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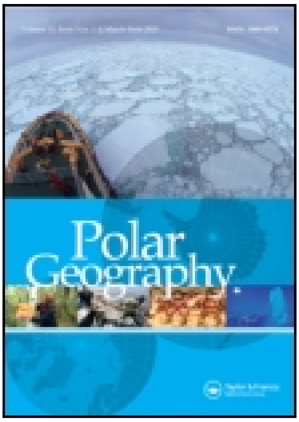

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Developing an arctic subsistence observation system

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Developing an arctic subsistence observation system

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The goal of the Arctic Observing Network Social Indicators Project subsistence component is to assess the adequacy of existing subsistence harvest data to advance our understanding of arctic change and to serve as the basis for recommending steps that can improve the observation network. The assessment is based on a database developed to include 1521 place/year records for Alaska and northern Canada. Of these records, 641 include estimates of harvest of all resources. Separate harvest reports are available for 131 species. Annual harvests are expressed as kilograms of edible harvest per capita for years ranging from 1965 to 2007. One or more measures per decade of comprehensive harvest in the 1990s and 2000s exist for 50 of the 411 arctic North American communities. Based on these results, in most, but not all regions, available data on subsistence harvests in Arctic North America cannot support analysis of changes in harvest over time. The Alaska Department of Fish and Game Community Subsistence Information System continues to provide harvest data for communities and has developed several regional sets of community harvest data in response to actual and potential environmental changes. The past harvest surveys conducted in the Nunavik, Inuvialuit, and Nunavut regions offer valuable experience as well as baseline data. The Arctic Borderlands Ecological Cooperative is a model of community–researcher collaboration. These past and current initiatives provide a foundation for the design of an expanded arctic subsistence observation network. The paper concludes with a discussion of challenges and recommendations.

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Introduction

As defined in the SEARCH Science Plan (SEARCH 2001), humans are an integral part of the arctic system and, therefore, a focus of arctic change. The SEARCH science plan reflects an equally broad view of the causes of arctic changes, with a primary focus on climate change, within the context of other forces for change. The SEARCH Implementation Plan identifies subsistence as one of three areas of human activity likely to interact with climate change (SEARCH 2005, p. 44). The goals for the subsistence component of the AON-SIP project are shared with each of the other project components:

(1) Compile existing data relevant to the project focus areas into a database; and
(2) Recommend how the database could be improved to support analyses to understand arctic change.

This paper begins with a brief examination of the importance of subsistence to the well-being of arctic residents. It then examines the SEARCH hypothesis that

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subsistence is an area of human activity likely to interact with climate change. In the section titled "Implications of Uncertainty Concerning the Cumulative Effects of Arctic Change on Subsistence" we review work that has identified the substantial uncertainties associated with the cumulative effects of arctic change on subsistence. We discuss the implications of these uncertainties for the design of the arctic observation system. The section titled "Sources of Subsistence Observations" introduces the sources of subsistence data incorporated in the AON-SIP subsistence database. This section is followed by a description and assessment of the data. The final section includes a discussion of the challenges in observation system design and a set of recommendations to improve the subsistence component of the arctic observation network.

Importance of subsistence to well-being

Subsistence, the term used in North America for the local harvest of resources for domestic use, remains an important part of the economies and cultures of the north (ADF&G 2010a; ASI 2010; NWMB 2008; Usher 2002). In Arctic Canada, Greenland, Northern Alaska, Chukotka, and the Sami homelands of Norway and Sweden, results from the Survey of Living Conditions in the Arctic (SLiCA) show that two out of every three Inuit and Sami households estimate that half or more of meat and fish their household consumes comes from their own or others' subsistence activities (Table 1). Table 1 reports the proportion of all meat and fish Inuit and Sami residents estimate that their households consumed in the previous year, that is derived from subsistence harvests. Table 2 reports the grouped number of separate types of subsistence activities engaged in by Inuit and Sami adults during the previous 12 months. At least 30% engaged in six activities or more. The amount of subsistence activities pursued, and satisfaction with the amount of fish and game locally available independently explain a significant amount of the variation in satisfaction with life as a whole (Poppel and Kruse 2008, p. 40). These are the results of over 8000 interviews conducted between 2003 and 2009 in SLiCA (Kruse *et al.* 2008). Keeping in mind that these measures of subsistence consumption and subsistence activity are crude, we can nevertheless be confident that subsistence foods continue to be a significant component of the diets and lifestyles of Inuit and Sami peoples in the Arctic.

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Observations of arctic change

There is little question, then, that changes in subsistence in the Arctic would be important to overall well-being. Are we in fact observing arctic changes likely to affect subsistence harvests? The answer is clearly yes. In 2002, Krupnik and Jolly edited *The Earth is Faster Now*, a volume describing nine different collaborations of arctic residents and scientists intended to document arctic changes (Krupnik and Jolly 2002). Additional descriptions and compilations of locally observed arctic changes include Ford and Smit (2004), Barber *et al.* (2008), Nichols *et al.* (2004), Brunner *et al.* (2004), Norton and Gaylord (2004), George *et al.* (2004), and Tremblay *et al.* (2008).

What kinds of changes relevant to subsistence harvests are being observed? Table 3 illustrates the types of arctic changes relevant to subsistence harvests being observed by arctic residents in nine different regions of Arctic North America. It is

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Table 1. Proportion of meat and fish consumed by households that is traditional food by country.

	Northern Canada (%)	Greenland (%)	Chukotka (%)	Northern Alaska (%)	Northern Norway (%)	Northern Sweden (%)	Kola Peninsula (%)	Total (%)
None	1	0	9	1	1	1	33	2
Less than half	24	33	34	15	12	12	38	29
About half	35	27	29	24	21	19	29	26
More than half	40	40	28	60	66	68	0	43
	100	100	100	100	100	100	100	100

Source: SLiCA data analysis.

Table 2. Number of subsistence activities engaged in during previous 12 months by country.

	Greenland (%)	Northern Norway (%)	Northern Sweden (%)	Chukotka (%)	Northern Alaska (%)	Kola Peninsula (%)	Total (%)
0 Activities	22	7	24	13	9	36	19
1 through 5 activities	47	54	45	24	36	32	41
6 through 16 activities	30	40	31	63	55	33	41
Total	100	100	100	100	100	100	100

Source: SLiCA data analysis.

based on four sources (Barber *et al.* 2008; Fox 2002; Fugal *et al.* 2002; Kruse *et al.* 2004a). The principal source of local observations in Barber *et al.* (2008) is a joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization. Fox (2002) is reporting on her own collaborative work in four Nunavut communities. Furgal (2002) is reporting on his team's work in Nunavik and Labrador. Kruse *et al.* (2004a) report their work in six regions of Alaska. We should note that all of these projects involved some combination of focus groups, key informant interviews, and participant observation. The studies differed somewhat in their mix of methods and their objectives. In the work reported by Kruse *et al.* (2004), for example, the main focus was on contaminants in subsistence foods. Participants in talking circles were asked to comment on any changes in the environment they had observed. In this way, observations of climate-related changes were documented along with changes as diverse as the use of pharmaceuticals and in the respect of youth for animals.

