# Integrated Arctic Observation System

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## Community based monitoring programmes in the Arctic: Capabilities, good practice and challenges

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| EXECUTIVE SUMMARY |
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Arctic people live in and observe the Arctic environment year-round. Intimate knowledge of the environment and environmental changes is fundamental to the survival of these people who frequently depend on natural resources for their livelihood. This report presents a review of the capabilities, good practices, opportunities and barriers of community-based environment monitoring programmes in the Arctic, with a focus on decision-making for resource management.

The review builds upon previous work that contributed to the Sustaining Arctic Observing Networks (SAON, Task #9; Johnson *et al.* 2016). We first identified 170 community-based monitoring programmes in the Arctic from the peer-reviewed literature and from searching the internet. Then we chose 30 programmes that reflect the widest possible set of situations and issues for more in-depth analysis. We reviewed the scientific literature and discussed experiences at workshops with practitioners and community members engaged in monitoring programmes in Nuuk in 2016 and in Fairbanks, Quebec and the Russian communities of Komi and Zhigansk in 2017. Key findings are summarized below.

**Capabilities.** There is a long history of involving community members of all ages in monitoring the Arctic. Programmes involve various organizations, including community groups, all levels of government, universities, schools and the private sector. Programmes monitor biological attributes, abiotic phenomena and socio-cultural attributes, often within the same framework. The observing domains that receive the greatest attention are "land/cryosphere" and "ocean/sea-ice". By their nature, community-based monitoring programmes tend to focus on those issues of greatest concern to local stakeholders, thus having considerable potential to influence on-the-ground management activities.

The programmes complement scientist-executed monitoring by utilizing different methodologies, engaging the experience of Indigenous knowledge holders and other long-term residents who have significant knowledge of the environment, and by enabling an increase in sample size or density, area and time. Most Arctic community-based monitoring programmes make observations between 61-70°N. They cover all the Arctic biomes with the exception of ice desert. Data are typically collected throughout the year. The majority of the programmes involve Indigenous knowledge. The programmes inform decisions at local, regional and national levels and often provide insight into processes and changes not captured in agency or research-driven monitoring programmes. Thus, they contribute to better informed decisions or better documented processes within the key economic sectors in the Arctic:

- Fisheries,
- Forestry,
- Herding,
- Hunting,
- Mineral and hydrocarbon extraction,
- Shipping, and
- Tourism.

Methods originating from both the natural and social sciences are often used, increasingly also drawing on Indigenous knowledge for programme design. New technologies enable the programmes to collect data and communicate findings with greater certainty than ever before. Some programmes have made their data publicly available, but few have links to data discovery portals or global repositories. The programmes have the potential to contribute to monitoring progress in relation to ten international environmental agreements of particular relevance to the Arctic. They could also contribute to achieving 16 of the 17 United Nations Sustainable Development Goals.

**Good practices**. Arctic community-based monitoring programmes are diverse, with many successful approaches. By providing actionable information to management authorities and community members, the programmes inform many kinds of decisions. Web-based knowledge management platforms are increasingly used for data storage and communication. Credible knowledge products are obtained in many ways, including through careful planning, thorough guidance of the participants, and validation of data through different approaches. Many programmes follow the principles of "Free, Prior and Informed Consent" and contribute, directly or indirectly, to protecting the rights of the Indigenous and local communities. Co-design of programmes and co-production of knowledge can help ensure relevance and utility of monitoring data.

**Opportunities and barriers**. Community-based monitoring offers strong potential for linking environmental monitoring to awareness raising and enhanced decision-making at all levels of resource management. Moreover, community-based monitoring programmes could provide hypotheses and data that potentially could fill gaps in climate modelling and in research within such areas as risk management, safety, and food and water security. Community-based monitoring is also a way to fulfill the rights of the citizens to take part in decisions that are related to their local and regional areas and to be able to take part in the knowledge production in order to develop and safeguard their environment.

One barrier to maximising the potential of community-based monitoring for decision-making has been the perception that information from local people is subjective and anecdotal. Today, a growing body of literature demonstrates that where Indigenous and local knowledge has been systematically gathered, the data collected by community members are comparable to those arising from professional scientists. Another barrier is that management authorities are sometimes slow at operationalizing or acting upon community observations in their decision-making. Regardless of this, involving people who face the daily consequences of environmental challenges in monitoring can help in adapting decision-making on natural resource management to local realities in a rapidly changing Arctic.

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# 1. INTRODUCTION

At a workshop in Fairbanks in May 2017, community members, practitioners and scientists from Alaska summarized the value and role of community-based monitoring (CBM) in the Arctic. They used the following words:

*"The challenges of our time call for greater, more effective collaboration. Environmental change is occurring rapidly. There is an urgency to the situation, a climate crisis. This makes the community-based monitoring and documentation of Indigenous and local knowledge more important than ever.*

*Arctic Indigenous Peoples find themselves not only at the 'front-lines' of climate change impacts, but are at the front-lines of creating hypotheses about change and adaptation. It is human nature when seeing a change to think about why that change is happening, which can be based on vast knowledge of the environment that often includes information passed down through the generations. Baseline data is often lacking. Indigenous and local knowledge can sometimes fill the gap.*

*Indigenous peoples are often the first to see change since they are traveling, and harvesting on the landscape. They can also provide historical context due to long-term intimacy with the environment, and importantly answer why the change matters. They know when it impacts community and culture (…). It's not just academic curiosity to understand a phenomenon. People are already acting and adapting to changing conditions (...).*

*The gap between information and action needs to be shortened. Information is needed to make choices. Information needs to be in the hands of people who are adapting. Community-based monitoring can shorten the gap between research and action, by empowering Indigenous peoples to collect data to address decision making needs"* (excerpt from Fidel *et al.* 2017).

The Fairbanks 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), the Russian communities of Komi and Zhigansk (September 2017) and in Quebec (December 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.

In many areas of the Arctic, civil society organizations, government agencies or researchers have established CBM programmes. The programmes use Indigenous and local knowledge and observations, and build upon existing community-based approaches to observing the environment. A recent review of the Sustaining Arctic Observing Networks (SAON) analyzed a sample of 81 CBM programmes in the Arctic (SAON, Task #9). One of the objectives of INTAROS is to survey and analyze existing CBM programmes in the Arctic and identify capabilities, good practices and challenges, while building on the review that contributed to SAON (Johnson *et al.* 2016).

This report presents the results of the survey of Arctic CBM programmes and offers analysis based on survey results as well as observations contributed by practitioners at the workshops listed above. Firstly, on the characteristics of the programmes, their coverage, the framework and format of their

knowledge products, and the linkages to sustainable development (Chapter 2). Secondly, on good practices in terms of undertaking and sustaining the programmes, obtaining impacts, connecting with other approaches, ensuring the quality of knowledge products, and addressing the rights of Indigenous and local communities (Chapter 3). The report concludes with a discussion of the challenges that Arctic CBM programmes face, the extent, causes and effects, and how to address them (Chapter 4).

**Methods.** The report is based on a self-reporting survey of CBM programmes (Chapter 2) and on a review of the scientific literature and workshops with CBM programme practitioners and community members engaged in CBM programmes (Chapter 3 and 4). Both the survey, the literature review and the workshops build upon the previous work of the Sustaining Arctic Observing Networks (Johnson *et al.* 2016; see Figure 1).



**Figure 1. Location of 81 Arctic community-based monitoring programmes identified for the Sustaining Arctic Observing Networks (adjusted from Johnson *et al.* 2016; www.arcticcbm.org).**

For the self-reporting survey of CBM programmes, we first identified 170 CBM programmes in the Arctic from the peer-reviewed literature and from searching the internet. Then we chose 45 CBM programmes for more in depth analysis to reflect the widest possible set of situations and issues. We prepared a multiple choice questionnaire with 50 questions directed at the organizers of each of these CBM programmes. Thirty out of the 45 CBM programmes targeted completed the survey (Annex A). The questions addressed key features of each CBM programme (aims, community engagement, data derived from the CBM-programme, the programme's linkages to other approaches, key challenges etc.). We used the answers to describe the characteristics and coverage of the CBM programmes as well as the framework and format of knowledge products emanating from the CBM programmes.

For each CBM programme, we then assessed (1) its ability to contribute, or probably contribute, to better informed decisions and better informed processes in the key economic sectors in the Arctic

region, (2) which of the ten multilateral agreements in the Arctic the programme could, or probably could, contribute to in terms of monitoring progress; and (3) which of the 17 UN Sustainable Development Goals the CBM programmes could contribute to achieving. All CBM programmes were assessed by one team member (MKP); in the few cases he was in doubt of an evaluation, consensus was reached through discussion with the other team members.

The workshops with CBM programme practitioners and community members engaged in CBM programmes were held in Nuuk (2016), Fairbanks, the Russian communities of Komi and Zhigansk, and Quebec (2017). Discussion topics included for, instance, how to sustain CBM activity, who uses the information generated and how, and whether there would be interest in sharing the information with others beyond current users, and the barriers and opportunities that exist for doing so. Separate proceedings are being prepared for the workshops held in Fairbanks (Fidel *et al.* 2017), Quebec and the Russian communities (in prep.).

We intentionally did not predefine CBM, but adopted an inclusive approach that encompassed programmes with different levels of community involvement as well as Indigenous and local knowledge projects with relevance to long-term observing. Further discussion of the definitions of CBM is available in Johnson *et al.* 2016.

## 2.  CAPABILITIES

### 2.1 Introduction
In this chapter, we describe some of the characteristics of Arctic CBM programmes and assess their capabilities in Cterms of coverage, framework and format of knowledge products, as well as linkages to international agreements and UN Sustainable Development Goals in the Arctic.

The chapter is based on a self-reporting survey of CBM programmes. First, building upon the previous work of the Sustaining Arctic Observing Networks (Johnson *et al.* 2016), we identified  CBM programmes in the Arctic from the peer-reviewed literature and from searching the internet. Then we chose 45 CBM programmes for more in depth analysis to reflect the widest possible set of situations and issues. We prepared a multiple choice questionnaire with 50 questions directed at the organizers of each of these CBM programmes. Thirty out of the 45 CBM programmes targeted completed the survey (Annex A).

While steps were taken to ensure objectivity, some aspects of this work remain subjective or impacted by sampling errors. Thus, only successful CBM programmes with active engagement were likely to respond. When identifying CBM programmes we also relied on the peer-reviewed literature, which may underestimate small-scale local and volunteer-based efforts, likely biasing our findings towards large, well-funded programmes.

### 2.2 Characteristics of Arctic CBM programmes

**History.** There is a long history of CBM programmes in the Arctic. Although most of the programmes that we assessed were established within the last 15 years (65% of 26 respondents; Figure 2), there are CBM programmes that are far older. For instance, in 1932, the Federation of Icelandic River Owners began monitoring salmon and trout fished in rivers in Iceland. A decade earlier, in 1919, monitoring of the changing year-to-year snow-coverage in Finland was initiated as a CBM programme by the Finnish Meteorological Institute. The record for an Arctic CBM programme is, however, to our knowledge, held

by community members in the Faroe Islands, North East Atlantic. They began keeping track of and reporting their catch of pilot whales to the government four centuries ago, in 1584.
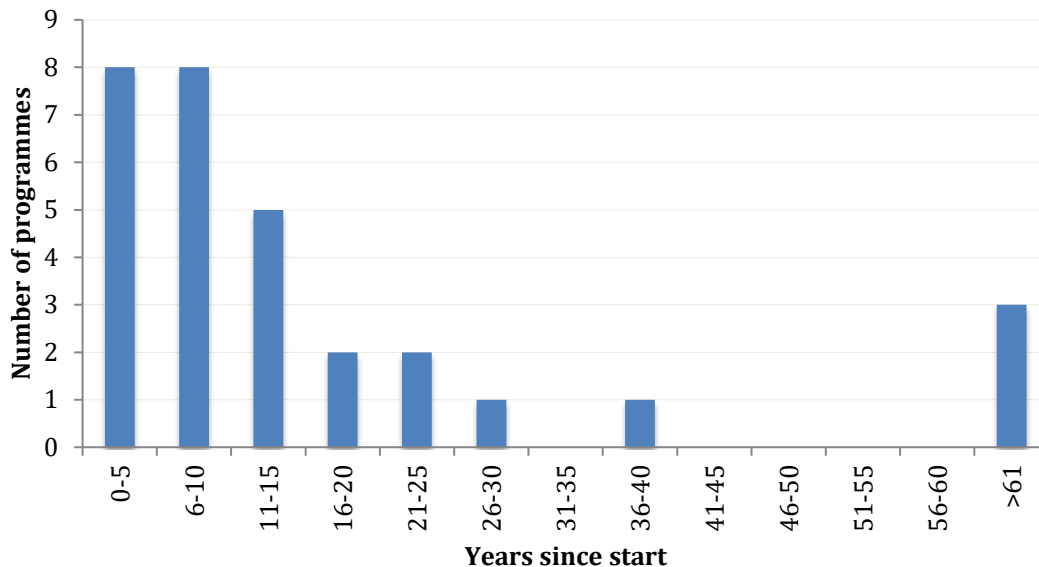
## Age of CBM programmes



Figure 2. Age of the Arctic community-based monitoring programmes (n=30).

