiaġvik	Need to learn new skills, tastes	New source of food	Carothers et al., 2013; Huntington et al., 2017b
Increased commercial ship traffic	Marine mammals temporarily become wary and hard to approach	Change in marine mammal distribution and local abundance, e.g., near the Red Dog Mine Port Site, reduced hunting opportunities	Huntington et al., 1999, 2017a; Kawerak, 2013a
Shift from sled dogs to snowmachines for winter transport	In Emmonak, single-day hunting trips become possible, resulting in a smaller use area	Reduced harvests of ringed seals (*Pusa hispida*) and fish	Hall, 1971; Burch, 1985; Fienup-Riordan et al., 2013; Raymond-Yakoubian, 2013; Raymond-Yakoubian and Raymond-Yakoubian, 2015
Larger boats, more reliable motors, GPS navigation	Able to travel in worse conditions	Expansion of overall use areas	Raymond-Yakoubian et al., 2014; Huntington et al., 2017a
Arrests of Diomede residents for illegal trade in walrus ivory	Loss of hunters due to incarceration	Loss of hunting and skin boat-making traditions as hunters avoid walrus hunting and skills are not passed on	March 2017 discussions
Imposition of bowhead quota by IWC	Changes in hunting patterns	Restriction on harvest, need to spend time lobbying for continued quota	Huntington, 1992; Noongwook, 2018
Schooling requirements	Loss of opportunities to participate in subsistence activities	Reduced transmission of subsistence skills and knowledge	Napoleon, 1996; March 2017, 2018 discussions; Raymond-Yakoubian, 2019
Greater participation in the wage economy	Shift to weekend hunting patterns to accommodate work schedules	Higher subsistence production in Utqiaġvik due to greater access to boats, snowmachines, and other equipment	Kruse, 1991; Galginaitis, 2013
Reduced income, purchasing power	Embarrassment at lack of equipment, avoidance of subsistence activities	Reduced participation in subsistence activities	March 2017 discussions; Raymond-Yakoubian, 2019

In Table 2, we present examples of several categories of response and potential limits to the effectiveness of a given strategy. Broadly, the strategies fall into two categories: specific actions that can be taken, such as hunting bowhead whales in fall as well as spring, and general approaches that promote problem-solving and innovation, such as persistence and a willingness to experiment.

As noted earlier, the information in both tables was the foundation for our co-analysis discussions. The literature survey also provided an annotated bibliography for the use of Arctic IERP researchers and others interested in Chukchi coastal communities' observations of and experiences with change. This information could be used, for example, to compare findings from research cruises or remote sensing with local observations and understanding. Such efforts are separate from the purpose of this paper.

RESULTS OF THE CO-ANALYSIS

Types and Effects of Change

Chukchi coastal communities face many types of change and disturbance, as illustrated in Table 1. Separating these by type (e.g., environmental vs. societal, or local vs. global) is less important than understanding the characteristics of each disturbance. For example, the duration of the disturbance marks the difference between a temporary problem, a seasonal problem, or a long-term problem. The passage of a single ship can disrupt marine mammal behavior for a day or two. The operation of the Red Dog Mine Port Site over many decades has caused a long-term shift in marine mammal distributions in the area. Similarly, a storm can keep hunters on shore for a few days. Poor spring weather or ice conditions can reduce harvests for a season. Declines in the reliability of shorefast ice have contributed to Kivalina not landing a bowhead whale (*Balaena mysticetus*) since the mid-1990s. Changes in ice breakup patterns have reduced the duration of good seal hunting conditions from weeks to days or even less.

The duration of a disturbance or alteration distinguishes variability from change. The Arctic environment has always been variable, and hunters have had to adjust from day to day, season to season, and year to year. This is considered normal. The annual Pacific walrus (*Odobenus rosmarus divergens*) harvest on St. Lawrence Island varies greatly due to weather and ice conditions as well as societal factors. The quote in the title of this paper—"We never get stuck"—is indicative of the expectation that community residents will have to find ways to make do, and that attitude is as important as the skill in doing so.