It is not the style of indigenous arctic residents to keep lists of arctic changes. Rather, they tell stories that interweave recent observations with understandings built on years of experience and learning from others. Table 3 is, therefore, not representative of the way arctic residents think. We hope that it does, however, convey the point that arctic residents are observing a remarkably diverse array of changes relevant to subsistence. Observations often differ from region to region, from community to community within a region and even among individuals from the same community (in part because their experiences differ). These differences are in fact a principal justification for developing a pan-Arctic regional perspective on change. Our question now is whether changes of any kind relevant to subsistence harvests are prevalent in Arctic North America.

The categories in Table 3 are necessarily generalized from hundreds of specific observations. They mask great differences in the details of observations. In Northwestern Alaska, for example, residents observed salmon further north. Observers in the Western Canadian Arctic commented on caribou moving onto the coast and even out on the islands while Southeast Alaska residents talked about sea otters moving to inside waters. All of these observations are categorized as 'changes in migration timing and routes'.

The arctic changes observed are often not attributed to one or more causes. Local observers are cautious about attributing causes and tend to stick to what they have personally experienced. They are, however, aware of climate change, the long-range

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Table 3. Type of arctic changes observed by arctic residents.

Observed Change	Example of effect or possible cause	Region of Arctic North America								
		Western Alaska	Yukon-Kuskokwim Delta	Northwest Alaska	Interior Alaska	Arctic Alaska	Southeast Alaska	Western Canadian Arctic	Nunavik and Labrador	Nunavut
Changes in migration timing and routes	Access to resources			•	•	•	•	•	•	•
Quality of fish declining	Softer, thinner, spoil faster	•	•			•		•	•	•
Abnormalities in fish or animals	Afraid to eat when abnormal	•	•	•	•	•	•			
New species	Salmon spawning further north			•	•	•		•		•
Reduction in thickness and duration of landfast and nearshore sea ice	Travel safety, access to hunting grounds			•		•		•	•	•
Unpredictability and greater variability of weather conditions	Travel safety	•		•				•	•	•
Less snow	Access to hunting grounds, wear and tear on snowmobiles and sleds		•					•	•	•
More bushes	More beaver		•	•	•				•	

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Table 3. Continued.

		Region of Arctic North America								
Observed Change	Example of effect or possible cause	Western Alaska	Yukon-Kuskokwim Delta	Northwest Alaska	Interior Alaska	Arctic Alaska	Southeast Alaska	Western Canadian Arctic	Nunavik and Labrador	Nunavut
Drier conditions	Habitat changes, resource changes, access to hunting grounds				•			•	•	•
Poor condition of seals	Related to reduced sea ice habitat	•						•	•	
More bear	Drive reindeer away, increased predation	•		•		•		•		
Poor quality of berries, beachgrass	Reduced harvest of berries	•					•		•	
Shorter winters	Less access on snow and ice							•	•	•
More extreme weather events	E.g. tornado near Aklavik, thunderstorms							•	•	
Freezing rain and icing	Health of wildlife							•	•	
Increased storm surges, flooding	Safety, erosion					•		•		
Increased presence of polar bear near communities	Safety					•		•		

Table 3. Continued.

Observed Change	Example of effect or possible cause	Region of Arctic North America								
		Western Alaska	Yukon-Kuskokwim Delta	Northwest Alaska	Interior Alaska	Arctic Alaska	Southeast Alaska	Western Canadian Arctic	Nunavik and Labrador	Nunavut
Deeper snows	Increased mortality of moose and caribou by wolves	•			•					
Fewer seabirds	E.g. in Prince William Sound area	•		•						
Less salmon	E.g. moving to cooler waters		•				•			
stronger sun	Sunburns, rashes								•	•
Increased fog	Travel safety							•		
Changing wind patterns	Poor igloo quality							•		•
Spruce beetle infestations	Die off of trees				•					
Fewer moose	May be related to change in habitat			•						
Red algae blooms	May be related to warmer water						•			

Source: Kruse, Cochran, and Merculieff (2004), Barber *et al*. (2008), Furgal *et al*. (2002), and Fox (2002).

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transport of persistent organic pollutants, the toxic legacy of abandoned military and mining sites, local pollution from landfills, the effects of drinking large amounts of soda pop, taking a myriad of pharmaceuticals, and are concerned about a loss of respect for animals, among many other causes of change in the Arctic. People observe their environment as a whole, not one element at a time. One resident commented:

> I've lived most of my life in western Alaska. I've been in groups like this in the past. The animals and berries are changing. I've noticed that the silver salmon had sore-like spots on their sides. They said a few years ago when the birds were dying that there was a yellow-like substance foam in the bay. We've never seen anything like that before. When I talked to the elders at home before I came here they talked about the migration patterns of the walrus and caribou changing. Recently two families lost their reindeer to caribou because they came right down the beach near Koyuk. The caribou used to come 15–20 miles inland and now they are migrating towards our area. One family lost most of their herd this year. It seems that in my lifetime the migration of the walrus and beluga are really changing too. Take an example from the lemmings, when there are too many, they go to different areas to feed. That is the way it is with the walrus too. They are going to new places to feed. Last year thousands of them went to Norton Bay. When we opened their bellies, we found rocks in there. They migrated towards the land; maybe it was because they ran out of things to eat.
>
> William Takak, Shaktoolik
> (Kruse *et al.* 2004a, p. 14)

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Looking back at Table 3, four of the most pervasive types of arctic changes include changes in migration timing and routes (e.g. caribou), declines in the quality of fish (e.g. softer flesh), abnormalities in fish or animals (e.g. abscesses), and new species (e.g. chum salmon in northwestern Alaska). All of these changes directly involve a subsistence resource. Three additional types of arctic changes observed in multiple regions that might affect subsistence harvests are a reduction in thickness and duration of landfast and nearshore sea ice; unpredictability and greater variability of weather conditions; and less snow. Each of these changes can affect the feasibility and risk of travel for subsistence harvesting.

Observed arctic changes include changes in vegetation and wildlife. Surprisingly, one of the most prevalent observations is that there are more beaver in Arctic North America. Many observers associate the increase in beaver with the northward spread of bushy vegetation. One resident observed:

> The Eldorado River I use–it has little streams that are dammed by beaver and the silvers were laying around in front of the dam. When I saw a female and picked it up, the eggs were coming out. I was thinking, they may spawn anywhere they can, but when all their streams are blocked what do they do?
>
> Hannah Miller, Council
> (Kruse, Cochran 2004)

Additional arctic changes observed in multiple regions include shorter winters, freezing rain and icing, increased storm surges, and flooding (Table 3). These changes can affect subsistence harvesting in multiple ways. Shorter winters can, for example, reduce opportunities for travel by snowmachine and increase opportunities to travel by boat, provided river levels are high enough. Freezing rain and icing can make it more difficult for caribou and muskox to feed or travel, while storm surges and flooding can directly threaten community infrastructure and subsistence camps.