**Community involvement**. The central feature that distinguishes CBM programmes from scientist-executed monitoring programmes is the involvement of community members in one or more steps of the monitoring process (see Methods in Chapter 1).

Most of the CBM programmes we assessed had less than 100 community members involved (67%), although some had 100-1,000 (20%) or more (13%; n=30). Overall, there was an over-representation of men in the programmes (50% of 24 programmes responding had <25% women). However, there were also examples of programmes mostly involving women, for instance, Nordland Ærfugl in the Vega islands off Norway, where landowners exploit eider down and register breeding eider ducks (>75% women; eiderducks.no). With regard to age groups, most CBM programmes involved a mix of youth (19-26 years), adults (27-60 years) and seniors (>60 years) (66%; n=30). Some also involved children (32%).

In most CBM programmes, community members themselves had proposed their involvement (77%; n=30) but, sometimes, they were appointed by community leaders or other bodies to participate because of their background (40%; n=30). Occasionally, the community members participated because they were obliged to if they wanted to fish or hunt in an area (7%; n=30). Several programmes included a mix of recruitment approaches, hence the numbers sum to in excess of 100%.

Why did community members propose their involvement in the CBM programmes? Our assessment suggests there are several reasons, sometimes within the same CBM programme. Mostly, community members wanted to have their voices heard and to protect their rights over land and resources (60%; n=30). Equally common was the fact that community members wanted to sustain wildlife health and abundance (57%). Less common reasons were social engagement (43%), personal benefits (36%), leisure interest (21%), or simply that it was mandatory to participate (11%). In a few cases, community members participated largely because it was an opportunity for learning and for contributing to a rebirth of traditional practices and knowledge.

Although community members were motivated to engage in the CBM programmes by a variety of factors, participation took time away from fishing and other livelihood activities. Roughly half the CBM programmes therefore compensated community members for their time (52% of 29 respondents), with the other half (48%) not providing compensation.

**Capacity enhancement.** An important question is whether the Arctic CBM programmes contribute positively or negatively to the local community.

We found that CBM programmes helped communities advance their own social and political goals and supported development of pride and self-esteem on the part of the individuals involved.

The Arctic CBM programmes particularly contributed to three dimensions of capacity enhancement:

1. Social enhancement (67%; n=30; e.g. education, and improvement of local organizations involved in managing natural resources),
2. Political enhancement (60%; e.g. participation in natural resource decision-making, leadership development, and increased local governance over natural resources),
3. Psychological enhancement (60%; e.g. development of pride and self-esteem in natural resource management).

A good number of the CBM programmes also contributed to the economic enhancement of the local community (43%; n=30; e.g. financial resources and control of subsistence resources). No CBM programmes contributed negatively although the organizers of a few programmes did not know if the monitoring had enhanced the capacity of the local community or not (7%). Our findings are based on self-reporting and provide a preliminary understanding of the benefits accruing to the local communities from successful Arctic CBM programmes in terms of capacity enhancement. Further work would be needed to verify and substantiate these findings on the ground.

## 2.3 Coverage of Arctic CBM programmes

**Attributes.** Arctic CBM programmes monitored biological (93%), abiotic (53%) and socio-cultural attributes (47%; n=30) (Figure 3). Many of the biological attributes monitored (e.g., mammals, birds, fish, shellfish, insects, plants, fungi) relate to goods and services provided by the natural environment or ecosystems. Abiotic phenomena included sea ice, water, snow, weather, wind, air quality, contaminants, sea currents and infrastructure development. Socio-cultural attributes included Indigenous knowledge (about multiple topics) as well as language, human health, and wellness. Several of the programmes monitored biological, abiotic and socio-cultural attributes at the same time (33%). Examples of CBM programmes are given in Chapter 3.

## Attribute categories coverage
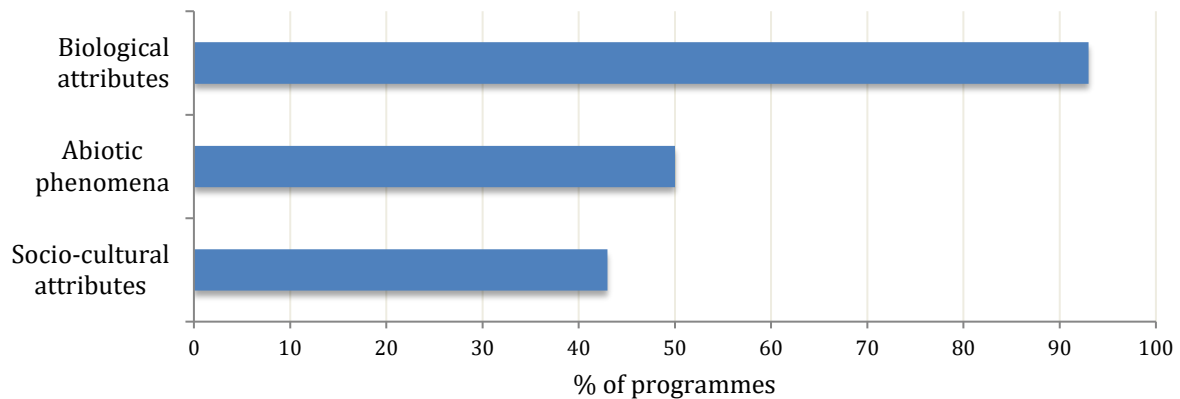


**Figure 3. The proportion of Arctic community-based monitoring programmes that monitor biological attributes, abiotic phenomena and socio-cultural attributes (n=30 programmes).**

**Observing domains.** We assessed the CBM programmes' coverage of the three main observing domains: atmosphere, ocean/sea ice, and land/terrestrial cryosphere. We found that 83% of the CBM programmes covered one domain and 17% covered two (n=30). Most CBM programmes covered land, including the terrestrial cryosphere (80%, n=30), whereas 33% of the programmes covered the ocean and sea ice, and 27% covered the atmosphere. In addition, the atmosphere is the focus of citizen science networks that collect data from citizens' weather stations and a number of these stations are found in the Arctic (https://wow.metoffice.gov.uk/; https://www.cocorahs.org/). There are also initiatives where school children rescue historical weather data e.g. from the early whaling expeditions providing observations of the summer half year sea-ice edge (oldweather.org).

**Geographic distribution.** There are CBM programmes in all countries of the Arctic (Johnson *et al.* 2016). The majority of the Arctic CBM programmes in our sample made observations between the latitudes 61° and 70° N (>50%; n=30; Figures 4-5).

Some CBM programmes, however, made observations further to the North. Piniakkanik Sumiiffinni Nalunaarsuineq (PISUNA) include observations in the fishing and hunting areas of Qaanaaq, Greenland (at 77° N). Likewise, tourists on expedition cruises make environmental observations north of Svalbard, off Norway (76-81° N; aeco.no). The central part of the Arctic Ocean is rarely visited by community members, and CBM programmes are unlikely to provide much data or information from this area (>81° N).

**Figure 4. Location of the Arctic community-based monitoring programmes in our sample (n=30).**

## Lattitudinal coverage
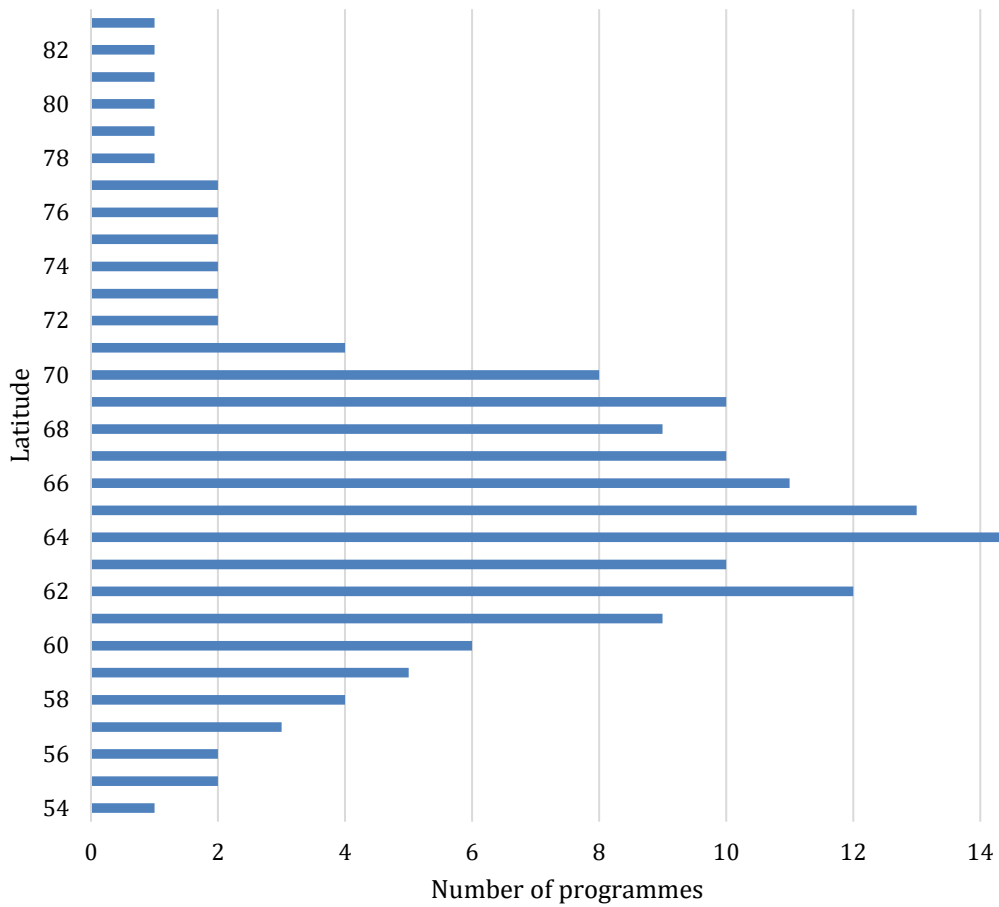


**Figure 5. Latitudes where the Arctic community-based monitoring programmes made environmental observations (n=30 programmes).**

**Biomes**. In terms of biomes, the Arctic CBM programmes covered taiga (boreal forest), tundra, freshwater, coastal and marine areas (Figure 6). Ice desert is a characteristic of the interior of Greenland, Iceland, Svalbard, and Novaya Zemlya off the north coast of Siberia. Community members, however, rarely visit the ice deserts, and minimal CBM-derived data and information are collected from this biome.
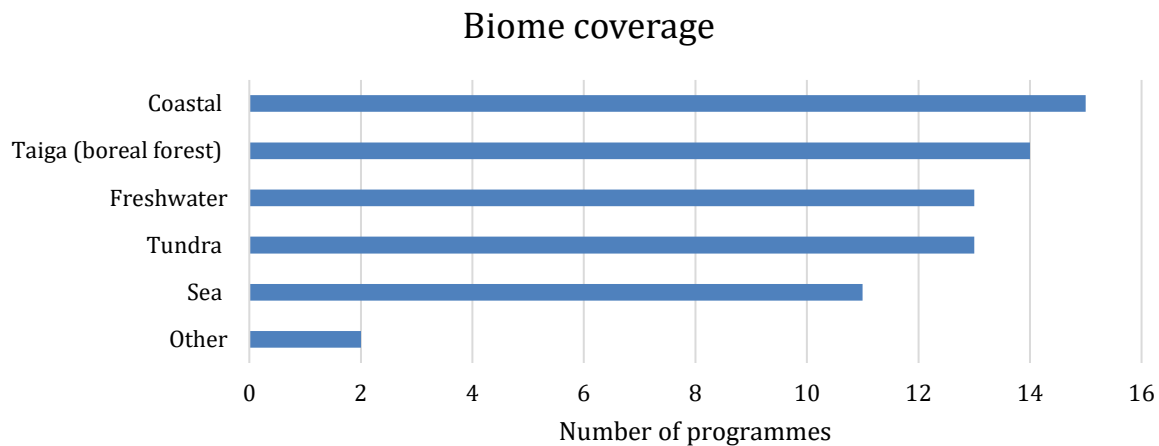
## Biome coverage



**Figure 6. Biomes covered by the Arctic community-based monitoring programmes (n=30 programmes).**

**Temporal coverage**. Community members in Arctic CBM programmes generally undertook environmental observations throughout the year (Figure 7). One in three of the Arctic CBM programmes had no distinct data collection period and collected data all year round (37%; n=30). Some CBM programmes had distinct time periods for data collection; for these programmes, there were peaks in the number of programmes where individuals collected data in May-June and September-October.