More recently, the environment has also undergone persistent changes. Sea ice forms later and breaks up earlier and more rapidly, affecting marine mammal hunting patterns as well as fishing and crabbing through the ice. The loss of suitable hunting and fishing days has reduced opportunities. On the other hand, earlier breakup can create earlier access, as is the case for Buckland seal hunters, and a late freeze-up has created a new fall bowhead whaling season in Savoonga. More rain in summer makes it harder to dry fish and meat, complicating the task of preserving foods in traditional ways. Ice cellars, dug into permafrost to provide subfreezing storage at no cost, are themselves threatened by thawing permafrost caused by warmer weather and other changes to soil conditions. Stronger and more frequent winds reduce the number of days suitable for boat travel, and larger boats cannot completely overcome this problem.

Shifts in the distribution and abundance of different species have also affected subsistence practices. The increased availability of salmon (*Oncorhyncus* spp.) in Utqiaġvik has created a new fishery and led people there to learn how to smoke salmon. The Hanasaki crab (*Paralithodes brevipes*) is a relatively new arrival in the waters off Savoonga, providing a new and valued source of food. In both cases, it appears that these changes are likely to persist.

As with environmental variability, short-term societal matters such as family health or a major construction project employing many local residents for a season are typically viewed as normal variability. Of greater note for the communities are long-term changes. Schooling requirements take up considerable time for children, reducing their opportunities to participate in subsistence activities and learn the necessary skills and knowledge. Few schools make allowance for subsistence or provide in-school ways of learning from Elders. Replacing dog teams with snowmachines, which began in the late 1960s, reduced the demand and thus the harvest of seals and fish that were formerly used as dog food. Faster snowmachines have had the counterintuitive effect of reducing the seal-hunting area in some communities, because hunters can go out and back in a day rather than making extended camping trips to more distant locations.

The decades-long shift towards greater participation in the wage economy has raised incomes and thus the ability of some people to purchase equipment used for subsistence. Even those without jobs may benefit from relatives willing to share their gear. On the other hand, having a job can reduce the time available for hunting or the flexibility to go when conditions are good. Some employers in the region provide subsistence leave, above and beyond vacation days, but not all work can be put off in this way. The other side of this phenomenon is that people without the means to go hunting or fishing may be left out of subsistence activities. Their situation may be compounded by embarrassment that they have to walk to a harvesting area or use old equipment, so some individuals avoid potential social discomfort by staying home instead of trying to participate in subsistence.

Another persistent shift has been in the regulatory environment. The quota imposed since 1978 by the International Whaling Commission (IWC) for the bowhead whale hunt has, among other things, meant that leaders of the whaling community have had to spend considerable

TABLE 2. Response categories, examples, and what might constrain the effectiveness of the responses. These examples were documented in the literature included in our project bibliography and supplemented by additional observations shared in our project meetings.

Response	Example	Limits on effectiveness	References
Using different areas	Variation in use areas over time	If species remain available somewhere in range and the areas are available for use	Stephen R. Braund & Associates, 2010; Gadamus and Raymond-Yakoubian, 2015a
		Added travel cost if new areas are farther away	
	Moving from Diomede to Nome	If moving is an option, if hunting remains good in new area, if newcomers are allowed to hunt there	March 2017 discussions
Using different times	Fall whaling in Savoonga	If species remain available and conditions are suitable	Noongwook et al., 2007
Using different species	Variation in harvest composition from year to year	If at least some species remain abundant	Stephen R. Braund & Associates, 2010; Fall et al., 2013; Raymond-Yakoubian, 2013
Being prepared	Continual observation, readiness to take action when opportunity presents itself	If there are opportunities to seize	Raymond-Yakoubian et al., 2014; Kawerak, 2013a, b; Huntington et al., 2017a; March 2017 discussions
	Use of social media to share information about animal migrations	Access to social media, presence of animals	Christie et al., 2018
Being persistent	"We never get stuck"—not giving up, but continuing to look for ways to make things work	Until the obstacles are too great to overcome	March 2018 discussions
Using new species	Hanasaki crabs in Savoonga	If there are new species available and if there are no regulatory barriers	Huntington et al., 2017b
Using new techniques and tools	Drones to scout for suitable ice, marine mammals	If techniques and tools are available and affordable and if the animals are still there; regulatory restrictions on some technologies	Raymond-Yakoubian et al., 2014; Schwing, 2016; Hughes, 2018; Woodford, 2019
Making new use of the harvest	Smoking salmon in Utqiaġvik	If there are options and the information needed to employ those options	Kersey, 2011; March 2018 discussions
Being willing to experiment	Hunting the first belugas (*Delphinapeterus leucas*) to pass Point Lay	As long as there are animals available; tolerance for risk	March 2017 discussions

