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20	UPM		**43**	NMEFC	
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DISSEMINATION LEVEL		
PU	Public, fully open	X
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

EXECUTIVE SUMMARY

Community based environment monitoring has considerable potential for improving the understanding of environmental changes as well as for improving the management of natural resources. Together with the organizers of six community based environment monitoring programs, the INTAROS project has developed a library of 'good practice' manuals in community based monitoring that could serve as tools for cross-fertilizing indigenous and local knowledge with scientific knowledge in the Arctic.

This Community Based Monitoring Library is available at a website at the following link: https://mkp28.wixsite.com/cbm-best-practice. The library is intended to enable community members and organizers of community based monitoring programs to access one another's experience and gain advice on how to collect and use data.

In the library, each manual is accompanied by a summary describing what worked, what didn't work and why, written by the organizers of the community based monitoring program. The manuals in the library have been selected on the basis of the following criteria:

- They have already been pilot tested on-the-ground in community-based monitoring programs in the Arctic,
- They have in the view of the program organizers led to salient, credible, and legitimate knowledge products and are used by decision-makers,
- They could contribute to both local and global repositories,
- They are of a sufficient generic nature so they may be used in other communities and areas of the Arctic.

It is proposed that over time there will be secondary copies of the library of community based monitoring programs in the Arctic at (or links from) the web-sites of the Atlas of Community Based Monitoring and Indigenous Knowledge in the Arctic (www.arcticcbm.org), and the Sustaining Arctic Observing Networks (www.arcticobserving.org).

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1. INTRODUCTION

At a workshop in Québec City, Québec in December 2017, community members, practitioners and scientists from Canada exchanged experiences on community based monitoring (CBM) in the Arctic. One of the workshop participants used the following words:

"Community based monitoring programs come from governments, communities and non-governmental organizations. We can only succeed at networking if we can share and try to trust each other. Community based monitoring is just going to expand. For it to succeed in the long term, we have to be willing to work with one another. Those of us who are at forefront of implementing programs need to make sure we are clear about value of sharing knowledge and data" (excerpt from Johnson *et al.* 2018).

The Québec workshop was one of a series of workshops on community-based environmental monitoring in the Arctic funded by the European Union Horizon 2020 Programme as part of the Integrated Arctic Observation System Project (INTAROS; intaros.eu). The other workshops were held in Nuuk (December 2016), Fairbanks (May 2017; Fidel *et al.* 2017), and the Russian communities of Komi and Zhigansk (September 2017).

This project aims to extend and improve existing and evolving observing systems that encompass land, air, and sea in the Arctic. INTAROS involves 49 participants from 20 countries. One of the project components focuses on enhancing community-based observing in the Arctic. Key activities include: knowledge exchange workshops, exploring opportunities to inter-weave existing CBM programmes in the Arctic with scientists' monitoring efforts, and piloting new tools in Greenland and Svalbard to support decision-making.

This report describes the contents of a web-based library of 'good practice' manuals in community based monitoring that could serve as tools for cross-fertilizing indigenous and local knowledge with scientific knowledge in the Arctic. The library was prepared by INTAROS together with the organizers of six CBM programs. We present the CBM programs that shared their materials with the library (Chapter 2) and a summary of the key lessons that each CBM program has learnt (Chapter 3).

Methods. The manuals in the library have been selected on the basis of the following criteria:

- They have already been pilot tested on-the-ground in community-based monitoring programs in the Arctic,
- They have in the view of the program organizers led to salient, credible, and legitimate knowledge products and are used by decision-makers,
- They could contribute to both local and global repositories,
- They are of a sufficient generic nature so they may be used in other communities and areas of the Arctic.

It is proposed that over time there will be secondary copies of the library of community based monitoring programs in the Arctic at (or links from) the web-sites of the Atlas of Community Based Monitoring and Indigenous Knowledge in the Arctic (www.arcticcbm.org), and the Sustaining Arctic Observing Networks (www.arcticobserving.org).

We intentionally did not predefine CBM, but adopted an inclusive approach that encompassed programmes with different levels of community involvement. Further discussion of the definitions of CBM is available in Johnson *et al.* 2016.

2. COMMUNITY BASED MONITORING PROGRAMS IN THE LIBRARY

The library of Arctic CBM programs comprise the manuals they use and a summary of the key lessons learned. In this chapter, we briefly profile the six CBM programs that have been included in the library:

- AAOKH (Alaska Arctic Observatory and Knowledge Hub)
- Arctic Borderlands
- Indigenous Observation Network Yukon River
- PISUNA (Piniakkanik sumiiffinni nalunaarsuineq)
- SIWO (Sea Ice for Walrus Outlook)
- Winterberry

The manuals and other materials from these six CBM programs are all available at the website of the Community Based Monitoring Library, link: https://mkp28.wixsite.com/cbm-best-practice. The manuals are not duplicated in this report

2.1 AAOKH

AAOKH stands for Alaska Arctic Observatory and Knowledge Hub. AAOKH is the community observing component that was continued when the SIZONet program was concluded. The SIZONet program was a long-term observing program to provide data responsive to the needs of scientists and stakeholders. SIZONet included instrumented observations such as: shore-based and drift-ice measurements of ice motion, key mass-balance variables and airborne ice thickness. One component of SIZONet involved collaborating with coastal communities in northern and western Alaska to document sea ice, weather and wildlife observations with goals to preserve and pass on local and traditional knowledge of sea ice and its use. The AAOKH program goals include working with local experts to empower and support communities to conduct scientific measurements that relate to community concerns. The AAOKH has an observing focus on changes in the cryosphere (snow, ice, permafrost) and its effects on the seasonal cycle of subsistence harvest activities. AAOKH serve as a forum to bring together local experts and researchers for communication and exchange of aspects of the seasonal cycle of snow and ice in all its forms and how this matters to the people in Alaska's Arctic.