## Temporal coverage
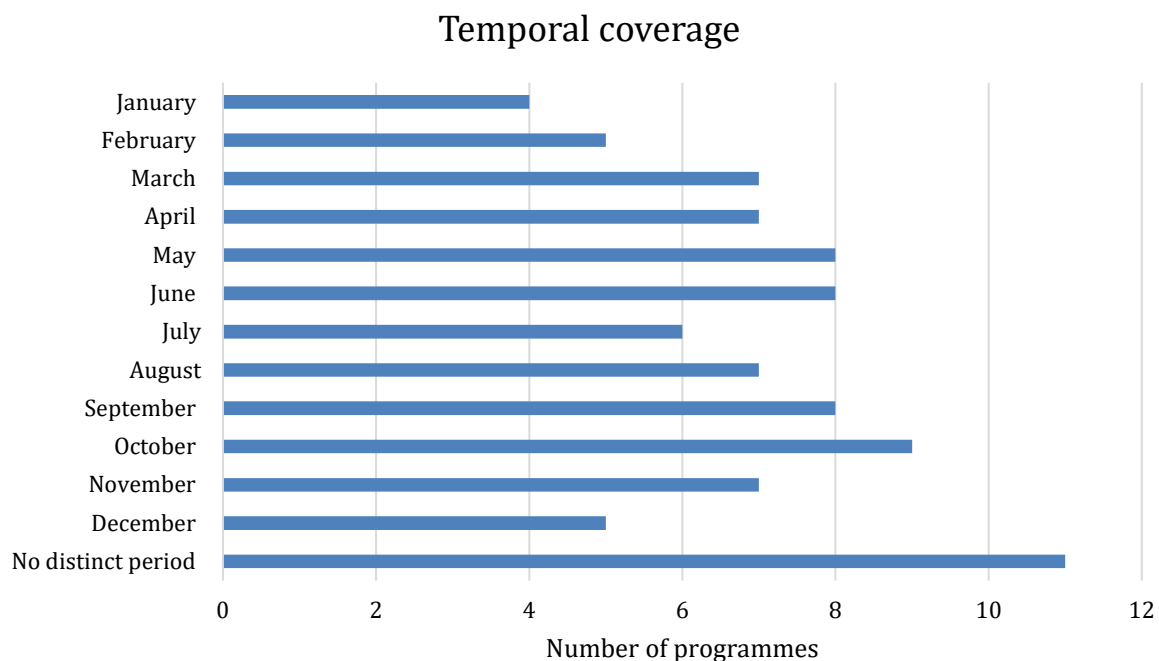


**Figure 7. Time of year when the Arctic community-based monitoring programmes undertook environmental observations (n=30 programmes).**

**The role of Indigenous knowledge.** The majority of the CBM programmes (53%; n=30) engaged Indigenous knowledge in some capacity. Of those that did not (30%), typically these were citizen science initiatives (Bonney *et al.* 2014) that engaged volunteers in collecting data for scientific research and monitoring purposes. These citizen science initiatives were often not based specifically in the Arctic but were either active over the entire country or in regions outside of the Arctic (Johnson *et al.* 2016). (See further discussion of Indigenous and local knowledge in the "good practices" and "challenges" chapters for additional information; Section 3.7 and 4.5).

**Linkages to economic sectors.** By their nature, CBM programmes tend to focus on issues of greatest concern to local stakeholders. We therefore assessed the Arctic CBM programmes' linkages to the economic sectors in the region. We found that the CBM programmes contributed to better-informed decisions or better-documented processes in the key economic sectors in the Arctic region (Table 1). These are the economic sectors of hunting/herding (60% of the CBM programmes; n=30), fisheries (47%), forestry (47%), shipping (43%), tourism (30%), and mineral and hydrocarbon extraction (17%).

**Table 1. The contribution of Arctic community-based monitoring programmes to key economic sectors in the Arctic region (green, contributed; orange, probably contributed; n=30 programmes).**

| Programme | Fisheries | Forestry | Herding/ hunting | Mineral and hydrocarbon extraction | Shipping | Tourism |
|---|---|---|---|---|---|---|
| A-OK | | | green | green | orange | |
| Arctic and Earth SIGNs | green | orange | | | | |
| Arctic Bordelands | green | orange | green | | | |
| Bird Phenology | | | | | | |
| BuSK | | | green | | | |
| CSIPN | green | orange | green | green | | |
| Evenk & Izhma Peoples | | orange | green | green | | |
| Farmers and Herders | | | | | | |
| Fávllis | green | | orange | | green | green |
| FMI Snow Depth | | orange | | | | |
| Fuglaverd | | | | | | |
| George River | green | orange | green | | orange | orange |
| Hares | | | green | | | orange |
| ION-Yukon River | | orange | | | | |
| LEO | green | orange | | | orange | orange |
| Marion Watershed | | orange | orange | orange | orange | |
| Nordland Ærfugl | | orange | | | orange | |
| Oral History | green | orange | | | | |
| Pilot whale | | | green | | orange | orange |
| Piniarneq | | | green | green | | orange |
| PISUNA | | | green | green | green | |
| Renbruksplan | | orange | green | green | | |
| River Owners Iceland | green | | | | | |
| SIWO | | | | | green | |
| Seal Monitoring | | | | | orange | orange |
| Walrus Haulout | | | green | | | |
| Wildlife Triangles | | orange | green | | | |
| Wild North | | | | | orange | orange |
| WinterBerry | | orange | | | | |
| Älgdata | | orange | green | | | |

## 2.4 The framework and format of knowledge products from the Arctic CBM programmes

**Field tools.** The methods used influence the format of the knowledge products. CBM programmes in the Arctic collect data in a variety of ways (Johnson *et al.* 2016). Broadly speaking, these can be

clustered into two approaches (further discussed in Section 3.6). One approach involves collecting physical or biological samples, measurements and observations (83%; n=30). The other uses more qualitative approaches based on perceptions from focus group discussions, workshops, and use of oral history-telling and interviews (40%). A total of 27% of the CBM programmes combined these two approaches, using both sample- and perception-based approaches.

**Time from data collection to decision-making**. Another aspect that is important for monitoring programmes is the time it takes from data collection to the data being available to users, particularly in rapidly changing environments such as the Arctic. CBM programmes have the potential to quickly lead to decision-making (Danielsen *et al.* 2010). We assessed how long the Arctic CBM programmes took from data collection until the data were available to the users. In 44% of 25 respondents, it took less than a month from data collection until the data were available to the users. For another 32% of the CBM programmes, it took between 6 and 12 months.

**Data validation.** Data validation approaches were built into the field data sampling strategies of 50% of the CBM monitoring programmes (n=30). It was most common for the CBM programmes to triangulate their data across community members or across methods (both approaches 27%; n=30). Less frequently, CBM programmes triangulated data across communities (20%) or used other types of validation (10%; n=30). Aside from validating data, most Arctic CBM programmes measured the efforts of the data collectors in their programmes (66%; n=30).

**Decision-making.** A key purpose of monitoring is to influence decision-making. Involving people who face the daily consequences of environmental changes in monitoring can enhance management responses across spatial scales and tackle environmental challenges at operational levels of resource management (Berkes and Armitage 2010). We assessed the CBM programmes in terms of their ability to influence decision-making at different levels. We found that the Arctic CBM programmes mainly informed decisions at a village, regional or national level (73%; 66%; 40% respectively; n=30). A small proportion of the programmes informed decisions at an international level (13%).

**Scientific support.** We assessed the overall technical expertise that underpins the monitoring programmes. Most CBM programmes had limited technical expertise available (65% of 20 respondents). The CBM programmes generally had the necessary technical expertise to sustain the operation of the programme, but some only had the expertise to sustain the programme in its present state and not in the case of e.g. a major breakdown in the programme.

**Sustained funding.** With regard to the long-term financial support that underpins the CBM programmes and assures long-term operation and sustainability, most CBM programmes had no continuous support or expectation of follow-up funding (75% of 20 respondents). The funding was tied to individual projects. A meagre 15% of the CBM programmes had a sustainable funding stream.

**Long-term data preservation.** International standards suggest that an archive should keep more than one copy, use different media technologies and preserve the datasets at different locations (Eynden *et al.* 2011; Parsons *et al.* 2011). Raw data and metadata should be retained to allow subsequent re-processing (further discussion in Section 3.5 and 3.6). Most CBM programmes have no archiving system or their data are only archived in a local archive and the long-term preservation of the data depends on a single small group of people (56% of 18 respondents). To help overcome some of these challenges, ELOKA has been founded in the U.S., but is available internationally as a data repository specifically designed for such data.

**Public databases derived from CBM programmes.** Most of the CBM programmes are presented on a website hosted by the programme or the responsible institution (90%; n=30; Annex A). Typically the websites present the aims of the programme, the communities involved, and the attributes and

locations that are being monitored. Occasionally, the CBM programmes have made their data publicly available via these websites (47%; see also Section 3.2 and 3.5).

**Overall challenges.** The CBM programmes reported that the principal challenge to their programmes was limited funding (67%; n=30). Other challenges were participant turnover at community level (33%), fatigue among community members (20%), various political challenges (17%), staffing turnover within government agencies (10%), and personal hardship (10%). None of the CBM programmes reported violations of intellectual property rights as a major challenge to their programme, presumably because the programmes had effective ways of addressing the rights of Indigenous and local communities (see Section 3.7). Challenges and how to address them are further discussed in Chapter 4.

**Sources of funding.** In terms of the source of financial support, the majority of the Arctic CBM programmes reported that they were being supported by government agencies (63%; n=30). Some were supported by civil society organizations (27%) and academic institutions (23%).

**Sustainability.** As a proxy for the prospect of sustaining the programmes, we assessed the financial costs related to data collection in CBM programmes. Most of the Arctic CBM programmes (67%, n=30) mentioned limited funding as the principal challenge. We asked the programmes how much the equipment required by one data collector costs. In most CBM programmes, the equipment needs were minimal (<100$; 73%; n=30). In a few programs, however, the equipment cost was 100-1000$ per data collector (20%) or more (>1000$; 7%).

## 2.5 Linkages to international agreements and UN Sustainable Development Goals

**International environment agreements**. In response to the global environmental crisis, several hundred international environmental agreements have been adopted by countries around the world (Mitchell 2003). These induce countries to change policies, and some have delivered major improvements by reducing environmental problems such as acid rain in Europe, the frequency of oil spills, the release of ozone depleting gases, and international trade in threatened wildlife (Kanie 2007). The Arctic governments (with a few exceptions) have adopted ten international environment agreements that are particularly relevant to the Arctic, and the EU has (in its policy on the Arctic) encouraged the implementation of these agreements (Table 2).