time traveling to meetings and other venues to defend their practices, which has taken them away from hunting and other responsibilities in the community. A major enforcement action in the early 1990s against illegal harvests of Pacific walrus tusks led to several hunters from the Bering Strait area being charged with this crime. One result was that the walrus harvest on Little Diomede declined sharply and has not recovered because some prominent hunters were jailed; as a consequence, others were reluctant to hunt. The transmission of skills and knowledge to younger hunters was thus interrupted, creating an even more lasting effect.

Response Strategies

Environmental changes in the Arctic attract a lot of scientific and media attention. Addressing the root causes of these changes, however, is a challenge. The causes are dispersed globally and include powerful economic interests as well as established patterns of energy-intensive human behavior. Some Arctic activists have advocated for global action on climate change, but it remains a major challenge.

Some societal influences on subsistence, on the other hand, are closer to home or have a clearer focal point. The effects of commercial shipping to Red Dog Mine or the North Slope oil fields can be raised with the companies involved. In the case of North Slope oil activities, a cooperative agreement was reached between whalers and companies to improve communication and reduce or avoid ship traffic that interferes with whaling. Even the IWC quota for bowhead whales is set by a single international body that meets on a regular basis, so whalers know when and where to go to advocate for their way of life. Changing the schedules of local schools and employers has in general proved hard to do, but at least community members have access to the relevant decision makers. Adoption of

new technology is up to the individual, subject to such considerations as affordability.

Whether the ultimate causes of change can be addressed or not, individual hunters can and do adjust in many ways to respond to change. Communities can pool their talents and resources to do so to an even greater extent. Hunting areas may shift and expand, both because animal distributions change and also because new technologies such as larger boats, more reliable engines, and GPS navigation allow for more efficient and safer travel, though going farther will take more time and fuel. Subsistence activities may also take place at different times, ranging from a shift of a few days or weeks if sea ice breaks up earlier, to Savoonga's creation of a fall whaling season. Harvest composition varies from year to year (e.g., Bacon et al., 2009) and can also shift over time in response to access, species availability, and other factors. Some changes, however, will require more than an individual or community can do alone. Collaboration and cooperation with those outside the community will also be necessary. Such efforts can be as simple as Utqiaġvik harvesters learning from friends and relatives farther south how to smoke salmon or as complicated and difficult as persuading the U.S. government and the IWC to permit the harvest of other species of large whales. All of these strategies depend on having animals to harvest at some time and place within reach of the community.

In addition to changing activities, Chukchi coastal residents also recognize the importance of attitudes in creating effective responses to change. These characteristics do not simply exist, but are developed and encouraged within the communities of this study (and undoubtedly far beyond) as distinct skills to be practiced and refined. Harvesters have always been prepared for variable conditions, whether in recognizing signs of danger or being ready to act when opportunities arise. Being ready is not so much a response in itself as the foundation for any other response, from making use of the now-briefer seal-hunting period after shorefast ice breaks up to using social media to share information among communities about animal migrations. Persistence is similarly a necessary virtue, again as illustrated in the adage that "We never get stuck." Using new species, such as the Hanasaki crab, or new tools, such as drones or satellite imagery, for scouting sea ice conditions, or learning new ways to prepare and store foods are all part of a ceaseless search for what will work best at any given time. Here, too, there are ultimately limits to what can be accomplished, but not for lack of trying.

For all the attention to changes in the Chukchi marine ecosystem, widespread changes in subsistence outcomes are hard to identify. There are many relatively modest effects, as shown in the examples in Table 1, but the reduction of seal and fish harvests due to the replacement of dog teams with snowmachines is so far a much larger change than has been forced by environmental change in the region. One reason for the lack of apparent effects is the range of responses used by subsistence harvesters, as shown in the examples in Table 2.