Implications of uncertainty concerning the cumulative effects of arctic change on subsistence

Given the number and diversity of arctic changes observed, and the number of possible causes, it is clearly unreasonable to expect even the most knowledgeable observers to predict the cumulative effect on subsistence harvests. To this high level of uncertainty, we must add the normal variability in subsistence from year to year. Ernest (Tiger) Burch conducted harvest studies in the community of Kivalina, Alaska, between 1959 and 1984. In his detailed work in the 1960s, he found that caribou comprised 16% of total harvest in 1964–1965 and 54% of total harvest in 1965–1966. Burch (1985, p. 77) explained that in 1964–1965, Dolly Varden accounted for 28% of the total subsistence harvest. In 1965–1966, residents experienced the worst recorded fall harvest of Dolly Varden, accounting for only 7% of total harvest. Caribou arrived shortly after the end of the fall fishery. Kivalina residents compensated for the low harvests of Dolly Varden char by increasing their harvest of caribou.

Uncertainty about the effects of arctic changes on subsistence is compounded by the fact that harvesters are not passive. They respond to changes. Berkes and Jolly (2001) collaborated with the Inuvialuit community of Sachs Harbour, Canada, to understand the adaptive capacity of Sachs Harbour to respond to climate change. Citing Krupnik (1993, p. 210), they point out that the 'Dynamic and flexible use of the environment constitutes the chief adaptive strategy of Arctic communities' (Berkes and Jolly 2001). Sachs Harbour households were able to apply their adaptive capacity to deal with year-to-year variations to the challenge of increased seasonal variability that they have observed as part of climate change. But Berkes and Jolly note, 'The question of the ability to adapt to further changes brings into focus longer-term adaptations and responses, including the flexibility of seasonal hunting patterns, detailed traditional knowledge of the environment that enables the Inuvialuit to diversity their activities, and inter- and intracommunity sharing networks' (Berkes and Jolly 2001). They conclude by pointing to the potential of co-management institutions to facilitate learning between communities and scientists, thereby increasing the system's capacity to respond coherently at multiple scales.

We see, then, that there are multiple contributors to uncertainty about the effects of arctic changes on subsistence. First, a diverse array of arctic changes has been observed, each change with its own potential effects on subsistence, as well as the potential to interact with other changes and cause yet different effects. The array of arctic changes is diverse even if we confine ourselves to climate-related changes. The array of arctic changes is substantially larger if we include long-distance transport of contaminants (which itself is affected by climate change), global scale resource development, government policies, and a myriad of other forces for change.

A second major contributor to uncertainty about the effects of arctic changes on subsistence is that arctic residents are used to responding to varying conditions. They have developed strategies for coping with surprises. Included in these adaptive strategies are the abilities to share subsistence products between communities and to purchase alternative foods. Third, in many arctic regions there are institutions directly involving local residents in development and implementation of policies that

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increase the ability of residents to adaptively respond. Fourth, differences in history, culture, and environment between communities make it difficult to extrapolate from a few case studies to hundreds of arctic communities. There are over 400 communities in Arctic North America alone. There is a strong consensus that case studies in which communities collaborate with scientists to understand the local effects of arctic changes are critically important (Berman *et al.* 2004; Ford *et al.* 2007; Gunn *et al.* 2009; Tremblay *et al.* 2008). As Huntington (2004, p. iii) concludes, how can we scale up from these case studies to understand arctic changes at the regional and pan-arctic levels?

The implications of these uncertainties for the design of a subsistence observation network include (1) multiple observations per decade so that year-to-year variations can be taken into account; (2) measurement of total harvest as well as individual species harvests to understand shifts between harvested resources; (3) multi-community studies within regions to take into account differences in the interactions among forces for change (e.g. climate and development), local environments (e.g. coastal and inland); and (4) tracking of local responses (e.g. collaboration of residents and scientists in monitoring and explaining change).

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Observation requirements

The SEARCH Implementation Plan (2005, p. viii) is based on the goal of understanding, 'the nature, extent, and future development of the system-scale changes presently observed in the Arctic. These changes include, for example, increasing average annual surface air temperatures, decreasing summer sea ice extent and sea ice mass, changing ocean circulation, northward movement of tree lines and vegetation zones, thawing glacial ice masses and permafrost, and changing socio-economic dynamics.' A top priority research objective in the Implementation Plan is to, 'develop [a] pan-arctic database of key human dimensions indicators of population, employment, and subsistence' (SEARCH 2005, p. xiii). The idea driving SEARCH is that long-term observations of the arctic system at a regional scale are critical: 'Integrated, long-term observations are needed to understand the full scope of arctic change in the context of the terrestrial components of the arctic system, the linkages between elements of the arctic system, and linkages to Northern Hemisphere atmospheric circulation and global climate' (SEARCH 2005, p. 27).

Defining the 'key human dimensions indicators' of subsistence could easily become a project in itself. Resolution 98-12 of the Inuit Circumpolar Council begins with the statement: 'Inuit hunting, fishing and other forms of subsistence gathering constitute a common basis of Inuit spiritual, cultural, social, economic and political way of life and are essential to the continued viability of Inuit communities and individuals' (ICC 2010). Based on this statement, it is obvious that subsistence is not only a matter of nutritional sustenance. Subsistence is more than a mode of production, it is, as the ICC stated, a 'way of life'. We could easily have embarked on a quest for indicators that together attempt to track changes in the subsistence way of life. Fortunately, the AON-SIP research team has benefited from the concurrent work of the Arctic Social Indicators (ASI) project. The Arctic Council initiated the ASI project as a follow-up to the Arctic Human Development Report (AHDR 2004). The intent of ASI is to devise a limited set of indicators that reflect key aspects of human development in the Arctic, are tractable in terms of measurement, and can be monitored over time at a reasonable cost in terms of labor and material resources. Over the past three years, four members of our project team have collaborated with over 50 other scientists and indigenous people in ASI. Building on the recommendations of the AHDR, ASI identified six dimensions to describe human development: material well-being, education, demography and health, cultural integrity, contact with nature, and fate control. Within each of these dimensions, scientists and indigenous people involved in ASI identified an indicator, or index composed of several indicators. The primary indicator for contact with nature is the 'consumption or harvest of traditional food' (ASI 2010, p. 124).