2.2 Arctic Borderlands

Arctic Borderlands Ecological Knowledge Cooperative is a community based monitoring program of the Arctic Borderlands Ecological Knowledge Society (ABEKS). It documents local experiences of ecological change within the range of the Porcupine Caribou Herd. ABEKS is comprised of and partners with Inuvialuit and Gwich'in organizations and governments, co-management groups, scientists and other government agencies. The project was started in 1994 by people living and working in the Northern Yukon. The group identified three main issues as being important for ecological monitoring in this area: climate change, contaminants and regional development. They identified the need to bring together science and local and traditional knowledge to promote better decision making in the North.

2.3 Indigenous Observation Network Yukon River

Through an international accord between Indigenous governments, the Yukon River Inter-Tribal Watershed Council and United States Geological Survey (USGS), the Indigenous Observation Network (ION) was formed. ION is a large-scale monitoring program with the goal to address water quality and

environmental change impacts on rural Indigenous communities across the Yukon River Watershed. The communities living in this area are highly dependent on the landscape and environment for subsistence and drinking water resources to maintain their traditional way of life.

2.4 PISUNA

PISUNA is an abbreviation of Piniakkanik sumiiffinni nalunaarsuineq (Opening Doors to Native Knowledge). This program was established by Greenland Ministry of Fisheries and Hunting to strengthen the involvement of hunters, fishermen and other interested in the documentation and management of living resources in Greenland. The program has introduced a system for communities to advance natural resource management recommendations to municipal and national authorities based on their review and assessment of participants' observations.

2.5 SIWO

The Sea Ice for Walrus Outlook (SIWO) is a resource for Alaska Native subsistence hunters, coastal communities, and others interested in sea ice and walrus. The SIWO provides weekly reports from April through June with information on weather and sea ice conditions relevant to walrus in the northern Bering Sea and southern Chukchi Sea regions of Alaska. The Outlooks are produced with information on weather and sea ice conditions provided by the National Weather Service - Alaska Region and Alaska Native sea ice experts.

2.6 Winterberry

Winterberry is a citizen science project where University of Alaska Fairbanks scientists and community volunteers investigate how shifting seasons could affect when berries are available to animals and people. In the far North, springs are coming earlier, summers are warmer, and fall is arriving later. Shifting seasons may have an effect on when berries are available to people, birds, and small mammals that eat them. Many of Alaska's berry-producing plants hold on to their fruits into the winter and even spring, and these berries are very important to animals such as voles, foxes, and grouse. Will a longer time between when berries ripen and when the snow falls mean more berries will rot or get eaten? Will this leave less for the animals that depend on these berries in winter and spring? The program invites the participants to join the individual volunteers, school classes, after school programs, parents and children - anyone interested in berries - throughout Alaska and northern regions of the globe in answering these questions.

3. KEY LESSONS LEARNT BY EACH COMMUNITY BASED MONITORING PROGRAM IN THE LIBRARY

In this chapter, we present a summary of key lessons learned from each of the six CBM programs as described by the organizers of each program. The text is also available at the website of the Community Based Monitoring Library.

For each CBM program, we describe the organization behind the program, the duration of the program, the objectives, the status of the work, the use of the data, the key achievements, the main challenges and solutions, and the plans for the future development of the program. Finally, we have highlighted "Other points" that might be of interest for those who consider using the manuals either in other areas of the Arctic or for other purposes.

3.1 AAOKH

By Olivia Lee, Seasonal Ice Zone Observing Network (SIZONet) and Alaska Arctic Observatory and Knowledge Hub (AAOKH)

ORGANISATION: University of Alaska Fairbanks

DURATION: April 2006 – current funding will end in 2019

OBJECTIVES: The SIZONet program was a long-term observing program to provide data responsive to the needs of scientists and stakeholders. SIZONet included instrumented observations such as: shore-based and drift-ice measurements of ice motion, key mass-balance variables and airborne ice thickness. One component of SIZONet involved collaborating with coastal communities in northern and western Alaska to document sea ice, weather and wildlife observations with goals to preserve and pass on local and traditional knowledge of sea ice and its use. After funding for SIZONet concluded, the community observing component was continued through AAOKH. The AAOKH program goals includes working with local experts to empower and support communities to conduct scientific measurements that relate to community concerns. The AAOKH has an observing focus on changes in the cryosphere (snow, ice, permafrost) and its effects on the seasonal cycle of subsistence harvest activities.

STATUS: The objectives are partly achieved. The AAOKH program is still developing further to expand the number of communities participating in observing efforts, and adding new observation types (e.g. permafrost observations) to be more supportive of community information needs. Development of protocols for more systematic observations of sea ice, wildlife and weather are also being developed to allow more robust analysis of observations.