This is not to say that further changes will have similarly modest effects, or that responses will continue to be effective. Coastal residents will remain innovative and committed to providing food for their communities. Modern technology will help in many ways, and remoteness and minimal competition for most of the marine resources of the region leave the coastal communities considerable flexibility in what, when, and where to hunt. On the other hand, increased commercial shipping (AMSA, 2009) and industrial activities such as offshore oil and gas activity (Gautier et al., 2009; Holland-Bartels and Pierce, 2011) create another type of competition, not for species per se but for access to an undisturbed sea, even as they may provide more local income. Those lacking cash or equipment will have less ability to participate in subsistence regardless of the abundance or accessibility of animals and plants. Regulatory restrictions could limit the ability of harvesters to adjust by not allowing the take of animals outside regulatory seasons even though the timing of animal presence or abundance has changed, prohibiting the take of species they have not harvested before, or by preventing them from making up for poor harvests of one species (e.g., bowhead whales) by increasing their take of another (e.g., caribou). Furthermore, the fixed infrastructure of today's communities limits the ability of hunters and fishers to always move to where the fish and animals are abundant or accessible.

Cataloguing the range of factors that influence Chukchi coastal communities and communities elsewhere is in itself of limited value in fostering resilience and adaptation to change. Community well-being will depend on many factors as well as the interplay among those factors, which limits our ability to predict or even to recognize which influences matter most. What is likely more important is the ability of communities to develop their own responses to change on their own terms and with support from and in cooperation with others when necessary and desired. The effects of environmental change on Chukchi coastal communities are not negligible but demonstrable and play out under the influences of societal and other changes that mediate both the effects of those changes and the responses to them.

DISCUSSION

Co-analysis and Community Perspectives

The movement towards collaborative research and the co-production of knowledge is in part recognition of the rights of community residents to be more than study subjects (Smith, 1999; Wilson, 2008; Kovach, 2009; Strega and Brown, 2015). Involving Arctic peoples in all phases of a research project is worthwhile on its own merits, recognizing the full intellectual contributions made by everyone involved in such projects and sharing the rewards of credit and income from the work of research.

Scientifically, it is also reasonable to ask what is gained from a collaborative or co-productive approach as compared with other methods. In our study, the answer lies less in dramatic insights and more in the steady accumulation of additional ideas and perspectives.

The co-analysis emphasizes the importance of the results of change rather than the sources of change, when it comes to their effects on communities and the strategies used to address those changes. Whether marine mammal distribution has shifted because of vessel traffic or reduced sea ice, hunters still have to find ways to adjust. The ability to adjust is useful no matter the cause of change. Addressing the source of the change, by negotiating with a shipping company or advocating for one's community at the IWC, is also a form of adjustment, and doing so can give a sense of agency, which reinforces the idea that one can affect the outcomes that matter. At the same time, changes that stem directly from a specific and identifiable human action, such as industrial activity or an oil spill, are also likely to produce a different reaction among those affected than would an event with unknown or natural causes, such as fluctuation in some animal populations. In the former case, stress is likely to be higher as individuals seek to blame those they see as responsible and realize the problem may have been preventable (e.g., Cunsolo Willox et al., 2013, 2015), whereas in the latter case, people may be better able to get on coping with the change (e.g., Himes-Cornell et al., 2018).

The co-analysis discussions emphasized the importance of attitude (e.g., Walker and Salt, 2012) as well as skill and knowledge, and the crucial role that traditional values and practices continue to play in successful subsistence outcomes. These are not new ideas in the literature on Arctic communities and change (e.g., Hovelsrud and Smit, 2010; Cochran et al., 2013; Ford et al., 2015; Huntington et al., 2017a), but they often receive less attention and emphasis than what is changing. The abilities, both learned and taught, to be ready and to carry on deserve more attention as effective elements of individual as well as collective (i.e., cultural) responses to change and greater recognition as traits essential to the well-being of remote communities in variable, changing, and challenging environments.

Together, these insights suggest a broader scope of inquiry and discussion, not limited to ecosystem studies or societal studies, but taking the community perspective as a starting point to address community needs and concerns (e.g., Huntington et al., 2019). Further documentation of how much is changing and how fast is useful only up to a point. Greater understanding of how people have already adapted to change and how those strategies can be fostered and supported in response to future change is a more useful contribution to supporting the well-being of the region's coastal communities. More important still is a leading role for tribal and community voices and leadership in deciding how they want to shape their own future (Raymond-Yakoubian and Daniel, 2018). Shared leadership provides an opportunity for true collaboration between scientists and coastal residents and, ultimately, the local, regional, and national policy makers whose decisions will have a large influence on what happens next.