The ASI team chose to consider consumption or harvest data as its principal measure of contact with nature to accommodate widely different systems of domestic production across the Arctic. The main difference important to the choice of consumption or harvest as the best measure is the degree to which the harvest has a commercial component. In Arctic North America, for example, caribou harvests are largely non-commercial. Most of the harvest is consumed locally, or shared with relatives in other villages and urban centers, or at times bartered or sold among local households. In the Sami regions of Norway, Sweden, Finland, and Russia, reindeer are harvested for commercial and domestic use. In these regions, the harvest component for local use and consumption is not commonly measured. In Greenland, a substantial portion of local harvests are sold in local markets, making it relatively easy to track consumption (Rasmussen 2010). In some regions it is easier to measure harvest for local consumption while in others it is easier to measure consumption. In Arctic North America, harvest has been the most common measure of choice.

While it may be 'easier' to measure subsistence harvests than subsistence consumption in Arctic North America, it has not proven to be 'easy'. Usher and Wenzel (1987) reviewed the accumulated body of Native harvest statistics in North America in 1987. They concluded, 'the existing body of information may be used to recreate an historical statistical series of substantial breadth and depth, useful for both socio-economic and biological research purposes' (Usher and Wenzel 1987, p. 145). The question then becomes, can we compile sufficient harvest data to support analysis of arctic change?

The AON-SIP team set about the task of compiling harvest data by describing what we mean by 'harvest data'. Since one of the primary adaptive strategies is to opportunistically shift harvest effort among different species, studies which measure harvest of only one species cannot reveal whether total subsistence harvest is affected by even a substantial change in the harvest of one species. Unfortunately, a requirement that a study estimate of total harvest means that most wildlife and fisheries management harvest inventories can contribute valuable data, but cannot track changes in total harvest. The agencies responsible for these studies usually have management authority for a subset of species (e.g. fish or marine mammals). It is important to build on these harvest inventories. In cases where they do not cumulatively estimate total harvest, we also need to look for harvest surveys that have a broad focus. In addition to requiring that target harvest data include estimates of total harvest is the requirement that there be separate harvest estimates by species. Species-specific data are necessary to examine hypotheses linking particular arctic changes (e.g. thinning of shore fast ice) and subsistence. It may be, for example, that seal hunting is affected more by this change than beluga hunting. Additional data selection criteria are that the estimates are generalizable at the community or regional level at an annual time scale. Finally, in an effort to

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match effort with available resources, we decided to focus compiling data sets for Arctic North America containing multiple location/year records. That is, we did not attempt to extract and compile harvest data from individual case studies. Instead, our intent is to create a large enough body of data to attract researchers to add smaller-scale study data to the dataset, thereby increasing its utility to the research community.

Sources of subsistence observations

The AON-SIP subsistence database has four major sources: (1) Subsistence Division of the Alaska Department of Fish and Game; (2) Inuvialuit Game Council; (3) James Bay and Northern Quebec Native Harvesting Research Committee; and (4) The Nunavut Wildlife Management Board. With the exception of Greenland, comparable data are not available for the rest of the Arctic (ASI 2010, p. 125). Greenland data has been compiled and could be added to the AON-SIP subsistence database in the future (Rasmussen 2010).

Alaska's Subsistence Division was established in 1978 during a time of national debate as to how best to meet the fish and wildlife demands of both rural and urban residents. The research conducted by the Subsistence Division has helped the state to remain an active player in fish and wildlife management in rural Alaska following the passage of the federal Alaska National Interests Lands and Conservation Act. The division hired research staff and developed a program of community harvest surveys, each coupled with an ethnographic study (Fall 1990). In response to actual or prospective environmental changes (e.g. Tongass National Forest Regional Plan, Exxon Valdez Oil Spill, Pebble Mine proposal), as well as to achieve economies of scale, the division has conducted surveys in multiple communities in the same region. The harvest surveys were designed as a one-time interview using recall to estimate annual harvests by species. These community studies plus other special studies form the basis of over 350 technical reports (ADF&G 2010a). Subsistence Division staff have also developed a database containing the aggregated results of the community harvest surveys. Queries to this database, the Community Subsistence Information System, or CSIS, can be made on the Internet (ADF&G 2010b). The CSIS is designed for use by communities. We obtained a copy of the database formatted for research purposes from Dave Koster at the Subsistence Division (Koster, personal communication, 21 April 2009). The database contains 37,606 place/year/species harvest records over a period of 1964–2007. Harvest amounts are reported for non-commercial use of 228 listed species. All community households, Native and non-Native alike, are represented. Harvest reporting units include number harvested, pounds of edible harvest, pounds per capita harvest, and a confidence interval for the per capita estimate. The division has developed 1536 research-based conversion factors defined by varying combinations of region, species, gender, season, and harvest method.

The AON-SIP team also obtained harvest data extracted from archived files of the Inuvialuit Game Council, Inuvik, NWT, Canada (Baryluk, personal communication, 4 July 2008). The Inuvialuit Harvest Study was intended to produce quantitative harvest estimates by community for use by the co-management system established by the Inuvialuit Final Agreement in 1984 (Joint Secretariat 2003). It provides a baseline for response to potential future impacts of an oil spill or other development impact. The Inuvialuit database consists of 1599 place/year/species

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harvest records. Only harvests by Inuvialuit households are included. The database received by the AON-SIP team includes non-commercial harvests reported in numbers for 47 species for the period 1988–1997. Data are based on monthly surveys of harvesters. Usher (2002) reports that the quality of the Inuvialuit Harvest Study is high. We applied the ADFG arctic region conversion numbers to estimate edible pounds of harvest. According to Usher (2002), conversion factors were developed for the Inuvialuit Harvest Survey. Should these become available, they could be easily substituted for the ADFG conversion factors.

A decade prior to the Inuvialuit Harvest Study, the James Bay and Northern Quebec Native Harvesting Research Committee published results of a 1976 Native harvest survey for the Northern Quebec Inuit (JBNQNHRC 1979). Published results for 13 communities include harvest in numbers and edible weight in pounds for 36 species. The data are based on monthly interviews with 598 harvesters for the first six months and by monthly calendars for the second half of the year.

The AON-SIP team entered into a data use agreement with the Nunavut Wildlife Management Board (NWMB 2008) with the initial idea of compiling computer files of aggregated data. As the aggregated data files turned out to be unavailable, the team manually entered the data from the published report (Priest and Usher 2004). As in the cases of the Inuvialuit Harvest Study and the James Bay and Northern Quebec Inuit Harvest Study, the Nunavut Harvest Study was a direct result of a land claims settlement, in this case the Nunavut Land Claims Agreement. Data were collected by periodic contacts over the year with 88% of the data collected within three months of the harvest (NWMB 2008, p. 7). The raw data file consists of 145,090 hunter/species harvest records covering Inuit harvesters in 28 communities over five years: 1996–2000. The file compiled from the published report contains 133 place/year records for 79 species. We applied the ADFG arctic region conversion factors to estimate edible pounds of harvest.