DATA USE: The data are collected by Indigenous community members who are compensated for their observations. The observations are sent to researchers at the University of Alaska Fairbanks to archive in a web-accessible database. Data have been used by community members to track trends in sea ice and weather in their own communities. For example community observers and elders in Wales, Alaska have been using the database to compare annual changes in sea ice freeze up and break up dates to share with their community. The data have also been used by scientists studying changes in sea ice, and ice conditions affecting sightings of marine mammal subsistence species. For example, a PhD graduate student used the database to supplement her analysis of coastal sea ice conditions in comparison to remote sensing sea ice data. In the future when sea ice change becomes even more prevalent, impacting winter storms, erosion and coastal infrastructure, the data may for instance enable communities to seek assistance from agencies such as the Federal Emergency Management Agency or Army Corps of Engineers for support to coastal community coastline protection.

ACHIEVEMENTS: The sea ice observing protocols have recorded over a decade of coastal sea ice conditions with a focus on the most important aspects of sea ice and weather at the time. Collaborating with Indigenous sea ice experts have also allowed the monitoring effort to incorporate local and traditional knowledge by putting current ice observations in the context of historical knowledge, and preserved the use of native language terms. Several SIZONet observers were respected elders in their communities whose knowledge has been preserved and can be shared with future generations.

CHALLENGES AND SOLUTIONS: The program is encountering two challenges. First, it is challenging to identify community observers who are committed to consistent observing effort. Building collaborative partnerships with communities takes time, and involves a relationship-building process. The AAOKH Science Steering Group, which includes Indigenous community representatives, helped to establish these relationships in some AAOKH communities. Second, slow and expensive internet service in northern Alaska communities makes it challenging to implement web-based technology for observers to send observations for QA/QC and archiving, and may also be difficult for communities to

use web-based tools to access the data. Improvements to high-speed internet access is expected soon for several coastal northern Alaska communities.

FUTURE DEVELOPMENT: Funding for the AAOKH program is stable for the 5-year program duration, but the future continuation of the program will depend on community interest and perceived value of the observing program. While there may be general interest in continued monitoring of cryosphere change, further development of the program could benefit from creating analysis products that allow these observations to contribute more effectively to decision-making (e.g. planning for long-term changes in subsistence harvest activities). The development of a web-based AAOKH Knowledge Hub is planned as a tool to inform communities of other related observing efforts, but may also serve as means for communities to share adaptation strategies related to subsistence impacts from ice and permafrost change. We are also currently testing the development and use of a mobile app for smart phones and tablets to help improve the data flow from observers to the database. Current data flow methods from observations sent by email or postal mail to the University research contact who then manually enters data into the database is time consuming. However, we anticipate that some of our older observers may not feel comfortable transitioning to mobile technology applications for data collection, and hence some of the current methods for data collection and database entry may be necessary to continue.

OTHER POINTS. The SIZONet observing protocols allows a narrative description of sea ice, weather and wildlife that allows the observer to emphasize content that he considers most relevant, that is also based on observing guidance provided by the research scientist collaborators. This protocol is valuable for recording local traditional knowledge, but can make it difficult to analyse the observations for management of natural resources. The observing guidelines for ice, weather and wildlife observations are not often referred to by observers after making one or two observations to contribute. The observing guidelines are most helpful for recruiting new observers to the AAOKH program that need to know what type of observations to report. In contrast, the protocols for using the CTD instruments for coastal water measurements are useful at almost every data collection instance. These protocols are printed and laminated to be carried into the field for easy reference. The combination of technology and specific series of steps for collecting and uploading data in the coastal water measurement protocols can be hard for observers to remember. The printed written instructions make it easier to complete the data collection and sharing tasks.
More structured, systematic observing protocols may be needed if the goal of the CBM program is to specifically inform management needs using a robust statistical analysis of the observing data. Sometimes the use of statistical analyses increases the likelihood that management agencies listen to the community members.

3.2 Arctic Borderlands

By Heather Ashthorn, Arctic Borderlands Ecological Knowledge Society.

ORGANISATIONS: Multiple funders, including Gwich'in Renewable Resource Board, Government of Canada, Government of Northwest Territories, Parks Canada and the Renewable Resource Surplus Fund.

DURATION: Ongoing since 1994.

OBJECTIVES: To monitor and assess ecological changes within the range of the Porcupine Caribou herd and adjacent coastal and marine ecosystems and to share local, traditional and scientific knowledge for co-management.

STATUS: The program has been in operation for over 20 years. Information documented by community monitors during interviews with local experts is used by the Porcupine Caribou Management Board, as

well as Environment Canada when making species risk assessments and by researchers in and outside of Canada to answer questions that involved communities identify as important to their community. In these ways, the objectives are met. There is still so much potential for the database to be used for the benefit of participating communities.

DATA USE: The data from ABEKS are used by local and non-local researchers, by the Porcupine Caribou Management Board (PCMB) and by the Government of Canada for co-management and decision making, particularly concerning harvest quotas for caribou by Gwich'in and Inuvialuit harvesters. Responsibility for management of the Porcupine Caribou Herd is shared between the US and Canadian federal, Territorial and First Nations governments and councils. ABEKS caribou and weather data is presented to the PCMB annually and they consider the information alongside conventional scientific indicators when establishing harvest quotas. However, the PCMB does not have a specific framework for decision making including local knowledge. Nevertheless, harvest of the Porcupine Caribou Herd has not had to be limited to date. To what extent the ABEKS data and other sources of local knowledge is to used in decision-making has still not been defined. This gap presents one of the biggest challenges to the future of the monitoring program.
For example, we are aware that the PCMB considered the ABEKS data in 2017. In February 2017, PCMB discussed the use of ABEKS data at their annual harvest meeting after we presented the caribou and weather data to them in graphic form. As of May 2018, however, we have not yet heard from PCMB how ABEKS data were considered but we are hoping to be informed soon. Without well-documented frameworks for decision making it is unclear how exactly the ABEKS data are being considered in the decision making process.