Theories of Change and Response

From an academic point of view, we can also consider the outcomes of the co-analysis discussions in light of existing theories of change and response, drawing, for example, from ecology and business management. The emphasis on the characteristics of disturbance, especially the role of duration, aligns with the ecological and social-ecological idea of pulse-press dynamics (e.g., Collins et al., 2011; Ratajczak et al., 2017). Pulses are short-term disturbances that cause disruption but from which the system recovers to something close to its original state. Presses are long-term disturbances that lead to long-term alterations in a system's structure and functioning. One poor hunting season may cause hardship and even loss, but communities and cultures have recovered from such events in the past. A change in sea ice conditions, however, may force marine mammal hunters to alter their practices to the point of abandoning previous modes of hunting, as with Kivalina and bowhead whaling, or creating new modes of hunting, as for Savoonga and fall whaling.

Responses to change can be considered technical or adaptive, a concept taken from business management (e.g., Heifetz et al., 2009). Technical changes are those that apply a known solution to a problem, whereas adaptive changes are those that require developing a new solution, typically because the problem is of a nature not previously encountered. Technical changes may often be sufficient for pulse problems, since the basic nature of the system does not change; in a system with high variability, subsistence harvesters have a number of alternatives to use if their primary methods are not sufficient in a given season. Under press-like changes, however, the system itself is likely to change, in turn sometimes, but not always, requiring the development of new knowledge, skills, and methods to achieve similar outcomes. Harvesting the Hanasaki crab may not be a major challenge, but it is still a new skill to learn. The use of new tools such as drones, satellite imagery, and GPS requires experimenting and the generation of new knowledge and skills. On the other hand, being ready to harvest when conditions are right has always been important, even if good conditions for some activities no longer last as long.

When discussing change and response to change, it is important not to overlook what should stay the same (Huntington et al., 2017a), such as being prepared, being persistent, and being willing to experiment (reflected in some entries in Table 2). Sharing remains an essential component of social life in Indigenous communities and their hunting, fishing, and gathering practices (Raymond-Yakoubian, 2013). Hunters need to be mentally and physically prepared (Kawerak, 2013b). Respect for the animals is critical to the long-term well-being of hunter and

hunted alike (Kawerak, 2013a; Gadamus and Raymond-Yakoubian, 2015b; Raymond-Yakoubian and Raymond-Yakoubian, 2015). Humility and cooperation are necessary for social cohesion. Effective response strategies exist not in isolation, but in a context of healthy interpersonal and human-animal and human-environment relationships (Hovelsrud and Smit, 2010). If that foundation is not solid, then dealing with change may become extremely difficult or impossible, no matter how extensive the available resources. With a solid foundation, by contrast, a great deal can be done even in the face of major environmental change. The ability of Savoonga's whalers to create a fall whaling season in the northern Bering Sea is but one example of what is possible through the synergy of Indigenous skill, knowledge, determination, and collaboration.

Our examples and findings are consistent with other studies of responses to change (e.g., Emery and Flora, 2006; Thornton and Manasfi, 2010; Walker and Salt, 2012), which have shown that humans draw on a wide range of available resources to support an equally wide range of response strategies. Our findings are also broadly consistent with other Arctic studies, which have found that environmental and societal factors both have a large influence on community well-being, including subsistence practices (e.g., Hoveslrud and Smit, 2010; Pearce et al., 2010, 2015; Ford et al., 2015; Rasmussen et al., 2015; Hastrup, 2018; ICC-Alaska, 2015), and that identifying demonstrable changes in community well-being (e.g., population trends) is difficult (Hamilton et al., 2016), perhaps because of the range of responses that provide a buffer against deleterious effects (Huntington et al., 2018).

Understanding the nature of changes, for example as pulse-press dynamics, and the types of responses those changes will require, such as technical and adaptive solutions, can help communities and their allies to focus their efforts and perhaps to make a more persuasive case when needed to convince others to also change. Our co-analysis approach has emphasized the continuing importance of traditional values and practices, such as the attitude of never getting stuck, as well as the need for attention to the conditions within and outside communities that foster effective responses to change. Movement towards approaches that use co-production of knowledge and are highly collaborative is a welcome step in this regard, especially if it can also lead towards collective action.

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