A major challenge in delivering international environmental agreements is that of linking the agreements to decision-making in the "real world". Jones *et al.* (2011) proposed that the most important objectives for monitoring progress in international environmental agreements were: (1) To evaluate environmental actions; (2) To inform policy choices; and (3) To raise awareness among the public and policy makers of sustainable development.

We assessed which of the ten international agreements in the Arctic the CBM programmes could contribute to in terms of monitoring progress. We found that Arctic CBM programmes could monitor progress in all ten agreements of particular relevance to the Arctic (Table 2). Moreover, two of the international agreements stand out as being particularly suitable for progress monitoring by the CBM programmes: The United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. A total of 100% and 80%, respectively, of the CBM programmes could monitor the progress of these (n=30). Our findings suggest that Arctic CBM programmes have the potential to become very important "vehicles" for the implementation of environmental agreements in the Arctic.

**Table 2. Multilateral environmental agreements in the Arctic that Arctic community-based monitoring programmes could (green), or probably could (orange), contribute to in terms of monitoring progress (n=30 programmes).**

| | AEWA | Bern | CBD | CITES | CMS | ICRW | OSPAR | POP | Ramsar | UNFCCC |
|---|---|---|---|---|---|---|---|---|---|---|
| A-OK | G | | G | | G | | | | O | G |
| Arctic and Earth SIGNs | G | | G | | G | | | O | O | G |
| Arctic Borderlands | G | G | G | | G | G | G | O | O | G |
| Bird Phenology | G | | G | G | | | | O | | G |
| BuSK | G | | G | | G | | | O | | G |
| CSIPN | G | | G | | G | | | O | | G |
| Evenk & Izhma Peoples | G | G | G | | G | | | O | | O |
| Farmers and Herders | G | | G | | | | | O | | G |
| Fávllis | G | G | G | | G | G | G | O | O | G |
| FMI Snow Depth | | | | | | | | | | G |
| Fuglaverd | G | G | G | | G | | G | | O | G |
| George River | | G | G | | | | | G | O | G |
| Hares | | | G | | | | | | | O |
| ION-Yukon River | | | | | | | | | | G |
| LEO | G | | G | G | G | | G | | | O |
| Marion Watershed | | | G | | G | G | G | G | | G |
| Nordland Ærfugl | G | | G | | G | G | | | O | G |
| Oral History | G | | G | | G | | | O | O | G |
| Pilot Whale | G | | G | G | G | G | G | O | O | O |
| Piniarneq | G | | G | | G | G | G | O | O | O |
| PISUNA | G | | G | | G | G | | O | G | G |
| Renbruksplan | | G | | | | | | O | | G |
| River Owners Iceland | | G | | | | | | O | | G |
| SIWO | G | | G | | | | | O | G | G |
| Seal Monitoring | | G | G | | | G | | O | | O |
| Walrus Haulout | | G | G | | | | | O | | O |
| Wildlife Triangles | G | G | G | | G | | | O | O | G |
| Wild North | G | G | G | G | G | | | O | | O |
| WinterBerry | | | G | | | | | | | O |
| Älgdata | | G | G | | | | | | | O |

Abbreviations: AEWA, Agreement on the conservation of African-Eurasian Migratory Waterbirds; Bern, Convention on the Conservation of European Wildlife and Natural Habitats; CBD, Convention on Biological Diversity; CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora; CMS, Conservation of Migratory Species; ICRW, International Convention for the Regulation of Whaling;

OSPAR, Convention for the Protection of the Marine Environment of the North-East Atlantic; POP, Convention on Persistent Organic Pollutants; Ramsar, Convention on Wetlands of International Importance; UNFCCC, Framework Convention on Climate Change.

**United Nations Sustainable Development Goals**. In 2015, the United Nations adopted the 17 Sustainable Development Goals (SDGs). In its policy for the Arctic, the EU has attached particular importance to actions that are in line with the SDGs in relation to research, science and innovation on climate change, sustainable development, and international cooperation. We assessed which of the 17 SDGs the Arctic CBM programmes contribute to achieving. We found that Arctic CBM programmes contribute to achieving 16 of the 17 SDGs in the Arctic including, e.g., "Life below water" and "Life on land" (Table 3).

**Table 3. The proportion of Arctic community-based monitoring programmes that contribute to achieving the United Nations Sustainable Development Goals (n=30 programmes).**



## 2.6 Summary: Capabilities

Chapter 2 describes the results of a self-reporting survey of the capabilities of Arctic CBM programmes. We examined the coverage, framework and format of the knowledge products and their linkages to key international policies in the Arctic. Our assessment is based on an analysis of the responses from

30 CBM programmes. The programmes were chosen to reflect the widest possible set of situations and issues.

There is a long history of CBM in the Arctic. Some programmes date back to the early 19th century or before. Community members of all ages are engaged in Arctic CBM programmes. In general, there is an overrepresentation of men but there are also programmes which mostly involve women. The programmes involve a broad variety of organizations, including community groups, all levels of government, universities, schools and industry.

Community members participate in CBM programmes for a variety of reasons. The motivation of community members is often to have their voices heard, protect their rights to resources, and sustain the health and abundance of wildlife. Many of the successful CBM programmes reported that they were contributing to capacity enhancement of the local community in several ways: socially, politically, psychologically and economically.

Arctic CBM programmes monitor biological attributes, abiotic phenomena, and socio-cultural attributes. Most programmes focus on the observing domains of "land/cryosphere" and "ocean/sea-ice". Few CBM programmes address the "atmosphere" domain. By their nature, community-based monitoring programmes tend to focus on issues of greatest concern to local stakeholders, thus having considerable potential to influence on-the-ground management activities. The programmes complement scientist-executed monitoring by enabling an increase in sample size, area and time. Most Arctic CBM programmes make observations between 61-70°N and only exceptionally beyond 81°N. Observations are undertaken in all major Arctic biomes, with the exception of ice desert. Data are typically collected throughout the year. The majority of Arctic CBM programmes involve Indigenous knowledge. The programmes contribute to better informed decisions or better documented processes in six key economic sectors in the Arctic: hunting/herding, forestry, shipping, fisheries, tourism, and mineral and hydrocarbon extraction.

Methods from both the natural and social sciences are often used. The programmes mainly inform decisions at village, regional or national level. Data are typically stored in one repository only and may therefore be susceptible to loss. Some programmes have made their data publicly available but few have links to data discovery portals or global repositories. Funding limitations are considered a significant challenge. To sustain the programmes, many use very low cost equipment.

The Arctic CBM programmes could contribute to monitoring progress in ten international environmental agreements of particular relevance to the Arctic. Moreover, they could contribute to achieving 16 of the 17 United Nations Sustainable Development Goals.

# 3. GOOD PRACTICE

Few people; extreme environments; huge distances; limited band-width; communities with a very close, and often historic connection to the environment. These are some of the features that characterize the Arctic.

How do you undertake CBM programmes under these conditions? In this chapter, we discuss good practice in Arctic CBM programmes in terms of establishing, implementing and sustaining the programmes, in obtaining impacts, being relevant and meaningful, and connecting with other approaches. We also discuss how to ensure the quality of monitoring data and knowledge products, and address the rights of participating Indigenous and local communities. Further suggestions for good practice in Arctic CBM programmes are available in Parlee & Lutsel K'e Dene First Nation (1998), Ecological Monitoring and Assessment Network (2003), Gofman (2010), Sigman (2015) and Johnson *et al.* (2015; 2016).

The chapter is based on a review of the scientific literature and workshops with CBM programme practitioners and community members engaged in CBM programmes. The workshops were held in Nuuk (Dec. 2016), Fairbanks (May 2017), the Russian communities of Komi and Zhigansk (Sep. 2017), and Quebec (Dec. 2017).

By "good practice" activities, we refer to activities that CBM programme facilitators or community members engaged in CBM programmes have highlighted to us as being important and effective when undertaking CBM programmes or activities that have been identified as useful in the scientific peer-reviewed literature.

The most recent review of good practice in Arctic CBM programmes was based on workshops held in 2013/14 (Johnson *et al.* 2016). There have been several important developments since. At the policy level, the use of Indigenous and local knowledge for informing decision-making has received increased attention. In 2016, U.S. President Obama convened the first Arctic Science Ministerial, meeting with Arctic Indigenous leaders to get their input into priorities for Arctic science. The joint statement released after the ministerial mentions community-based observing and "traditional and local knowledge" as components of an integrated Arctic observing system (White House 2016a). The Canadian government announced its intention to co-develop a new Arctic policy framework with northerners and Indigenous peoples (White House 2016b). Increased interest in Indigenous perspectives is also now seen in some national Indigenous districts in Russia (e.g. in the Evenk national Indigenous district declared in Zhigansk, Yakutia). Another example is the Greenland Government's coalition agreement in 2016 which specified at the ministerial level that the government's resource management should be based on both scientific advice and the observations and knowledge of Indigenous and local community members. At the technical level, there has been rapid development and uptake of user-friendly approaches to storing and sharing data and information in CBM programmes.

In this chapter, we highlight examples of good practice in Arctic CBM programmes in this new context, while emphasising emerging approaches which might be of broad interest.

## 3.1 Good Practice: Establishing CBM programmes

Every year, new CBM programmes are established in the Arctic (Kouril *et al.* 2016). Careful design can go a long way towards making the programmes successful.

It is fundamental that CBM programmes address the communities' priorities. Communities need to define the questions that the CBM programme should address. Moreover, the communities themselves should define the approaches for measuring and answering the questions (Fairbanks Workshop).

Community meetings to introduce and discuss the idea of a local CBM programme should be set up in the form of a dialogue. The focus should be on fruitful cooperation, and the role of the facilitators should primarily be to listen to the community members. The facilitator should be mindful of new ways of looking at things and avoid preconceived conclusions. The participants must come to their own conclusions, together, following the discussions.

How CBM programmes are established in practice depends on the context – particularly the stakeholders and the land/resource tenure system - as well as the proposed objectives of the CBM programme. A number of CBM programmes address fishing, hunting and herding, which are key economic sectors and important to the identity and culture of many Indigenous and local communities in the Arctic. An example from Arctic Russia is described in Box 1.

During the design of CBM programmes, one needs to consider what questions the monitoring aims to answer, and what community members and others are likely to do with the results. Moreover, management relations and support structures (roles and responsibilities, communication lines, funding etc.) also need to be considered (Section 4.6). If the purpose of the CBM programme is to influence decision-making, an understanding of who makes decisions needs to be obtained along with agreement on how the monitoring results will reach this body (Section 3.4). Sustainability of the effort should be incorporated into the design of the CBM programme from the start if the goals of that programme require long term work. One important approach to enhance sustainability of the observations is to respect the existing political and organizational structures in the area, and embed the monitoring within these existing institutions. Another important way is to keep the methods as simple and locally appropriate as possible (Section 3.3 and 4.3).

Men and women often have different community perspectives. For instance, men may focus interest on the weather and access to resources, and this frequently gains more attention. However, women focus for example, on the quality of meat and health of animals, is very important, too (Fidel *et al.* 2017). To ensure that CBM programmes address communities' priorities, both men and women should be directly involved in programme planning and design.

**Box 1. Example: Introducing a CBM Programme in Arctic Russia**

CBM programmes often begin with a meeting with the local community to introduce and discuss the idea of a CBM programme. Prior to this meeting, the community leader must have identified thos community members among the local fishers, hunters and herders, men and women, who are particularly knowledgeable about the natural resources.

At this initial meeting, the facilitator typically asks the participants about the challenges they face. Some of these challenges are often related to their livelihoods of fishing, hunting and herding. Community-based monitoring is then introduced as a tool that can assist with documentation and communication of changes or challenges to decision-makers; this approach can be useful in supporting communities to address challenges in a proactive way.