ACHIEVEMENTS: The most important achievement was the collaboration between governments, communities and researchers and the compilation of over 20 years' worth of local ecological knowledge shared by local experts, as well as the material needed to include local knowledge and traditional knowledge (TK) in decision making frameworks.
The program uses fairly simple protocols which have been designed to be easily administered in each community. Since the guidelines are not complicated, they are used consistently from year to year.
The guidelines provide an in depth overview of the monitoring process, remuneration, expectations and history of ABEKS (see:
https://docs.wixstatic.com/ugd/ee3e9e_db9e1e9734954ae8b7de05fafac9f1d6.pdf)
The results of the 2017 survey can be found here:
https://docs.wixstatic.com/ugd/ee3e9e_eed7f804f2e546f8bdf4efeaffea78dd.pdf.

CHALLENGES AND SOLUTIONS: We encountered five challenges. First, it was a challenge to make survey questions both relevant, understandable and usable. This was achieved by careful evaluation and review of the program throughout its lifetime and through consultation with the participants. An example of a survey question that was useful is "Did you hunt caribou this year?" In contrast, it was not useful to ask "How many hunters hunted caribou this year?" Second, it was a challenge that data management should be neutral and accessible to the communities involved. This was achieved by hiring an arms' length data manager with a background in data collection and compilation and developing protocol for gaining access to the data. Third, it was a challenge for the collaboration to make the program relevant to everyone involved. This was achieved through excellent communication, including yearly visits by the program coordinator to each community and organization of gatherings involving all participants to allow for information exchange. Fourth, it was a challenge to maintain funding that represented all parties. This is achieved by careful management by a Board of Directors and presentation of program results to all funders annually or semi-annually, as well as attendance at the Annual Harvest Gathering to explain the results of the program. ABEKS strives to respond to concerns raised by funders by demonstrating utility of the data through regular analysis and collaboration with technical committees. Relationship building is key to the success of the program. Fifth, it was a challenge to ensure shared ownership of the program. This involves ensuring that all communities are involved in running the program and is achieved by collaborating with

Renewable Resource Councils and Hunter and Trapper Associations in each community. One option for increasing involvement in communities was to shift administration of the monitoring program to these councils (i.e. to decentralize the administration).

FUTURE DEVELOPMENT: The expectation is that the program will continue indefinitely and that, as the database grows, the information given by local experts will contribute to a greater understanding of caribou, berries, mammals, birds, fish and weather in the study area, as well as make a significant contribution to co-management of local resources to enhance food security and protect ecological integrity. In order to meet these expectations, all communities will have to take ownership and lead the program in their area, monitors will have to be well supported with quality training and financial and technical support throughout their contracts and co-management authorities will have to create decision making frameworks that make appropriate use of the data so that funders are satisfied that there is an ultimate purpose.

OTHER POINTS: In the study area, there is unlimited potential for ABEKS data to be used to the benefit of people and communities. The ABEKS protocols may also be useful in other parts of the Arctic with wild caribou populations. In the past, researchers working on graduate degrees have partnered with communities involved to develop studies that are mutually beneficial. Governments have requested access to the data to enhance their assessments of various ecological conditions. ABEKS documents local experiences of ecological change, which is different from Traditional Knowledge, however, many community members have pointed out over the years that most of the experts who are interviewed are TK holders and so the information they give is informed by TK. It is, therefore important that the data remains the property of the people who contribute to it and also important that the process for gaining access is to the satisfaction of the communities involved. Currently, anyone wanting access to ABEKS data is required to apply to the communities they are requesting data from. This process works to preserve and protect intellectual property but can be seen, incorrectly, to limit access. We cannot emphasize enough that the data represents and is a part of the people involved in the project and should be approached with respect for their experience and contribution. Other monitoring programs may find the ABEKS process helpful in developing locally appropriate programs.

3.3 Indigenous Observation Network Yukon River

By Edda Mutter and Maryann Fidel, Indigenous Observation Network (ION).

ORGANIZATIONS: Yukon River Inter-Tribal Watershed Council, U.S. Geological Survey Mission Area Program, Arctic Village, Anvik, Allakaket, Eagle, Gwichyaa Gwich'in Tribal Gov., Council of Athabascan Tribal Gov., Kotlik, Hooper Bay, St. Michaels, Emmonak, Alakunak, Tanacross, Nenana, Chuloonawick, Circle, Ohogamuit Traditional Council, Pilot Station, Ruby, Louden Traditional Council, Koyukuk, Iqurmiut Tribal Council, Yupiit of Andreafski, Stebbins, Nulto, Russion Mission, Tanana, Venetie, Carcross Tagish First Nation, Nacho Nyak Dun First Nation, Kwanlin Dun First Nation, Little Salmon/Carmacks First Nation, Ta'an First Nation, Taku River Tlingit First Nation, Teslin Tlingit Council First Nation, Tr'ondek Hwech'in First Nation.

DURATION: 2006 **–** Ongoing, continuously seeking additional funding.