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The AON-SIP subsistence database

Following separate processing using the Statistical Package for the Social Sciences (SPSS), the four data sources were combined to yield 1521 place/year records, of which 641 records include estimates of harvest of all resources as well as species-specific harvest estimates (Table 4). The database and related materials can be downloaded from the AON-SIP website (WWW.SEARCH-HD.NET). There are, with some room for argument over the definition of a place, 411 places in Arctic North America (based on the AHDR definition of Arctic). Of these 411, the database includes one or more comprehensive harvest records for 248, or 60% of all places (Table 4). In other words, we have comprehensive harvest data for over half of North American arctic communities. Keeping in mind the possibility that there are long-term trends in harvest, the database ideally would include a proportionately high number of relatively recent records. We have comprehensive harvest records for 104 places in the years 2000–2007, equaling 25% of all places. Recent coverage varies widely by region. Comprehensive harvest data within the 2000–2007 period exist for at least 20% of communities in 12 of the 32 regions (Table 4).

To raise the data quality evaluation bar a bit further, since we know that year-to-year variation in harvest can be large, we would like multiple year baseline observations. We have at least two years of observations in the 2000–2007 period for 20 of the 411 arctic North American communities. Finally, any current data would

Table 4. Number of unique places with comprehensive harvest survey by decade by region.

	Number of unique places with comprehensive harvest survey						Percentage of places with comprehensive harvest survey				
Region	Number of places	1970s	1980s	1990s	2000s	Entire period	1970s (%)	1980s (%)	1990s (%)	2000s (%)	Entire period (%)
Inuvik region	10		6	6		6	–	60	60	–	60
Baffin region	13			13	13	13	–	–	100	100	100
Keewatin region	7			7	7	7	–	–	100	100	100
Kitikmeot region	7			7	7	7	–	–	100	100	100
Nord-du-Quebec	15	12					80	–	–	–	–
Aleutians East Borough	6		2	3		5	–	33	50	–	83
Aleutians West Census Area	7			5		5	–	–	71	–	71
Anchorage Municipality	1						–	–	–	–	–
Bethel Census Area	34		4	1	11	15	–	12	3	32	44
Bristol Bay Borough	3		3	1		3	–	100	33	–	100
Denali Borough	5		4	1		4	–	80	20	–	80
Dillingham Census Area	10		7	3	10	10	–	70	30	100	100
Fairbanks North Star Borough	11						–	–	–	–	–
Haines Borough	7		2	2		2	–	29	29	–	29
Juneau Borough	1						–	–	–	–	–
Kenai Peninsula Borough	37		7	11	4	14	–	19	30	11	38
Ketchikan Gateway Borough	2		1			1	–	50	–	–	50
Kodiak Island Borough	11		8	9	5	10	–	73	82	45	91
Lake and Peninsula Borough	18		17	8	12	17	–	94	44	67	94
Matanuska-Susitna Borough	28		12			12	–	43	–	–	43
Nome Census Area	17		5	3	3	7	–	29	18	18	41
North Slope Borough	9		5	2	2	6	–	56	22	22	67
Northwest Arctic Borough	12	1	2	4	4	7	8	17	33	33	58
Prince of Wales-Outer Ketchikan CA	15		13	11		14	–	87	73	–	93
Sitka Borough	2		2	1		2	–	100	50	–	100

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Table 4. Continued.

Region	Number of unique places with comprehensive harvest survey					Percentage of places with comprehensive harvest survey					
	Number of places	1970s	1980s	1990s	2000s	Entire period	1970s (%)	1980s (%)	1990s (%)	2000s (%)	Entire period (%)
Skagway-Hoonah-Angoon Census Area	11		7	4		9	–	64	36	–	82
Southeast Fairbanks Census Area	18		5		6	6	–	28	–	33	33
Valdez-Cordova Census Area	36		28	5	3	30	–	78	14	8	83
Wade Hampton Census Area	13		5			5	–	38	–	–	38
Wrangell-Petersburg Census Area	5		4	1		4	–	80	20	–	80
Yakutat City and Borough	1		1		1	1	–	100	–	100	100
Yukon-Koyukuk Census Area	39		12	4	16	26	–	31	10	41	67
Total	411	13	162	112	104	248	3	39	27	25	60

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be best viewed in the context of a harvest trend over time. Using just one observation per decade as a minimum to describe subsistence harvests for a single community, we have measures of comprehensive harvest in both the 1990s and 2000s for 50 of the 411 arctic North American communities. There are measures of subsistence harvest over three decades for 20 communities.

What is the trend in frequency and extent of comprehensive harvest surveys in Arctic North America? Figure 1 shows an apparently cyclical pattern of comprehensive harvest surveys in Arctic North America. Underlying this pattern, however, is the sequence of Canadian land claims settlements in 1975, 1984, and 1993 (with the Labrador Inuit agreement following in another region not included in this database in 2009). Also underlying the pattern is the passage of the Alaska National Interests Land and Conservation Act (ANILCA) in 1980, the Exxon Valdez spill in 1989, Tongass National Forest Plan development in 1987) and harvest surveys funded by developers of such projects as the Red Dog Mine and the Pebble Mine. At least the land claims settlements can be considered one-time events. While another land claims settlement in arctic Canada is unlikely, Nunavut is considering a new comprehensive harvest survey program and it is possible other regions will do likewise. Such surveys, however, are expensive and complex to implement. Even with impetus of the land claims settlements and other historic events, the frequency and extent of comprehensive harvests surveys has been inadequate to support analysis of arctic change in all regions.

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Designing an expanded subsistence observation network

We can conclude that such programs as the ADF&G CSIS and the three Canada land claims harvest surveys are invaluable to the goal of observing subsistence harvests. They provide a large body of comparable data. The CSIS is ongoing and will continue to augment the subsistence observation database. These programs also offer design principles:

(1) Comprehensive community harvest surveys can produce valid measures of total and species-specific annual subsistence harvests.
(2) Elements of a well-designed harvest survey include collaboration with local communities; representative samples (or a census) of households; face-to-face interviews by trained interviewers; rigorous follow-up to achieve high response rates.

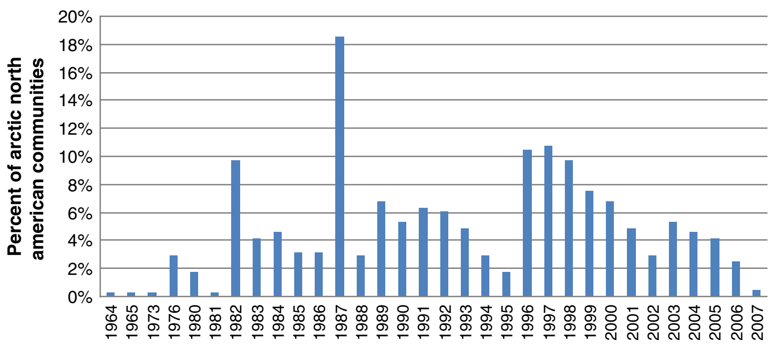

Figure 1. Number of communities with comprehensive harvest survey by year.