As an example, within a programme in Arctic Russia led by the *Centre for Support to Indigenous People of the North*, the Evenk and Izhma participants found that they wanted to monitor (Workshops in the Russian communities Zhigansk and Komi):

- Fish species, fishing activities and fishing methods,
- The animals that the community members hunt,
- Attacks by predators,
- The use of resources in the area by people from inside and outside the community,
- The changes in climate and the environment around the community (snow, ice, pollution).

When establishing this CBM programme, the facilitator agreed with the community members that they should regularly collect and share their observations on these topics. This could improve the livelihoods of the community and strengthen the community's rights to the use of the resources. More specifically, it would contribute to:

- Improved and more sustained access to fish,
- Better hunting regulations for animals that are hunted,
- Better management of predators,
- Better acknowledgement of the rights of their own community to use their land, and
- Improvements in addressing pollution in rivers and lakes.

In CBM programmes of this kind, monitoring is usually done as part of the routine fishing, hunting and/or herding activities. It is important to provide community members with guidance in terms of field techniques and how to make use of the data. Members of the CBM group will observe the various aspects of the environment in their area and meet

**Conclusions - Establishing CBM programmes:** Community members should play a central role in planning CBM programmes. The monitoring should reflect the priorities of the local communities, with attention to diversity within communities (including men and women's priorities), and be kept as simple and locally appropriate as possible. Management relations and support structures should be carefully considered during the design of CBM programmes. The programmes should be embedded within existing organizational structures. It is important (but not easy) to set up procedures to ensure that the community members' observations and management proposals reach and can be used by the management authorities in the area (see below). Attention should be paid to providing guidance to community members in field techniques and how to make use of the data.

## 3.2 Good Practice: Implementing CBM programmes

Moving from establishing to implementing CBM programmes will require organizational and support structures to sustain the efforts.

At the community level, at least one person needs to have responsibility for ensuring that meetings are held and that community members' observations are discussed and communicated to the management authorities and that feedback from the management authority is shared with all the participants. Maintaining interest among community members hinges on effective two-way communication between the participants and the management agency (discussed further in Section 3.3). Establishing parallel reporting lines can sometimes reduce delays in communication (Nuuk Workshop).

In those CBM programmes aimed at informing decisionmakers there is a risk that if the management authority does not take action or respond in a timely manner to the reports they receive, the community members may lose interest. The CBM programme must encourage the management authority to take the government policies of listening to local stakeholders seriously and ensure proper follow-up of information provided by community members.

Social media can be useful for exchanging observations, ideas and experiences between community members, further enhancing their commitment and engagement (examples below). In the same vein, it can be very useful for participants to meet community members engaged in other CBM programmes, to share information and gain inspiration.

The existing CBM programmes provide many examples of how data and information are stored, and results are fed to users and back to data gatherers. Sometimes CBM programmes store their data and information in ring binders or Excel spreadsheet files on a computer. The data can be located in the community with one of the community members or in the office of the institution facilitating the CBM programme. One advantage of using ring binders is that they are easy to maintain over time. The archiving and retrieval process is not dependent on external assistance, and recurrent costs are minimal (Brammer *et al.* 2016). However, a distributed archiving process can help with data back-up and reduce the risk of losing data stored in a single location.

Feeding results back to the data gatherers often requires special efforts. In Finland, *SnowChange Cooperative* uses videos for reporting the results of oral history documentation of Indigenous and local knowledge about river basins, reaching community members, youth and the broader public (Mustonen 2014; Mustonen *et al.* 2018). The *University of the Faroe Islands* stores data from hunters' self-monitoring of mountain hare hunting in a web-based database and uses Facebook to discuss managing the outfield landscapes with the hare hunters (Magnussen 2016).

One disadvantage of storing CBM data and information in ring binders and digital files is that the data can be difficult to access, not only for other community members but also for decision-makers and those that can influence management decisions. This problem gets worse when data and information is accumulated from wider areas and over a longer time span (Quebec Workshop). Some CBM programmes use web-based digital ('knowledge management') platforms for storing data and for feeding the results back to data gatherers. Several CBM programmes have developed their own platforms. The *Gordon Foundation* has set up a platform for sharing data on water quality (MackenzieDataStream.ca). This platform is in use in 23 communities along the MacKenzie River. With support from Google, the *Arctic Eider Society* has developed a platform that connects with social

media networks. This is used for multiple, Inuit-identified priority areas within research, education, environmental stewardship, and health in five communities in Hudson Bay (arcticeider.com/sikuhelp).

***Carleton University*** with partners such as the Kitikmeot Heritages Society and ***ELOKA (Exchange of Local Observations and Knowledge for the Arctic)*** are cooperating with several CBM programmes to lead the development of an adaptable open source software called Nunaliit ([http://nunaliit.org,](http://nunaliit.org) [https://gcrc.carleton.ca/index.html?module=module.gcrcatlas_atlases)](https://gcrc.carleton.ca/index.html?module=module.gcrcatlas_atlases) to develop tailor-made platforms for visualizing and storing different types of data and information generated by CBM and community-led research projects. Platforms include digital atlases and maps and online databases that store, archive, and share observations documented by Indigenous observers, with attention to ensuring that communities control data access.

ELOKA uses a series of platforms to support CBM including Nunaliit and custom applications. For example, the Yup'ik Environmental Knowledge Project and Atlas ([http://eloka-arctic.org/communities/yupik/atlas/index.html)](http://eloka-arctic.org/communities/yupik/atlas/index.html) shares and documents Yup'ik place names and environmental knowledge in the Yukon-Kuskokwim Delta in Alaska under the guidance of Calista Education and Culture. The online atlas contains over 3,000 Indigenous place names and a rich collection of stories, videos, and other related information. The communities have trained local students to add their own data to the atlas. Custom products such as the SIZONet platform meet the specific needs of CBM programmes ([https://eloka-arctic.org/sizonet/](https://eloka-arctic.org/sizonet/) and [https://eloka-arctic.org/pisuna-net/](https://eloka-arctic.org/pisuna-net/)).

***The Government of Nunavut***'s Department of Environment documents Inuit knowledge through participatory mapping of fish, marine mammals, birds, aquatic plants and invertebrates. They have completed the mapping of 22 coastal communities (Quebec Workshop). This programme feeds data into an online map-based platform (Nunaliit) and, at the same time, prepares paper reports with monitoring results for the communities. The role of the platform is to help direct science priorities, identify fisheries development priorities and advise management bodies.

***The Local Environmental Observer*** network of the Alaska Native Tribal Health Consortium has established a platform whereby individuals can post observations when they see something unusual, for instance related to seasonality, timing of snow melt, water quality, or sanitation (leonetwork.org). Community members who post an observation are often connected to a scientist that can help them answer questions about the issue. This programme keeps observers engaged through a digital newsletter and also hosts conference calls. The network also serves as a link to more systematic community-based monitoring, such as harvest monitoring by local government agencies or sea-ice observations that feed into ELOKA.

**Conclusions - Implementing CBM programmes:** Online platforms create possibilities for sharing community-produced observations across sites and scales of decision-making. One disadvantage of using web-based platforms, however, is the expertise and resources required to establish and maintain a platform. Because funding is often time limited, platform maintenance is a particular challenge. Programs should consider an appropriate long-term repository of data, including the best platform or data repository, during the design phase. The discussions should consider implications for community access and control of data and information beyond the period of available program funding.

## 3.3 Good Practice: Sustaining CBM programmes

To sustain CBM activities and ensure that CBM programmes continue to be relevant over time, it is important to maintain the long-term interest and involvement of community members. When a

management agency is involved or leading the process, it is also important to avoid frequent turnover of their staff.

What can CBM programmes do to maintain the long-term interest and involvement of community members? Several CBM programmes suggest the strongest incentive is seeing that the information from the observing efforts is actually being used to inform management decision-making (further discussed in Section 3.4). CBM programs must ensure that information is made available to decision-makers at the relevant and appropriate scale, including community organizations (such as Hunters and Trappers Organizations in Canada), co-management boards, and regional and state agencies, when appropriate (Nuuk Workshop).

Another opportunity for maintaining interest among community members is to use tools and approaches for data collection that can be easily incorporated into their day-to-day activities (Section 3.1). CBM programmes can also consider carefully how programme participants benefit from the programme and set up a reward system of tangible benefits for those community members who participate.

In Nunavut, the ***Community-Based Monitoring Network*** of the Nunavut Wildlife Management Board collects data on observations and hunting activities based on the 1992 Land Claims Agreement (www.nwmb.com). The network has a goal of providing information to the Board that will help develop management plans, identify important harvesting areas, document species distribution, movement, and health of wildlife, and identify issues that may require further research. A clerk in each community uploads the observation data such as start and end point of each hunting trip, means of transport, and what was harvested. Different cash or prize drawings are made every other week, monthly, and twice a year as incentives for observers in participating communities (Quebec Workshop). After three full years of data collection in three communities, the programme moves on to three new communities, based on a call for expressions of interest from other Nunavut communities interested in participating in the network.

Frequent staff turnover at the management authority level can constrain sustainability and this can be difficult or impossible to avoid. Encouraging the involvement of multiple management authority staff members reduces the risk that loss of any one person will have a detrimental effect on the CBM programme's overall activities (Nuuk Workshop).

**Conclusions - Sustaining CBM programmes:** Actions that CBM programmes can take to encourage continued interest among community members include ensuring that the participants' observations are used for decision-making and that they are informed of how the information is being used. Other actions that can be taken are the use of tools and approaches for data collection that can easily be incorporated into the day-to-day activities of the participants, and setting up a relevant reward system. The effects of frequent management authority staff turnover can sometimes be minimized by involving multiple staff members in the CBM programme.

## 3.4 Good Practice: Obtaining impacts through CBM

Arctic CBM programmes have impacts on a wide range of decisions, from quotas and fishing permits, to wetland restoration, Indigenous food systems, and safety measures (see below).

Many CBM programmes have developed and begun using specific protocols and procedures to enable management authority agencies to incorporate local and CBM-derived information on natural resources and resource use in decision-making. Nevertheless, CBM practitioners report that management agencies are slow at taking action in response to observations emanating from CBM

programmes. This suggests that further advocacy is needed to get management agencies follow government policies on local stakeholder participation in land/resource management, and to incorporate information from CBM programmes into their decision-making (discussed in Section 4.1). This also suggests that further efforts are needed to raise awareness within management agencies as to the value of Indigenous and local knowledge and observations, and to wholeheartedly incorporate CBM programmes into national policies, the administrations' funding streams, and the job descriptions of the Arctic governments (Nuuk Workshop).

In Iceland, the *Federation of Icelandic River Owners* is keeping track of the number of salmon and trout fished in 180 rivers across the country. The programme was established in 1932. Every year >1,000 anglers report their catch. The results of the monitoring are used to divide the economic benefits from the river owners' selling of fishing permits and to ensure sustainable harvesting (angling.is). The monitoring programme is operating in accordance with the Fisheries Act of the Government of Iceland (No. 61 of 2006, with adjustments). With national policy support, the programme has been institutionalized and today constitutes a central component of Iceland's management and monitoring of its rivers.

In Greenland, the *Piniakkanik Sumiiffinni Nalunaarsuineq* (PISUNA) programme of the Ministry of Fisheries and Hunting introduced a system for communities to advance natural resource management recommendations to municipal and national authorities based on the fishers' and hunters' own review and assessment of observed trends in the status of natural resources (https://eloka-arctic.org/pisuna-net/ and www.pisuna.org). The PISUNA programme keeps track of management interventions resulting from the monitoring. Ninety kinds of interventions have been proposed involving 30 species of fish, mammals and birds. Some proposals have been dealt with (e.g. changes in hunting seasons of ducks and geese) but many are awaiting decisions and action by the local or central authorities. The experiences suggest that management interventions are useful to track because they can indicate the possible management impact of the programme and provide direction about the aims of the CBM programme.