OBJECTIVES: The program's main objectives are driven by the YRITWC organizational mission and vision to protect and preserve the Yukon River watershed. Through an international accord between Indigenous governments, the YRITWC and United States Geological Survey (USGS), the Indigenous Observation Network (ION) was formed. IOS is a large-scale monitoring program with the goal to address water quality and environmental change impacts on rural Indigenous communities across the Yukon River Watershed. The communities living in this area are highly dependent on the landscape and environment for subsistence and drinking water resources to maintain their traditional way of life.

YRITWC is using USGS-approved quality assurance and quality control (QA/QC) protocols to ensure high quality data collection, and consistency across the large watershed.
The YRITWC engages Indigenous communities directly. The ION monitors water quality and the active layer (permafrost) in the Yukon River Watershed by combining rigorous scientific training with the skills and knowledge of local community members. The community members collect environmental data that are verifiable and defensible. ION is guided by Indigenous Knowledge to advance the knowledge of environmental changes on hydrological processes and fluvial bio-geochemistry over a variety of temporal and spatial scales in the Arctic and Sub-Arctic environments.
The YRITWC is led by an Alaskan and a Yukon Executive Committee (EC). The ECs are composed of Indigenous leaders, appointed by each region of the Yukon River Watershed. The ECs meet regularly and determines the direction of the YRITWC, and the staff work to accomplish these goals. An Indigenous Research Protocol also guides the work. In this way the activities are guided by Indigenous Knowledge.

STATUS: The objectives have been partly achieved. In partnership with the USGS Mission Area Program we have built an extensive water quality dataset at 54 sites, collected more than 1,500 samples and trained more than 1,000 environmental technicians to collect water quality data. Furthermore, the ION has collected eight years of permafrost (Active Layer Network) data at 20 sites across the Yukon River Basin, and documented Indigenous Knowledge and environmental observations about landscape changes. IONs approach is holistic and includes the collection of traditional knowledge and western science information to address past and current observed impacts to landscape and water quality, seasonal variability as well as community responses to the changing hydrology and ecosystems in the watersheds. ION has enhanced our understanding of changes in environmental systems in the Arctic and Sub-Arctic regions. ION is managed by the Yukon Tribes and Frist Nations, and it is an on-going monitoring effort without an end date.

DATA USE: Data from the Indigenous Observation Network in Yukon River Basin have been used both by at local and the regional level. The communities have used the data at the local level for community planning. For instance, the data have been used for management of safe drinking water and wastewater, for solid waste management, and for advocacy to protect clean water and salmon stocks. The ION reports apply relevant water quality standards (Alaska) and guidelines (Canada) to determine whether water quality exceeds dangerous values for the use of specific areas for example as source of drinking water, or as a recreational area, or an aquatic habitat for wildlife.
At the regional level, the data have been used to inform the Yukon River Water Quality Plan. This Water Quality Plan was adopted by the YRITWC signatory Alaska Native Tribe and Canadian First Nation representatives at a summit in May 2013. The goal of the Plan is to protect Indigenous water rights by ensuring the Yukon River and its tributaries 'substantially unaltered from natural conditions'. One of the plan's visions is to generate sufficient data through ION to assess river water quality and quantity, which then will allow Tribes and First Nations to set measurable and specific water quality guidelines. Furthermore, the ION data have also been utilized by scientists to better understand large scale environmental and climate associated changes occurring within the watershed.

ACHIEVEMENTS: The most important achievements have been:

- Built a cohesive network of people and organizations across the Yukon River Watershed with shared goals and activities
- Made the data available to community members in acceptable forms through the creation of plain language community reports for each partner community
- Built capacity of Alaska Native Tribes and First Nations to conduct their own water quality monitoring program to address community needs

- Contributed to long term dataset of water quality while also addressing specific data gaps on the Yukon River
- Build strong relationships between Alaska Native Tribes and First Nations to form monitoring programs ownership and trust in their data collection
- Strengthen Alaska Native Tribes and First Nations environmental awareness
- Data use in decision-making for local water governance and education
- Publication of seven peer reviewed scientific articles, with more in review
- Publication of brochures and pamphlets, including training materials

CHALLENGES AND SOLUTIONS: The ION program was evaluated by Nicole J. Wilson in 2017. Challenges identified by YRITWC staff and Wilson are:
First, funding to maintaining a long-term and sustainable water quality monitoring program is a huge challenge and for instance affecting sampling frequency and timing. It is easier to get funding for new innovative projects, than to secure continued funding for monitoring that has existed over years. Moreover, it has been a challenge to obtain funding to focus on baseline parameters to address local contaminant concerns such as heavy metals and sediments from mining or leakage from local sewage lagoons and landfills as well as climate change indicators.
There are limited funding opportunities at the watershed scale. Limited transboundary funding has fragmented the ION. Yet, water quality and active layer monitoring has continued within Tribal or First Nations Environmental departments in communities who value ION, with limited support provided in kind from YRITWC and USGS. The YRITWC has secured funding for projects focused on community contaminant concerns but only limited support to maintain a watershed scale ION.
Second, traditional knowledge in ION monitoring program should incorporate traditional indicators for water quality, quantity and rate of flow. The platform for data visualization 'Fieldscope' that allows community members to enter their water quality data has not been used frequently by community members. It would have been good to have included more outreach about its utility and to have more fully appreciated the limited connectivity of rural communities.
Third, communication is a challenge when working across a large and remote watershed. Many communities don't have reliable internet or phone connections. We have worked to make information available through mailing paper reports, and newsletters. We also take advantage of opportunities, such as Tribal Environmental conferences when many partners are already in town, to host luncheons, allowing ION partners to meet face-to-face whenever possible.