(3) Harvesters can report experienced-based local knowledge of causes of changes.

What data would a more comprehensive subsistence observation network produce? Studies involving the community of Kivalina, Alaska, offer an example of the potential of a more comprehensive network, although of course the example is at the community, not regional, level. Kivalina is the sole community in the AON-SIP subsistence database that includes comprehensive harvest observations in each of the five decades (1960s, 1970s, 1980s, 1990s, 2000s), including multiple year observations in two decades (1960s and 1980s) (Magdanz *et al.* 2010). Multiple annual records in the 1960s document the large year-to-year variation in harvest by species. Harvests of caribou expressed as edible pounds per capita, for example, were as follows: 1960–1961 (581), 1964–1965 (209), 1965–1966 (830) (SRB&A 2009, p. 37). An apparent declining trend in harvest of all resources can also be observed with the following per capita harvests: 1960s (1600 based on four years), 1970s (1541, 1 year), 1980s (778, 1 year), 1990s (761, 1 year), 2000s (594, 1 year) (SRB&A 2009, p. 37). Interpretation of the trend is complicated by at least three factors: the shift from sled dogs to snowmachines, sampling error, and year-to-year harvest variations within each decade. Burch reported that much of the apparent declines between the 1960s and 1980s can be attributed to the decreased use of sled dogs (Burch 1985, p. 111). The 1992 harvest study and the 2007 harvest study were both subject to sampling error. Confidence intervals based on these sampling errors overlap, thus precluding a conclusion that the two results are significantly different. Even if the two results were significantly different, the difference could reflect year-to-year differences rather than a decadal trend.

The same set of studies provides more insights at the species level. Building on the above documented harvest of caribou in the 1960s, later harvests in kilograms per capita were as follows: 1970s (371), 1980s (179, 284), 1990s (138), 2000s (85). The 1970s and 1980s figures are not subject to sampling error. Applying the relevant sampling errors to the 1992 and 2007 estimates, we find that both are significantly less than the lowest prior observation in the 1980s, and the 2007 estimate is significantly lower than the 1992 estimate.

What are the local knowledge explanations for the change? The SRB&A study team asked Kivalina harvesters if they had observed changes in caribou use, abundance, quality, distribution/migration, and habitat. Eighty-four percent of Kivalina harvesters had noticed one or more caribou resource changes, the most prevalent of which was a change in caribou migration. Forty-six percent of Kivalina harvesters observing a change in caribou migration attributed the change to traffic on the road linking the Red Dog Mine with the port dedicated to ore shipments. One harvester reported:

> Our caribou are not migrating through as much as when they first built that road. There used to be thousands and thousands of caribou that come through here and to Kivalina, and I notice the caribou are always coming up through this side [south of road], and going up toward Atqasuk and Nuiqsut and Kaktovik. A few would cross but most go up behind the mine and head up that way. The first year they built this road, that is when everything changed. . . .Even right now. I would say it's all because of this road and trucks coming up and down too much. (SRB&A 2009, p. 64)

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Noatak harvesters also reported a change in caribou migration. They attributed the change they experienced to an entirely different cause:

> We've had guides drop off hunters right in the middle of their [caribou] migration route, and it changed their migration route. I've seen hunters all through there. It made them [caribou] go further north or further south. I didn't pay much mind to that this last fall, but I do know that we had a lot of boat traffic and place traffic too. The majority of that was that they [sport hunters] were being picked up at the Kelly River. (SRB&A 2009, p. 65)

Similar observations of resource changes by harvesters from one community lend support to hypotheses about causes of resource changes. A subsistence observation network could serve to both monitor change and provide early clues as to the causes of change that could be tested in special studies. A common question arising with a harvester-based observation system that includes local knowledge as source of understanding change is what happens if the local knowledge disagrees with science-based indicators of change? Our experience has been that such disagreements are an excellent motivator for the special studies needed to reach a common understanding of change. Important to the success of this approach is the availability of funds to support special studies as the need for them arises. In cases where the potential impact is associated with a development, the potential funding source is clear. Funding for special studies related to climate-change, however, would likely have to come via the normal science research grant process and therefore be subject to timing and uncertainty challenges.

We can also conclude that to understand arctic changes we need more observations over time and better regional coverage. Unfortunately, it is unrealistic to expect program or research grant agencies to commit the long-term funding required to expand the observation system based on the model of comprehensive harvest surveys. There currently are no region-wide harvest survey programs underway in Canada, although there are plans to do so in Nunavut. The Canada harvest surveys that do exist were funded by terms of land claims agreements that have been fulfilled. In Alaska, the ADF&G CSIS is a state program. Interestingly, substantial recent work has been funded (indirectly) by developers of such projects as the Red Dog mine and the Pebble mine. Development-induced harvest surveys are useful to examine climate-change related effects as well, but are not likely to achieve the goal of comprehensive regional coverage. We have not discussed the state of harvest data in other parts of the arctic, but suffice it to say that, with the exception of Greenland, comprehensive subsistence harvest (or consumption) data collected on a regional basis are virtually non-existent.

Is there an additional approach that can build upon comprehensive harvest survey data systems and expand the observation sufficiently to support analyses of arctic change? The ASI approach is to identify a small number of indicators of change (e.g. 7) across all domains of well-being to be tracked on a pan-arctic scale at a regional level on a five-year or less reporting period, ideally separately reporting indigenous and non-indigenous observations (ASI 2010, p. 157). Subsistence harvest or consumption is one of the seven selected indicators. The seven ASI indicators are not intended to support an in-depth analysis of arctic change. If observations of these seven indicators were available as a time series on a regional basis, however, we would be able to detect arctic change, observe differences across regions, and to

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formulate hypotheses about the causes of arctic change. Special studies could then be targeted to test these hypotheses.

Our recommended model for an approach to augment the subsistence observation network composed of existing harvest surveys has these design principles:

(1) Limit the observations to a few (e.g. 10) indicators.
(2) One output of the system must be an estimate of total harvest.
(3) Achieve and maintain a representative sample of households, including a response rate of at least 70% and a known chance of selection for every household.
(4) Ask harvesters to share local knowledge about the causes of change in their harvests.
(5) Collaborate with communities in survey design, implementation, and interpretation of results.
(6) Reduce fixed costs associated with data collection.

How do we get from a complex, comprehensive harvest survey approach to a simple, indicator approach? The challenge of complexity stems from the number of species included in a comprehensive harvest survey and the addition of socioeconomic questions to provide context for the harvest data. Harvesters are asked to report on 40–80 species. A well-designed harvest survey such as the CSIS provides the interviewer with a written protocol designed to efficiently focus on the subset of species harvested by a household, typically 15–25. Is it possible to select indicators of subsistence harvests and thereby simplify the observation system?