In Canada, the *Arctic Borderlands Ecological Knowledge Society* aims to monitor and assess ecological changes within the range of the Porcupine Caribou herd and adjacent coastal and marine ecosystems. Information is documented by community monitors during interviews with local experts. The information is used by the Porcupine Caribou Management Board and by the government for co-management and decision-making, particularly with regard to harvest quotas for caribou among Gwich'in and Inuvialuit harvesters, and also by researchers.

In Finland, *Snowchange Cooperative* has established a CBM programme with fishers in Jukajoki Basin. This area is a peat swamp that has been heavily damaged by industrial activities and is the location of one of the largest aquatic habitat restoration activities in the Arctic (Mustonen 2014). The CBM programme helps fishers document the fish resources and communicate key aspects of local knowledge about the peat swamps to those in charge of restoring the wetlands (snowchange.org). The programme thus helps guide the habitat restoration efforts, contributes to co-management and complements other initiatives to include local perspectives in the stewardship of the landscape.

In Norway, the *International Centre for Reindeer Husbandry* has tested the use of Indigenous and local knowledge for improving Indigenous Saami food systems. Their perspective is to develop Indigenous and local knowledge standards for improved production and processing of reindeer-based food. They have documented reindeer herders' Indigenous knowledge standards on Saami slaughtering processes and meat-smoking practices (reindeerherding.org). The new standards contribute to strengthening the Saami's Indigenous food systems.

In Alaska, the **Sea Ice for Walrus Outlook** (SIWO) initiative provides weekly reports from April through to June, depending upon presence of sea ice, with information on weather and sea-ice conditions relevant to walrus in the northern Bering Sea and southern Chukchi Sea regions of Alaska. The National Weather Service contributes satellite images and ice and weather forecasts for each community. Local observers in the communities send in their observations and pictures of the current conditions each week, as well as relating similarities and differences compared to years past, helping improve operational weather and ice forecasts (Deemer *et al.* 2018). This information is posted to the project's website and Facebook page. Hunters in Indigenous communities can use the information to plan and coordinate scouting and hunting trips.

**Conclusions - Obtaining impacts through CBM:** Arctic CBM programmes can have an impact on many kinds of decisions by providing information to management authorities and community members. Some CBM practitioners have found it useful to keep track of the management interventions that result from CBM programmes. Greater impacts may be obtained by further developing protocols and procedures to enable management agencies to incorporate CBM-derived information into decision-making, and by bringing communities together, sharing information, and promoting advocacy on the importance of using information from CBM programmes. Greater impacts may also be achieved by further developing national policies in support of CBM programmes, and requirements to incorporate information from CBM into the decision making process.

## 3.5 Good Practice: Connecting and cross-weaving with other approaches

As well as providing data with which to inform management decisions at local or provincial and national levels, CBM has the potential to shed light on changes in the environment on a national and even international scale (IASC 2013). In this section, we will highlight good practice among Arctic CBM programmes in (1) connecting with scientist-executed monitoring programmes and (2) contributing to global data repositories to ensure maximum scientific usage and track larger-scale trends.

In terms of CBM programmes connecting with scientist-executed monitoring programmes (1), there is limited knowledge of good practice. Some Arctic CBM programmes are intertwined with scientist-executed monitoring programmes at the interpretation level (communities contribute to designing the methods and to collecting data and initial interpretation of the results, and the preliminary results are then handed over to scientists), and scientists present the (combined) results for decision-makers. Other CBM programmes run on their own; representatives of community members or facilitators of the CBM programmes present the results of the programme to decision-makers, who may receive information on the same topic from parallel monitoring programmes undertaken by scientists (in those few cases when such information is available).

One example of a CBM programme that is successfully intertwined with larger-scale scientist-executed monitoring is the **Indigenous Observation Network** (ION), which is led by the Yukon River Inter-Tribal Watershed Council and includes partner Indigenous communities and the U.S. Geological Survey. Data collected by ION is informing basin-wide planning of the Yukon River in Alaska and Canada. Communities have used the data for community planning on safe drinking water, wastewater and solid waste management, and for advocacy to protect clean water and salmon. Regionally, the data have been used to inform the Yukon River Water Quality Plan that was adopted by Alaska Native Tribe and Canadian First Nation representatives in 2013. The goal of the Plan is to keep the Yukon River and its tributaries 'substantially unaltered from natural conditions', and the data generated by the ION is used to guide further monitoring efforts and assess river conditions with this overarching goal in mind. Other examples of CBM programmes that are intertwined with larger-scale scientist-executed monitoring are the **Alaska Arctic Observatory and Knowledge Hub** (Section 3.7) and the **Federation of Icelandic River Owners** programme to monitor rivers in Iceland (Section 3.4).

Examples of CBM programmes run on their own but where the results are forwarded to management authorities for decision-making after comparisons of findings with advice from scientists, include fishing and hunting harvest statistics programmes in many countries, and the *Piniakkanik Sumiiffinni Nalunaarsuineq* programme in Greenland (Section 3.4 and 3.6).

In terms of CBM programmes connecting with international repositories (2), there are many open access global repositories that may be of relevance to Arctic CBM programmes. Fourteen examples of repositories from the federated metadata search portal, the Arctic Data Explorer (http://arctic-data-explorer.labs.nsidc.org/) are listed in Table 3. According to the information at this website, a small number of CBM programmes have already shared datasets with these repositories or are referenced by their catalogues. A total of 117 out of the 45,527 datasets in these 15 repositories are derived from CBM programmes (0.3%).

**Table 3. Examples of open access, global repositories of relevance to Arctic CBM programmes and the number of datasets derived from indigenous and local knowledge. Indigenous and local knowledge data may only include metadata, pointing to repositories such as ELOKA. Source: http://arctic-data-explorer.labs.nsicd.org (Jan. 2018).**

| Repository Name | Datasets total | Datasets derived from Indigenous and local knowledge |
|---|---|---|
| National Science Foundation Arctic Data Center | 10,753 | 48 |
| Polar Data Catalogue | 2,557 | 46 |
| National Aeronautics and Space Administration Earth Observing System Clearing House | 14,316 | 12 |
| University Corporation for Atmospheric Research National Center for Atmospheric Research Earth Observing Laboratory | 2,024 | 6 |
| National Oceanic and Atmospheric Administration National Oceanographic Data Center | 6,352 | 0 |
| NOAA's National Centers for Environmental Information, World Data Service for Paleoclimatology (NOAA WDS Paleo) | 3,703 | 0 |
| Biological and Chemical Oceanography Data Management Office | 1,526 | 0 |
| Global Terrestrial Network for Permafrost | 1,404 | 0 |
| Rolling Deck to Repository (R2R) | 914 | 0 |
| U.S. Geological Survey ScienceBase (USGS ScienceBase) | 499 | 0 |
| International Council for the Exploration of the Sea (ICES) | 470 | 0 |
| Norwegian Meteorological Institute (Met.no) | 201 | 0 |
| University Corporation for Atmospheric Research National Center for Atmospheric Research Research Data Archive | 173 | 0 |
| The Digital Archaeological Record (tDAR) | 85 | 0 |

Moreover, to help make the datasets derived from monitoring programmes discoverable, data discovery catalogues may be useful. For instance, a total of 46 monitoring programmes with CBM or

citizen science components in the Arctic, including the **Western Arctic Beluga Health Monitoring** and the **Inuvialuit Settlement Region Community-based Monitoring Programme**, have published metadata on their datasets in the data discovery catalogue EUDAT-B2FIND according to information in the catalogue (http://eudatmd1.dkrz.de/dataset?tags=Community-based+monitoring).

CBM programmes may potentially fill gaps in the existing Arctic data delivery chains. Our overview of attributes monitored by the existing CBM programmes (Chapter 2) suggests that the programmes are particularly effective in tracking the delivery of goods and services from natural ecosystems. Ecosystem benefits are a prime focus of several international environmental agreements (Convention on Biological Diversity 2018) yet are extremely hard to monitor using a top-down approach. Moreover, CBM programmes can complement Arctic scientist-executed monitoring programmes by enabling an increase in sample size, area and time.

Participants at the Fairbanks Workshop stressed the immense value of data sharing; the more information is distributed, the more valuable it becomes because people can make use of it. However, the participants also noted that not all data can, or should, be shared (Pulsifer 2015). Intellectual property rights, data sovereignty, and customary law must be respected (Young-Ing 2008; Scassa *et al.* 2015).

CBM programmes are based on Indigenous and local knowledge systems that cannot be directly compared with scientist-executed monitoring programmes. When connecting different branches of science with CBM programmes, one has to recognize the often asymmetric power issues arising (Tengö *et al.* 2017). When scientists "assimilate local ecological knowledge within Western worldviews" (Mistry and Berardi 2016), there is a risk that it may further marginalize Indigenous and local people. For organizers of CBM programmes to effectively share their data with global repositories, suitable terms of cooperation must therefore be established. Agreements on cooperation between CBM programmes and the global repositories should address principles of intellectual property rights, "Free Prior and Informed Consent" (further discussed in Section 3.7 and 4.5; United Nations 2008), respect for knowledge holders, and reciprocity (Pulsifer *et al.* 2011).

**Conclusions - Connecting and cross-weaving with other approaches:** There is limited knowledge on good practice in connecting CBM programmes with scientist-executed monitoring programmes. Some programmes are intertwined into scientist programmes at the interpretation level, others run independently and in parallel with scientist programmes where these are available. Further work is required to identify the gaps in existing Arctic data delivery chains that CBM programmes might plug into. Examples of the successful incorporation of both CBM and scientists' programme data into decision-making should be highlighted to encourage further cooperation. Only a tiny number of CBM datasets are currently included in Arctic data repositories. Representatives of Indigenous and local communities should decide whether data from their CBM programmes should be connected with global repositories and the process must take place in accordance with their "Free, Prior and Informed Consent". When appropriate, CBM programmes could make their datasets publicly available and connect with global repositories founded for the purpose such as ELOKA.

## 3.6 Good Practice: Ensuring the quality of knowledge products

One barrier to maximising the potential of Indigenous and local knowledge in CBM programmes for decision-making has been the perception among management agency staff and scientists that information from local people is subjective and anecdotal (Moller *et al.* 2004; Eicken *et al.* 2011). A growing body of literature demonstrates, however, that where Indigenous and local knowledge is systematically gathered, data collected by community members are as reliable as those of professional scientists (Danielsen *et al.* 2014a-c).

The community perspective is relevant too. If scientists do not possess the social and cultural skills to appreciate context and locality then Indigenous and local communities will often view their initiatives with suspicion. There is therefore a need to establish credibility in both directions (Huntington 2011; Huntington *et al.* 2013). We would like to further describe and discuss good practices in how scientists can improve their legitimacy and credibility within communities but this is beyond the scope of the present report.

In this section, we draw on previous research on CBM internationally to discuss good practice in terms of accuracy and precision of knowledge products from CBM programmes. Although measurements by community members can compare well with similar measurements by scientists, CBM approaches to monitoring can, in some contexts, be more vulnerable than professional techniques to various sources of bias, thus decreasing their accuracy (defined as the closeness of the resulting measurements to their true values).

Key potential problems include a lack of measuring experience on the part of observers (which often leads to over- or under-estimates of abundance and size); potential conflicts of interest (with recorders perhaps inadvertently providing data that are biased towards managers' preconceptions); a tendency, in the absence of careful documentation, for methods to drift over time, or for results to reflect long-term ('fossilized') perceptions more than current trends; and the potential for the spatial or temporal coverage of monitoring to be unrepresentative of the entire system of interest (Danielsen *et al.* 2005).

Besides accuracy, the utility of monitoring can be limited by the precision of the results (that is, the closeness of repeated measurements of the same quantity to each other). Sources of low precision (leading to high variance around the estimated true value of the attribute of interest) may include small sample sizes; overly thin or patchy temporal or spatial deployment of sampling effort; the physical loss of data; and the inconsistent application of methods, either over time or across observers. These problems can affect all monitoring but are likely to be a particular problem where financial or professional human resources are limited.

The potential limitations of CBM can be overcome by careful planning, explicit consideration of likely biases, and thorough guidance and supervision of the participants.