FUTURE DEVELOPMENT: Our strategic plans for the future of ION involve several ideas. We would like to continue the ION baseline monitoring program at established sites, as well as enhance the network by addressing more specific community contaminant concerns, protect water sources and address drinking water issues. Overall, we will maintain, build and strengthen partnerships with relevant entities and stakeholders.
We need to focus our effort in networking with stakeholders interested in the preservation and conservation of the Yukon River Watershed and engage in discussions to highlight the importance of ION. For example, we participate in many local Environmental Conferences. We also attend some International efforts. We currently have observer status at the UN, and we have applied for observer status at the Arctic Council in order to become more integrated in international efforts.
To continue and enhance the ION monitoring program, additional funding is needed. We have submitted proposals to seek funding from federal funders, in addition to pursuing smaller funding sources like Foundations and Charitable Trusts.

OTHER POINTS: For organizations interested in establishing their own water quality program, the YRITWC website offers publically available water quality training material, water quality equipment manuals, Quality Assurance Project Plan template and other useful resources. To select good water

quality monitoring sites it is useful to ask the local community what waters are important to them and why.
We feel that documenting high quality environmental data can support Indigenous self-governance of important resources and we welcome others to use the materials provided. Don't hesitate to contact us if you do use the materials. We would be interested to know how they are being used, and can answer any questions you may have about them..

3.4 PISUNA

Piniakkanik Sumiiffinni Nalunaarsuineq (PISUNA)[1]. Websites: www.pisuna.org and https://eloka-arctic.org/pisuna-net/.

ORGANISATIONS: Greenland Ministry of Fisheries and Hunting; Association of Fishers and Hunters in Greenland (KNAPK); Qeqertalik and Avannaata Municipalities.

DURATION: 2009 **–** Ongoing.

OBJECTIVES: The environment of Greenland is rapidly changing. PISUNA aims at helping decision-makers in communities, local authorities, and central government by providing information from the regular collection and interpretation of data on living resources and their utilization.
There are five objectives. First, to strengthen documentation of the locals' knowledge of the living resources by utilizing their observational capacity. Second, to encourage local analysis, interpretation and discussion of changes in the living resources, thereby increasing local capacity and creating an understanding of the need for management interventions. Third, to make local observations, analysis, and recommendations available to the government. Fourth, to enhance the local stakeholders' influence over government decisions on fishing and hunting, and fifth, to provide a forum for data-based dialog between local stakeholders and the government.

STATUS: The objectives have been partly achieved. Greenland now has a community-based observation program that provides an opportunity for Indigenous and local community members' insights and knowledge on the environment to be used and their 'voices' heard. This observation program can provide an important basis for the effective protection and sustainable use of Greenland's biodiversity and ecosystem services. The work is continuing.

DATA USE: Greenlandic Natural Resource Councils are set up by the government with the assistance of the PISUNA program comprising volunteers from among some of the most experienced and interested local hunters, fishermen and other people interested in the environment. When members of these councils are in the field, they collect data on living resources and their use. These data are summarised, discussed and interpreted at regular meetings of each council. Moreover, possible management actions emanating from the results are also discussed. Data interpretation is led by the volunteer co-ordinator from each council. The local actions are enacted upon and those actions that require government approval are forwarded to the municipal and national government for their decisions and action.

ACHIEVEMENTS: A total of 90 community members have participated; 55 have been documenting living resources as active members of the Natural Resource Councils at the community level. A total of 15 communities (villages) in three municipalities have been engaged in the program. Five communities

[1] Adjusted from paper by F. Danielsen, E. Topp-Jørgensen, N. Levermann, P. Løvstrøm, M. Schiøtz, M. Enghoff, and P. Jakobsen in *Polar Geography* 37: 69-91; 2014, available at: http://www.monitoringmatters.org/articles/CountingWhatCounts_PISUN_PolarGeography372014.pdf.

use the program on a regular basis - for documenting trends in resources and proposing management actions. All the data and recommendations are publicly available in a searchable, "real-time" web-server database with local observations of living resources in Greenland, see below.
A total of 494 proposed natural resource management actions have emanated from the program. The proposed natural resource management actions related to six categories: change in fishing and hunting seasons (146 proposed actions); change in quotas (123); other changes in rules and bylaws (125); enabling trade in products from specific resources (36); facilitating more research (30); and other proposed actions (36).
Overall, the proposed actions concerned 90 different actions for 30 species and types of resource use. Most of them were submitted to the local government authority and a few were submitted from the local government authority to the central government. The proposed changes in fishing and hunting seasons related for instance to common eider and Canada goose (expansion of season) and musk ox and thick-billed murre (reduction of season). The proposed changes in quotas concerned for instance Atlantic cod (increase in quota) and musk ox and thick-billed murre (reduction in quota). The proposals to enable trade in products from specific resources related to four species: harp seal, Atlantic cod, Greenland halibut, and spotted wolffish.
Examples of the local Natural Resource Councils' proposals for further research include:

- Kangersuatsiaq recommended Atlantic cod surveys in the North, where the stocks are growing fast, in order to clarify the options for fishery.
- Kangersuatsiaq recommended wolffish surveys the North to clarify the options here.
- Attu recommended that the caribou population be monitored before each hunting season to allow for annual adjustment of management.
- Attu recommended a review of the current management regime for walrus in the Kangaatsiaq Management Area.
- Akunnaaq will test harvesting of Arctic tern eggs while monitoring to ensure sustainability.
- Akunnaaq asked for testing of acoustic devices to regulate humpback whale abundance in the vicinity of fishing gear.
- Qaarsut will assist in censuses of common eider breeding colonies.
- Kitsissuarsuit found that the reason behind the thick-billed murre breeding population decline needed further study.