Existing comprehensive subsistence harvest data offer an opportunity to identify a few indicators while meeting the design principle of producing an estimate of total harvest. With the help of Stephanie Martin at the Institute of Social and Economic Research, University of Alaska, we identified the top 10 harvest species measured in kilograms of edible harvest per capita in each of the 641 community-specific comprehensive harvest survey records. On average, the top harvest species accounts for 42% of total harvest (Figure 2). The top two harvest species account for 60%

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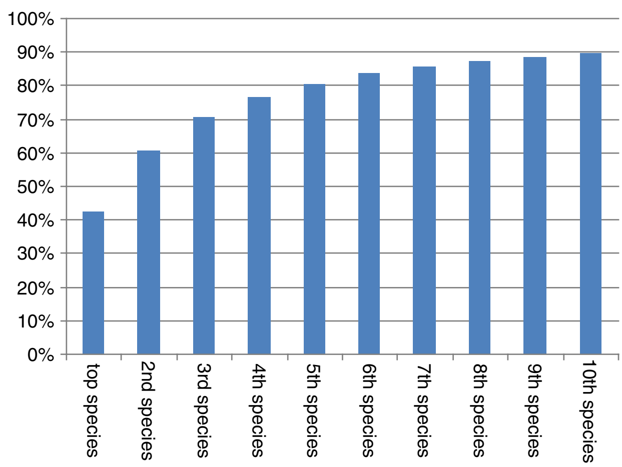

Figure 2. Percentage of total harvest accounted for by top 10 species among North American arctic communities.

Table 5. Frequency of occurrence of species in top-10 harvest list.

Species	Number of places		Number of places
Caribou	377	Broad whitefish	15
Moose	258	Seals unspec	15
Sockeye salmon	251	Bowhead	14
Coho salmon	225	Shrimp	14
Chinook salmon	187	Grizzly	13
Ringed seal	159	Herring	11
Arctic char	136	Blackfish	10
Beluga	119	Herring roe	10
Chum salmon	101	Cisco	9
Seal	88	Eider	9
Clams	81	Smelt	8
Bearded seal	77	Canada goose	7
Char	77	Inconnu	7
Whitefish	77	Swan	6
Pink salmon	72	Tanner crab	6
Muskox	50	Ducks	5
Crabs	48	Herring spawn on kelp	5
Lake trout	48	Kingcrab	5
Black bear	46	Whitefronted goose	4
Polar bear	44	Arctic ground squirrel	3
Walrus	40	Bering cisco	3
Dolly varden	38	Geese	3
Harbor seal	36	Harpseal	3
Pike	32	Mussels	3
Dalls sheep	26	Arctic cisco	2
Grayling	25	Furseal	2
Trout	23	Spotted seal	2
Beaver	22	Young bearded seal	2
Humpback whitefish	22	Geese unspec	1
Snowgoose	22	Lake whitefish	1
Steller sea lion	22	Least cisco	1
Narwhal	18	Ptarmigan	1
Burbot	16	Rainbow smelt	1
Cod	16	Round whitefish	1
Hare	16	Turbot	1

Source: AON-SIP subsistence database.

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and the top 10 account for 90% of total harvest. Table 5 displays the frequency of occurrence of species in the top-10 harvest list.

We can conclude, then, that if we selected as our 10 indicators of subsistence harvest the top 10 species harvested by a community (at that time) we could estimate, on average, 90% of total harvest and have separate species indicators that could be used as a first step in understanding arctic change in subsistence. How would we know the top 10 species? Recent comprehensive harvest survey results would be ideal, but as we know, the likelihood of such data for any single community is small. Local knowledge could be used. The order of the top 10 is unimportant in the selection process and the likelihood of missing one of the top five species is small. Thus, one could expect a local knowledge-based selection to yield a species list accounting for at least 80% of total harvest (i.e. the top five species would be likely included in a selected list of 10 species).

A more rigorous approach would be to conduct a comprehensive harvest survey as a benchmark when a community joins the subsistence observation network. Subsequent surveys could focus on the top 10 species. There is also the question of possible changes in the species composing the top-10 list. Again, local knowledge would be invaluable in revising the list. It is important to note that such a system would not yield species-specific harvest estimates aggregated across the arctic as the species would not be likely to be included on all community top-10 lists. But harvests of species not included in the top-10 list would likely be minor. The mean kilograms per capita for the tenth species, for example, is 1.7 kg.

Achieving and maintaining a representative sample of households is the most challenging design principle. Superficially, the simplest approach is to conduct a census of households. Too often this approach requires more interviewer time than available funds can support. As a result, not all households are successfully contacted and the response rate is low (e.g. below 50%). These samples cannot be assumed to be representative.

Sampling households is often necessary, particularly in communities with several hundred households or more. A random sample of households (e.g. with a random start, selecting every fifth household from a listing of all households) is simple to implement but is inefficient. We know from previous harvest surveys that a minority of households (e.g. 20–30%) account for a majority of the harvest (e.g. 70–80%). Only 20–30% of a random sample of households is, therefore, likely to include the most active subsistence households. A random sample of 120 households, for example, would on average include 36 highly active subsistence households. A more efficient sampling approach is to first stratify each household in a community into one of two strata: (1) highly active harvesters; and (2) not highly active harvesters. The assignment of households can be accomplished by interviews with a few active local harvesters, keeping in mind that some households may specialize and account for a significant portion of a community harvest of a single species (e.g. seal). It is also important to note that in deference to elders, active local harvesters may assign households composed of formally active harvesters to the highly active stratum. Both strata are sampled, but the highly active stratum is sampled at a higher rate (e.g. a census or one in two households). Sampling weights (i.e. the inverse of the sampling rate) are applied to estimate total community harvests. Errors in assignment to sampling strata do not statistically bias the results; the only effect is to increase the sampling error.

A reviewer of this paper correctly noted that the subset of households that contain highly active harvesters may change from year to year. An active harvester may, for example, encounter equipment loss or personal injuries that reduce his or her harvest activity in a particular year. The result of a change in actual harvest activity would be to increase the sampling error (i.e. the active harvester stratum would have a higher variance than expected). The results would remain unbiased estimates.

The greatest expense of implementing a survey, whether it is a complex comprehensive harvest survey or a simple 10 indicator survey, is the fixed costs of data collection. A face-to-face interview, whether complex or simple, involves finding the respondent with repeated contacts, making an appointment for an interview, and frequently resetting a time for the interview. There are usually substantial training and travel expenses. How might these fixed costs be reduced?