CBM programmes use sample- and perception-based methods for data collection (further discussed in Section 2.4). For sample-based programmes, one important way of reducing bias is to allocate individuals with a rank based on their knowledge, allowing data to be disaggregated according to this ranking. For perception-based CBM programmes, other measures are relevant, as summarized in Table 4.

1. Establish independent focus groups in multiple communities that know resource abundance in the same geographical area (triangulation across communities);
2. Convene regular, e.g. annual, village meetings to present and discuss data and interpretation and obtain feedback from the entire community (triangulation across community members);
3. Facilitate the collection of auxiliary data through, e.g. community members' direct counts of resources in the same area (triangulation across methods);
4. Include individuals within the focus groups who are themselves directly involved in using and observing natural resources (thereby increasing the number of primary data providers);
5. Use unequivocal categories of resource abundance;
6. Ensure that the moderator of the focus group discussions has skill and experience in facilitating dialogue.

Below we present the experiences of three CBM programmes in terms of demonstrating the quality of their knowledge products. In Greenland, the ***Piniakkanik Sumiiffinni Nalunaarsuineq*** (PISUNA) programme of the Ministry of Fisheries and Hunting compared community members' perceptions with trained scientists' reports. The comparison of trends in abundance focused on 24 attributes that were summarized by 33 community members from 2009-2011 in Disko Bugt. The community members and the professional scientists produced similar results for 12 attributes (Table 5). Only for two populations, nearshore Greenland halibut and breeding Arctic tern, was there disagreement between local and scientists' reports of trends in abundance. For ten attributes, it was not possible to locate any scientist-produced data to allow for a comparison with the community members' findings. The results suggest that this CBM programme yields information that can be as reliable as that derived from professional scientist-executed monitoring.

**Table 5. Comparison of community members' perceptions and trained scientists' assessments of trends in abundance of sea ice, two human activities and 21 populations of fish, mammals and birds in North West Greenland 2009-2011 under the Piniakkanik Sumiiffinni Nalunaarsuineq (PISUNA) programme.**

| | Attribute | Perceptions* | Scientists' assessments | Source* | Correspondence |
|---|---|---|---|---|---|
| Fish | Polar cod, D | ‡ | Few data | Siegstad 2011 | N.a. |
| | Wolffish *spp.*, D | ↑ | ↑/⇔ | Siegstad 2012 | (□) |
| | Greenland halibut | ↑ | ↓/⇔ | Siegstad 2011; 2012 | ⊘ |
| Marine mammals | Ringed seal | ↓ | Few data | Boertmann 2007; Rosing-Asvid 2010 | N.a. |
| | Harp seal, D | ↑ | ↑ | Department of Fisheries and Oceans 2010; Rosing-Asvid 2010 | □ |
| | Narwhale | ‡ | Few data | North Atlantic Marine Mammal Commission 2012 | N.a. |
| | Humpback whale | ↑ | ↑ | Heide-Jørgensen *et al.* 2011 | (□) |
| | Minke whale, D | ↑ | ↑ | Heide-Jørgensen *et al.* 2010 | (□) |
| | Minke whale, U | ⇔ | Few data | No information | N.a. |
| Land mammals | Arctic fox, D | ↑ | Few data | Boertmann 2007 | N.a. |
| | Caribou, N | ⇔ | ⇔ | Cuyler *et al.* 2005; Cuyler & Nymand 2011 | □ |
| | Musk ox, L | ‡ | Few data | No information | N.a. |
| Birds | Snow goose, D | ↑ | ↑ | Boertman 2007 | □ |
| | Greenland white-fronted goose | ↓ | ↓ | Boertmann 2007; Boyd & Fox 2008 | □ |
| | Canada goose | ↑ | ↑ | Bennike 1990; Fox *et al.* 1996; Boertman 2007 | □ |
| | Common eider | ↑ | ↑ | Chaulk *et al.* 2005; Merkel 2010 | (□) |
| | White-tailed eagle | ↑ | Few data | No information | N.a. |
| | Large gulls*, D | ↑ | Few data | Boertmann 2007 | N.a. |
| | Arctic tern, D | ↑ | ⇔ | Boertmann 2007; Egevang & Frederiksen 2011 | ⊘ |
| | Brünnich's guillemot, breeding | ↓ | ↓ | Burnham *et al.* 2005; Labansen & Merkel 2012 | □ |
| | Little auk, D | ↑ | Few data | Egevang & Boertmann 2001; Boertmann 2007 | N.a. |
| Other | Winter sea ice*, U | ↓ | ↓ | Danish Meteorological Institute | □ |
| | Offshore ships, U | ↑ | ↑ | Arctic Marine Shipping Assessment 2009 | (□) |
| | Trawling, D | ↑ | Few data | No information | N.a. |

Legend: ↑, increased abundance; ↓, declining abundance; ⇔, no major change in abundance; ‡, increased abundance reported in some areas, decline in other areas; Few data, little or no abundance data available; □, correspondence between community members' and scientists' assessments; (□), probable correspondence between community members' and scientists' assessments but the time, area and/or temporal/spatial scale of the assessments do not match; ⊘, no correspondence. D, Disko Bugt; L, Naternaq/Lersletten and Svartenhuk; N, Nassuttooq/Nordre Strømfjord; N.a., not applicable; U, Uummannaq Fjord. *For literature cited, Latin names and details, see Danielsen *et al.* 2014c.

In Alaska, the CBM programme of the **Yukon River Inter-Tribal Watershed Council** (YRITWC) has created datasets that have been widely recognized for their high quality. YRITWC is an Indigenous non-profit organization consisting of 73 Canadian First Nations and Alaska Native Tribes within the Yukon River Watershed. They have the vision 'to be able to drink water directly from the Yukon River'. When the organization was formed in 1997, they dedicated themselves to several tenets, one of which was *'…to understanding the Yukon River Watershed by means of monitoring, measuring and researching, and to use this knowledge to clean, enhance and preserve life…'.* Indigenous peoples living within the river's watershed were concerned about maintaining the health of the river as it is seen as essential to supporting their way of life.

In 2006, a partnership was created with 31 Indigenous governments in Alaska and Canada, the U.S. Geological Survey (USGS) and YRITWC to develop a monitoring programme on the Yukon River and its tributaries in order to study water quality indicators of the river and thus monitor its health (Indigenous Observation Network, ION). The aim of the data collection was for the communities to inform community water resource planning and regional decision-making, whereas the USGS's interest was to investigate climate change indicators and water quality impacts. To be successful, the data needed to be considered reliable by both the partner Indigenous community members as well as the scientific community.

Sampling protocols were developed in partnership to ensure high-quality data collection. Over the years, ION has created a 10-year water quality baseline dataset from which to measure the health of the river. Over 300 community members have been trained in USGS water monitoring protocols, and this has resulted in >1,500 samples collected at 54 sites along the 3,700 km length of the river, from the headwaters to the Bering Sea.

These efforts generated a baseline record (long-term at some sites) of water quality in the river basin, important for understanding climate change impacts. In interviews with Indigenous partners, data generated by ION was recognized as more credible than data collected by industry or government, because 'our people' were the ones collecting it, and the data was found to be useful for decision-making at both regional and community level (Wilson 2017). The data have been utilized in 17 peer-reviewed scientific publications to better understand large-scale environmental and climate-associated changes occurring within the watershed.

In Canada, the **Inuvialuit Settlement Region Community-Based Monitoring Program** (CBMP) has established an elaborate plan for verifying their data and information. This program compiles bird, fish and mammal harvest information each month from six communities to support decision-making by Inuvialuit organizations and co-management boards. Nine Community Resident Technicians work together with local Hunters and Trappers Committees, using iPads and an associated application to remotely upload data onto the Inuvialuit Settlement Region Platform. The program employs a four-step verification process, which involves (1) the Community Resource Technicians comparing written data records with what has been uploaded to the online platform (2) the Hunters and Trappers Committees (HTC) comparing data to previous years, using their unique local knowledge to assess reporting accuracy, and searching for anomalies and observations that are beyond the normal or expected range, (3) the Resource Person associated with each Hunters and Trappers Committee verifies the paper records with the online version to check for data transfer errors, and (4) the CBMP Coordinator verifying paper data records, with the online platform and transferring relevant information to appropriate groups and/or managing anomalies and observations as observed by the HTC (Quebec Workshop).

**Conclusions – Ensuring the quality of knowledge products:** CBM programmes are taking a number of different measures to ensure the quality of the knowledge products they generate. Key potential measures include careful planning, explicit consideration of likely bias, and storing the data in its most

disaggregated form and with details of exactly how it was collected. Other measures include carrying out checks to keep errors in recording and data storage at an acceptable level, and incorporating triangulation of the recorded data, or allocating individuals with rank based on their knowledge and allowing data to be disaggregated according to this ranking. Finally, as in any initiative, thorough guidance and supervision of the participants is important. As CBM programmes differ in their goals and focus, some may not take these measures, but still be relevant and important.

## 3.7 Good Practice: Addressing the rights of Indigenous and local communities

Many CBM programmes offer successful examples of the use of Indigenous and local knowledge for sustainable environmental monitoring. Rights may relate to: (1) land and resources; and (2) the knowledge and information that belongs to Indigenous and local communities.

With regard to rights related to land and resources (1), many CBM programmes in the Arctic have the primary aim of enabling Indigenous and local communities to be "heard" by management agencies, thereby promoting the rights of the Indigenous and local communities to land and resources. One example is the CBM programme of the new self-rule *Thcho Government* in Canada. This programme has engaged Indigenous and local community members to monitor the Marian watershed, where mining is planned. Information from the observers has led to the relocation of planned paved roads to avoid fish habitats and the migratory routes of moose (Quebec Workshop). Stories such as this need to be told and broadly disseminated (see also Section 4.5).

Other examples of CBM programmes that enable Indigenous and local communities to be "heard" by management agencies are the CBM programmes established by the *Centre for Support to Indigenous People of the North* in Russia and the programmes by *SnowChange Cooperative* in Finland, *Piniakkanik Sumiiffinni Nalunaarsuineq* in Greenland, and the *Arctic Eider Society* in Canada (further discussed in Sections 3.1, 3.2 and 3.4).

With regard to the knowledge and information that belong to Indigenous and local communities (2), all CBM programmes must follow principles of "Free, Prior and Informed Consent" and take care to protect the intellectual property rights of Indigenous and local communities.

Visitors sometimes do not respect the rights of Indigenous and local communities. There are, however, protocols and procedures for enabling a respectful use of Indigenous and local knowledge. *YRITWC*, for instance, has published a sample agreement between researchers and Indigenous peoples. This document describes the expectations that Indigenous peoples may have of researchers when collaborating on projects, see:
https://docs.wixstatic.com/ugd/dcbdaf_0c50d62580124f2b9789ad6d1194d536.pdf.

Clarifying data ownership and data use rights is essential for all CBM programmes. The *Arctic Borderlands Ecological Society* (ABES) has been documenting local experiences of ecological change in the area of the Porcupine Caribou herd since 1993. Local experiences are different from Indigenous knowledge, however, and many community members have pointed out to ABES over the years that most of the experts who are interviewed are Indigenous knowledge holders and so the information they give is informed by Indigenous knowledge (Fairbanks Workshop). It is important that the data remains the property of those who create it. It is likewise important that the process for gaining access is to the satisfaction of the communities involved. Currently, anyone wanting access to the data is required to apply to the communities they are requesting the data from. This process works to preserve and protect intellectual property but can be seen, incorrectly, as limiting access.

The ***Alaska Arctic Observatory and Knowledge Hub*** has developed an approach of respecting the data ownership of the Indigenous and local communities while, at the same time, making some data publicly available. With the Exchange for Local Observations and Knowledge of the Arctic (ELOKA) and building on a predecessor project, the Seasonal Ice Zone Observing Network, they have established a database of local observations on sea ice, wildlife and weather (Eicken *et al.* 2014). The data come from daily narrative observations by sea-ice experts and Indigenous subsistence hunters in Arctic coastal Alaska, and includes over 6000 observations from 2006 to the present. Eleven coastal communities contribute to the database although not all communities provide regular observations. There are two levels of access to the data: guest and registered user. The guest level of access contains summary information categorizing ice, weather and wildlife observations but does not contain the full text of observations, which may contain sensitive information. The database can be searched by hunter, community, data and keyword. The information in this database is generously shared with the public by the observers and the communities within which the observers reside. Before browsing or using the information in the database, however, guests have to agree to adhere to a set of ethical and appropriate use guidelines, and to cite the data if it is used in publications, see https://eloka-arctic.org/sizonet.