The documentation available in the description of management actions typically involves data on species, time (month and year), area (usually, in broad terms, the fishing and hunting area of the community but, in some cases, also the specific site within this broader area), observer, trend in relation to same time last year, importance of the finding, possible explanation, and proposed action. The documentation sometimes also includes number of fishing or hunting days, fishing or hunting gear, and fishing and hunting effort and catch.

CHALLENGES AND SOLUTIONS: Over the course of the project, we made two major changes to this process. First, we introduced a symbolic honorarium for community members who attended the Natural Resource Council meetings if their report was properly filled in and submitted to the local government in time. This gesture proved very important. It has substantially ramped up the timely submission of quarterly reports.

Second, we changed the flow of data from community members so that all local reports would go from local government to KNAPK with a copy to central government (APN) and not only to central government. This enabled KNAPK to benefit directly from local knowledge on trends in resources, equipping it to enter into a more well-informed, data-based dialogue with the central government on quotas and fishing and hunting regulations and measures. Management proposals requiring central government action would still be forwarded directly to APN by the local government.

FUTURE DEVELOPMENT: PISUNA has become widely accepted as the central tool in Greenland for enabling local communities to document and discuss trends in living resources and to propose

management adjustments. In the 2017 budget, Qaasuitsup Municipality (from 2018 split into the two municipalities, Qeqertalik and Avannaata) has set aside staff time for coordination and financial resources for reimbursing community members for their time spent in discussing and reporting their findings, suggesting a strong commitment to continue the PISUNA program on the part of the municipal authorities.

OTHER POINTS: We have learnt several lessons. For instance, we have found that the use of analogue calendars and very detailed formats for recording observations on each field trip do not work well, except with a few fishers and hunters. Together with community members, we have instead developed a simple quarterly summary form. Through its structure, the form encourages self-evaluation of local observations and knowledge and, at the same time, promotes local discussion of trends, their possible reasons and relevant actions.
Our experiences have reinforced just how important it is to have strong local coordination of the community monitoring network. The project has benefitted from a committed senior staff member within the local government authority who is well-known and respected among the community members, and who has assisted the village-level volunteer coordinators with their work and encouraged close links between the community monitoring and the decision-makers in the local government authority.
Finally, our experiences have also shown that a close dialogue between researchers, community members, civil society organisations and government staff can be very effective in translating community monitoring principles and ideas into implementation in the 'real world'.
Fishers and hunters propose concrete actions, based on their own observations. The authorities are beginning to listen. Fishers and hunters are beginning to get a stronger 'voice' in topics of great importance to them. The locals and the municipality want to continue. With the PISUNA program and the awareness about it, there is now a proven tool available for communities who want to adapt their resource use to the changes in climate.

3.5 SIWO

By Lisa Sheffield Guy, Sea Ice for Walrus Outlook.

ORGANISATIONS: Arctic Research Consortium of the U.S. (ARCUS), Eskimo Walrus Commission (Kawerak, Inc.), the National Weather Service Alaska Region, University of Alaska Fairbanks – International Arctic Research Center.

DURATION: Annually during spring since 2010 when sea ice is present in the Bering Strait. The program is on-going.

OBJECTIVES: The main objective of the Sea Ice for Walrus Outlook (SIWO) is to provide Alaskan Native subsistence walrus hunters and Bering Strait coastal communities with weekly reports on spring sea ice and weather conditions to promote hunter safety, food security, and preservation of cultural heritage.

STATUS: The primary objective of providing weekly reports on spring sea ice and weather conditions has been achieved in each year since 2010 when SIWO began its work. In some weeks, historically, there were no local observations available. During those weeks, our objectives were only partly achieved.

During the 2017 season, 43 reports were received from local observers during the 11-week season. The SIWO website received more than 1,200 visits. SIWO engagement via Facebook is generally higher than website engagement, with more than 700 followers representing 34 Alaskan communities and 39 countries.

DATA USE: The data, in the form of local observations and photographs, weather and sea ice forecast

information, and satellite imagery are primarily used by subsistence hunters and others traveling in Bering Strait coastal communities. SIWO information is also used by regional biologists and managers, by weather personnel to validate forecasts with on-the-ground observations, and is freely accessible to others interested in weather and walrus in the region.

ACHIEVEMENTS: The most important achievement to date is the network itself, which includes Indigenous experts, weather forecasters, scientists, and project managers. The relationships built through eight years of collaboration and co-produced outlooks continue to strengthen.