Most field researchers have probably experienced the ‘miracle’ of an overnight turnaround in community engagement in a household survey. When people in a

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small community decide that they want something to happen, it does. Designing the survey so that it is easy to participate is important to lowering fixed costs, but more important is the community's view of the desirability of participating. If the community is part of the design, implementation, and interpretation of results, and if the resulting data are viewed as in the community's interest to collect, then the fixed costs of the survey can likely be reduced.

An excellent example of a community-centered regional observation system is the Arctic Borderlands Ecological Knowledge Co-op (Kofinas 2002). The Co-op is set up as a long-term monitoring program, has operated since 1996, and now involves five communities. It is an informal cooperative allowing it to operate within an 'unusually complex political landscape that involves two nation states, three state/ territorial governments, and five Native claimant groups' (Kofinas 2002, p. 58). Communities were involved as partners along with wildlife managers, and researchers in the selection of indicators. Locally hired monitoring associates conduct annual interviews consisting of both closed and open-ended questions. Results are shared in three forms: written documents, a web-based resource, and face-to-face meetings, including annual gatherings of community members, wildlife managers, and researchers. The annual gatherings have proven to be excellent opportunities to exchange ideas about arctic changes. And not least, the entire operation has been run on about the equivalent of $170,000 per year (G. Kofinas, Personal communication, 2011). The Arctic Borderlands Ecological Knowledge Co-op operates under the mantra of 'keep it simple'. We think that starting small and keeping it simple are both good principles under which to develop a subsistence component to an Arctic Observing Network.

Assuming a model of community collaboration is part of the design of the subsistence observation network, how could the fixed costs associated with data collection be reduced? Let us assume that the community has chosen to join the subsistence observation network and has been involved in local design, implementation, and review of the results of a first year survey based on face-to-face interviews. Respondents now understand how the survey works. In year two, they could be invited to complete a short, on-line self-administered questionnaire. More than a third of households in northern Alaska and Greenland have internet connections (Table 6).

In communities where Internet connections are scarce, telephone interviews are possible. Contrary to popular belief, telephone coverage in the Arctic is generally good. Table 6 shows the percentage of indigenous households possessing telephones by region and country based on SLiCA results (Poppel *et al.* 2007). Eighty percent of households in the SLiCA sampled regions of Alaska, Canada, and Greenland have telephones. Only in two regions of Chukotka are the percentages of households possessing telephones below 50%. Researchers at the Institute of Social and Economic Research at the University of Alaska have been conducting telephone interviews with rural Alaska households by phone since the early 1980s. They have found that rural respondents are as comfortable using the phone as urban respondents. In fact, the telephone provides more confidentiality of responses, as other household members do not hear the questions and therefore often cannot attach meaning to the answers given. The main challenge of telephone interviewing in rural areas is that many, even most, telephones are unlisted. This is not a problem if the first interview is face-to-face and the respondent shares their phone number strictly for purposes of future interviews on the project. Once the respondent has

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Table 6. Percentage of households with telephone or Internet connection.

Region, country	Connection to the Internet (%)	Percentage of households with telephone
Nunavik, Canada	*	86
Labrador, Canada	*	87
Inuvialuit, Canada	*	86
Nunavut, Canada	*	82
Sydgrønland, Greenland	43	84
Midgrønland, Greenland	45	88
Diskobugten, Greenland	44	86
Nordgrønland, Greenland	56	96
Østgrønland, Greenland	25	79
Anadyr, Chukotka	4	58
Central, Chukotka	3	30
Eastern, Chukotka	3	44
Western, Chukotka	9	69
North Slope, Alaska, USA	44	90
Northwestern Arctic, Alaska, USA	39	90
Bering Straits, Alaska, USA	29	87
Total	33	80

Source: SLiCA 2011.
*Data not available.

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participated in a face-to-face interview, it is easy to conduct follow-up interviews by phone at much less expense.

A third way to lower the fixed costs of interviewing is to rely on local interviewers. This is the approach used in the Arctic Borderlands Ecological Knowledge Co-op. Local residents not only conduct the interviews, but also meet in 'annual gatherings' with other interviewers as well as scientists and wildlife managers to discuss results. The Co-op approach of sharing data and ideas in annual gatherings is key to the growth of a subsistence observation network. The Co-op experience has been that communities joined the Co-op after community residents had experienced an annual gathering.

Summary

Subsistence is a way of life shown to be important to the well-being of arctic residents. Scientists and arctic residents have documented climate-related effects on subsistence, making subsistence a logical focal point for studies of arctic change.

Much effort has been spent by the international community of scientists and indigenous peoples in the identification of a small set of indicators of well-being to be tracked on a regional basis. One of seven indicators selected as part of the ASI project is traditional food, as measured by either subsistence harvest or consumption. To assess the adequacy of subsistence data to support analysis of arctic change, the research team compiled existing subsistence harvest data for northern Canada and Alaska into an Arctic Observing System Social Indicators Project Subsistence Database.

The AON-SIP subsistence database contains 1521 place/year records of which 641 records include estimates of harvest of all resources as well as species-specific harvest estimates. There are one or more records for 60% of the communities in Arctic North America. Only 25% of places have one or more records based on observations made in the years 2000–2007. Regional coverage is not good: comprehensive harvest data pertaining to the 2000–2007 period exist for at least 20% of communities in 12 of the 32 regions. Expansion of the existing subsistence component of the arctic observation network is necessary to understand arctic change.

The sole ongoing comprehensive harvest survey program in North America is the Alaska Department of Fish and Game Community Subsistence Information System (CSIS) program. This program will continue to provide subsistence harvest data and is an invaluable component of the subsistence component of the Arctic Observing Network. Given its mandates and funding constraints, it is unlikely that the CSIS can be expanded to meet the frequency of observation and scope of regional coverage necessary to understanding arctic change. In Canada, there are currently no ongoing regional harvest studies, although a program in Nunavut is being planned.

While comprehensive harvest surveys are an invaluable component of a subsistence observation network, a simpler model of data collection is needed if we expect to achieve the necessary expansion of frequency of observations and regional coverage. The recommended approach follows that recommended by the international ASI project. Analysis using the AON-SIP subsistence database shows that it is possible to account for 90% of total community harvest by measuring the harvest of the top 10 species harvested by the community. Thus a community-specific 10 indicator approach could be used to augment comprehensive harvest survey data.

The foundation of the subsistence observation network would be community involvement in the design, implementation, and interpretation of results of a subsistence indicator survey. Following a first year comprehensive subsistence harvest survey, fixed costs of an ongoing subsistence indicator survey can be reduced through a combination of web-based interviews, telephone interviews, and local interviewers.

Critical to the development of a subsistence observation network is the opportunity for community representatives (usually local interviewers), scientists, and wildlife managers to come together to share data and ideas. Experience has shown that this is the best way to foster interest and commitment by communities. It is also an excellent means of communication of local knowledge about arctic change to the scientists and managers.

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