CHALLENGES AND SOLUTIONS: First, the primary challenge is relationship-building in coastal communities, which requires trust, consistent good communication and understanding, and a shared vision and goal. The success of the SIWO network is due in large part to sustained financial support from the National Science Foundation's Division of Arctic Sciences (PLR-1304316). This funding has allowed SIWO to be in operation each year, provided support for the webpage, and most recently has contributed toward stipends for local observers.
Second, another challenge is the poor internet service in rural areas of Alaska. This can make viewing SIWO information and receiving photographs or videos from local observers quite difficult. One solution has been to provide forecast products and images in small, lower resolution file sizes, generally below 900kb.
Third, SIWO is a geographically distributed network and many (perhaps most) of our partners and contributors have never met in person. We hope to address this challenge in the future by finding support for in-person workshops and for local observers to travel to meetings and share their perspectives.
Fourth, a final challenge is the flexibility required from all partners to undertake SIWO based on the presence of sea ice. For example, the 2018 season began weeks earlier than expected in response to extremely low ice conditions in the region. Good communication and a fine-tuned workflow are required to adapt to the shifting schedule of seasonal ice.

FUTURE DEVELOPMENT: There is great potential to develop SIWO both geographically to areas outside the Bering Strait, and temporally to provide weekly forecasts during other times of the year, particularly during fall hunting and earlier in spring. The SIWO team is seeking additional funding to support a workshop that would give all partners, including local observers, space to discuss the future directions of the program and what is most needed from a safety and food security perspective. We also seek to continue and increase financial support for local observers for their contributions and travel to relevant meetings and workshops.

OTHER POINTS: For any similar efforts, we strongly encourage involvement of local communities and observers from inception of the project. Local observer compensation and travel should be written into proposals alongside support for science and administrative personnel.
For the purposes of SIWO, our flexible format that allows observers to share what they feel is most relevant to safe subsistence travel in their area works well. The program use no manuals and the guidelines are very open. However, an approach with a more structured format for observations (i.e., measurements of temperature, wind, etc.) would prove valuable for other purposes such as validation of weather forecast models.
Flexibility in format of local observation submission has been an important feature of this program. Observers can report via email, telephone, social media, or our online submission form (https://www.arcus.org/siwo/submit). Due to rural internet constraints, optional photos and gathering of information via phone have allowed the program to represent more isolated communities.

3.6 Winterberry

By Katie Spellman and Christa Mulder, University of Alaska Fairbanks.

ORGANISATION: Melibee Project (2010-2015) and Winterberry Citizen Science (2017-2021)

DURATION: September 2010 - June 2021

OBJECTIVES: The University of Alaska Fairbanks's Far North Phenology Network (FNPN) is aimed at tracking the phenology of boreal forest and arctic tundra plant species in a warming world. Phenology is the study of the timing of life events, and changes in the timing of the seasons has created new conditions and interactions for northern ecosystems that we hope to better understand through coordinated monitoring of plants. Two changes we focus on that motivated our berry monitoring projects, include the accelerating spread of invasive species in Alaska, and the changings in the timing of the growing season. Both of these could affect berry species important to people and wildlife in the far north. Berries are an important part of northern culture, recreation, and healthy diet. They also make up an important part of the diets of many boreal and Arctic animals, particularly in the late fall and winter months.
Because berries are an approachable topic for youth, all the FNPN projects have emphasized youth engagement in environmental monitoring, and the process of learning, teaching and sharing knowledge across generations. Alongside land managers and adult volunteers, it has been educators, families, classrooms, youth camps and youth clubs who have contributed the bulk of the data collected in FNPN projects.
Materials from two FNPN projects are presented here, one that supports monitoring of reproductive phenology of berry species from budding to fruiting during the growth season (Melibee Project), and a second that supports monitoring of berry abundance, condition and availability to animals in the fall and winter (Winterberry).
The Melibee project had two primary objectives. First. to investigate timing of flowering in blueberry (*Vaccinium uliginosum*) and cranberry (*Vaccinium vitis-idaea*) across Alaska through a combination of volunteer observers and historical herbarium records. Second, to determine the extent of overlap in flowering times between these berry species and White Sweet-Clover (*Melilotus albus*), an invasive legume species that could alter pollination of the berry species. The interest in berry monitoring was high, and we developed a second program called Winterberry Citizen Science. The objective is to determine the effect of shifting timing of the seasons on the timing of fruit ripening, berry abundance, and berry condition (rotten, damaged, etc.).

STATUS: For the Melibee project, the first objective was completed, and the results were published in peer-reviewed journal articles, as well as newsletters to the volunteer observers. The second objective is in progress; we continue to work on the assessment of flowering overlap and we refine our models. The Winterberry project has just started, and the first year of monitoring is not yet complete.

DATA USE: We have used the data for publications and presentations. Volunteer observers have used their own data from the Melibee Project to determine the timing of when *M. albus* identification and control will be most effective. They can now predict when to send crews out to remove the invasive species from areas they are concerned about during the time of the summer when the control effort will have the greatest probability of success.

ACHIEVEMENTS: We developed a novel approach for scoring the phenophase (or stages in the berry life cycle such as bud, flower, unripe, ripe fruit) of a berry plant both in person, and on herbarium specimens. We also showed the importance and value of volunteer observers for a topic area where data is very limited (Spellman and Mulder 2016).

CHALLENGES AND SOLUTIONS: Limited project staff and keeping up communications across all the observers is always challenging. We have learned that budgeting for a full-time coordinator would have been wise.

FUTURE DEVELOPMENT: Our berry observing program is supported through 2021 by the National Science Foundation. We plan to build an enhanced data entry and visualization tool on our website to

increase ease of submitting data, creating usable data visualizations, and sharing of information across communities.

OTHER POINTS: These protocols and materials focus on species chosen for specific research questions that also overlap with berry species of interest in Alaska. However, the same protocols may be used for any berry or fruit species in Boreal or Arctic plant communities.

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