Providing further guidance to community members, management agency staff and scientists in CBM tools and how to respectfully connect information across knowledge systems is important. The ***Arctic and Earth Signs*** programme aims to provide a venue for CBM that encourages partnerships across multiple generations and knowledge systems. The project, based at the University of Alaska Fairbanks' International Arctic Research Center, is unique in that children (ages 5-14) and youths (ages 15-24) share a respected voice in co-identifying an issue to focus environmental monitoring on, along with a community team of educators, community members, elders, and scientists. After the team has received training on how to facilitate the process, it identifies an issue important to the community to be able to plan for rapid changes. The youths document Indigenous and local knowledge from elders and long-time community members, and deepen their knowledge of the topic through culturally-responsive curricula. They co-design an investigation or monitoring project with their community team, using the options from a diverse array of monitoring protocols in the Global Learning and Observations to Benefit the Environment programme (GLOBE; www.globe.gov). The youths are empowered to use the data to lead an environmental action or stewardship project that will help address the issue in their community, and share their data and project with their Indigenous and local community as well as scientists, and the international GLOBE community.

The ***Imalirijiit*** programme in Canada is also training youths in CBM tools and how to respectfully connect information across knowledge systems. This programme, now in its 2nd year, is beginning to collect baseline data on water quality and contaminants in local country food in the George River area in Nunavik prior to the opening of a rare earth mine. The programme also develops the capacity of local youth in environmental science and interactive mapping.

**Conclusions – Addressing the rights of Indigenous and local communities:** The Arctic CBM programmes provide many examples of where the rights of Indigenous and local communities to land/resources and to protect their knowledge are being successfully addressed. Such experiences should be further disseminated. There are existing protocols for enabling a respectful use of Indigenous and local knowledge that should be made more broadly available. Data ownership and data use rights in CBM programmes must be clear and follow principles of "Free, Prior and Informed Consent". Further guidance should be undertaken in CBM tools and in how to properly address the rights of Indigenous and local communities.

## 3.8 Summary: Good Practice

In Chapter 3, we discuss good practice in Arctic CBM programmes, based on a literature review and workshops with CBM programmes in Alaska, Canada, Greenland and Russia. When establishing CBM programmes, representatives of community members should play a central role. The monitoring should reflect the priorities of the local communities and be kept as simple and locally appropriate as possible.

When implementing CBM programmes, it is vital to have organizational and support structures that sustain the CBM effort from the community up to the management authority level. In recent years, the use of Indigenous and local knowledge for informing decision-making has received increased attention at policy level in the Arctic. Management authorities must enact policy in practice, listen to Indigenous and local community members, and provide feedback to the communities on how CBM results are used. Knowledge management platforms and other new data-sharing approaches may hold great potential.

To sustain CBM programmes, they must ensure that the participants' observations are used for decision-making and that they are informed of how the information is being used. When there is high turnover of management authority staff, the negative effects may be minimized by involving multiple staff members in the CBM programme. Greater impacts may sometimes be obtained through CBM by documenting the management interventions that result from CBM programmes. Likewise, impacts may be obtained by bringing communities together, sharing information, and promoting advocacy on the importance of CBM-derived information.

With regard to connecting and cross-weaving with other approaches, some programmes are intertwined into scientist programmes at the method level, others run independently and in parallel with scientist programmes where these are available. At present, few CBM-derived datasets are included in Arctic data repositories. Representatives of Indigenous and local communities should decide whether data from their CBM programmes needs to be linked with global repositories; the process must take place in accordance with their "Free, Prior and Informed Consent". When appropriate, CBM programmes could connect with global repositories such as ELOKA.

CBM programmes concerned with the credibility of their knowledge products can ensure careful planning, explicit consideration of likely bias, and storing of the data in its most disaggregated form, with details of exactly how it was collected. Other measures include carrying out checks to keep errors in recording and data storage at an acceptable level. As CBM programmes differ in their goals and focus, some programmes may not take these measures but can still be relevant and meaningful.

Addressing the rights of Indigenous and local communities is important to most CBM programmes. The Arctic CBM programmes provide multiple examples of where the rights of Indigenous and local communities to land/resources and to protect their knowledge are being successfully addressed. One critical measure related to the data derived from CBM programmes is that data ownership and data use rights must be clear and follow principles of "Free, Prior and Informed Consent".

# 4. CHALLENGES AND HOW TO ADDRESS THEM

This chapter examines a range of different challenges encountered in implementing and conducting CBM in the Arctic, including challenges associated with the linkage between different CBM programmes, between CBM and management authorities, and between CBM and scientist-executed environmental monitoring programmes. For six commonly occurring types of challenges the extent, effects, causes and potential interventions to address each challenge are considered.

The text below is intended to help provide an overview of potential hurdles that CBM programme facilitators, community members, collaborating scientists or decision-makers might face during the implementation and operation of CBM activities. The set of entries below is neither comprehensive nor ordered according to priority. Rather, it aims to inform the development of roadmaps towards knowledge co-production and resource co-management for new CBM efforts, and may serve as a reference for discussions in CBM programmes already underway.

Like Chapter 3, this chapter is based on a review of the scientific literature and workshops with CBM programme practitioners and community members engaged in CBM programmes. The workshops were held in Nuuk (Dec. 2016), Fairbanks (May 2017), the Russian communities of Komi and Zhigansk (Sep. 2017), and Quebec (Dec. 2017).

## Challenge: Limitations in the ability or interest of management agencies to access, understand, and act on CBM-derived guidance

Governments across various jurisdictional scales have demonstrated increasing interest in supporting community-based observation and monitoring in the Arctic and in identifying mechanisms for information from these programmes to inform action. At the same time, CBM practitioners report continued challenges in working with governments to operationalize or act upon community observations in decision making.

**Extent**
Government agencies and institutions reaching into the lives of Arctic communities and individual people may not be responsive to or act upon knowledge and information emerging from CBM activities. This is also the case with (international) scientific organisations advising government agencies and institutions. This challenge can take one of several forms, including: an unwillingness to engage with communities; an inability to access or ingest information from CBM efforts; or a lack of management follow-through on insights gained from CBM (Eicken 2010; Johnson *et al.* 2015; 2016).

**Causes**
The range of causes underlying these challenges is broad. Despite recent progress (Armitage *et al.* 2011; Kendall *et al.* 2017), both government agencies and academia continue to struggle to understand the nature and relevance of CBM and the Indigenous and local knowledge that informs many CBM efforts. Misconceptions include a perceived lack of reliability of observations derived from CBM and failure to appreciate equivalency of information generated through CBM and by professional scientists – the latter demonstrated by a growing body of literature (Johnson *et al.* 2015). In part, power dynamics, history of governance and land or resource use rights, and conflicting viewpoints regarding present-day land and resource management issues may create an adversarial relationship between management authorities and community members (Nadasdy 1999; Armitage *et al.* 2011; Eicken *et al.*

2011). Government staff tend to understand realities differently from community members. Moreover, involving community members in observational programmes is only one of many factors in the policy-economy area that government staff need to consider. Further, CBM programmes sometimes communicate data as a mixture of political viewpoints and evidence, involving advocacy-based evidence rather than evidence-based advocacy.

At the same time, there are a number of factors that make it difficult for government agencies to respond proactively and rely on CBM as an important tool in responding to rapid Arctic change. These factors include bureaucratic hurdles and political hurdles to implement innovative approaches such as CBM in a management context, potential disconnects between the legal or regulatory system and agency research divisions, and a lack of resources or expertise to implement good guidance on CBM implementation.

With respect to the latter, not involving community members in designing observation programmes is problematic. Natural scientists are typically involved but often lack an understanding of the broader dynamics of governance of land and resources. Moreover, while changing, typically scientists' reward systems are still skewed towards publishing and the scientific process, rather than helping address real-world problems in a co-production of knowledge setting.

Finally, the international scientific bodies responsible for advising Arctic governments on resource management (and many other government agencies) are only now beginning to consider the establishment of procedures to take the observations and knowledge of community members into account for their advisory services (Nordic Council of Ministers 2015; Alaska Arctic Policy Commission 2015; PAME 2017).

**Effects**
Government agencies' inability or unwillingness to access and respond to community members' findings in their decision-making presents a major, decisive hurdle to the successful implementation and operation of CBMs. In the long term it likely results in termination of CBM efforts. More importantly, it deprives both the communities and government from realising the benefits of CBM-informed management of resources or response to Arctic change, such as opportunities for increased income and food security from sustainable resource use in small rural communities, or more effective response to community-level hazards associated with rapid Arctic environmental change.
Decisions that impact communities, and don't take into account information from community-driven CBM, often lose credibility with community members.

**Intervention**
Possible interventions to address the challenge outlined above include:
- Further developing best practices, protocols and procedures to enable government agencies and international scientific organisations to incorporate local and CBM-derived information on natural resources and resource use in their decision-making (see also Section 3.4);
- Bringing communities together, sharing information, and promoting advocacy on the importance of using information from CBM programmes;
- Raising awareness (through meetings, publications, audiovisuals etc.) within government agencies and international scientific organisations on the value of local knowledge and observations;
- Education and training on CBM activities as part of a research and monitoring portfolio, including training in collection of evidence from CBM programmes;
- Developing monitoring and evaluation protocols for CBM programmes that prioritize community feedback and involvement.
- Involving representatives of community members and CBM programmes in the planning and evaluation of observation programmes;

- Emphasizing use of the CBM outcomes to scientific organizations and government agencies to show value of community investment in the development and sustained use of CBM programmes (see also Section 3.6);
- Emphasizing community engagement in academic assessment and promotion.

## Challenge: Insufficient linkages between the CBM programmes and the priorities of Northern communities

While priorities vary across localities and regions, many Arctic communities prioritise individual and community health, economic opportunities, incl. improved employment opportunities, and other aspects of fate control, such as participation in the regulatory process or place-based education. In contrast, many CBM programmes are addressing topics that are based on outside perspectives and may only marginally or not at all address community priorities.

**Extent**

At the Fairbanks Workshop, CBM programmes were criticised for sometimes monitoring attributes irrelevant to the lives of the people in the Arctic. While this may be true in some cases, there are also a number of CBM programmes that contribute to better-informed decisions or better-documented processes within fisheries, hunting/herding, transport/shipping, forestry, mineral and hydrocarbon extraction, and tourism (Chapter 2). These are key economic sectors in the Arctic. Community members are often motivated to participate in CBM programmes to address critical socio-economic and cultural issues for Arctic people such as "protecting rights to land and resources" and "sustaining the health and abundance of wildlife". Only in a small number of CBM programmes do community members participate for financial benefit alone.

**Causes**

The activities of CBM programmes do not always align with the priority issues of community members due to insufficient involvement of community members in their design, or due to assumptions that are made by non-residents about what the priority issues of Northern communities are. Thus, university researchers often focus on pan-Arctic large scale processes that may be of little interest at the local level. Government agencies may be constrained by legislation or regulatory frameworks on the type and scales of information that is collected.

Communities are diverse, and it can be difficult to identify and derive priorities for monitoring that reflect consensus (see discussion in Wheeler *et al.* 2016). Additionally, some CBM programmes may not reflect the immediate priorities of community members, but nevertheless may address issues of relevance to livelihoods of Northern communities, such as those that contribute to a better understanding of a particular component of the environment. When community members are robustly engaged in designing CBM programmes, the result should be a focus that reflects at least some of the community's priorities for observing and monitoring.

**Effects**

If CBM programmes do not address the priorities of Northern communities, community members are unlikely to contribute their time and resources to the observing efforts. In these programmes, community members are typically only involved in the data collection phase (rarely in the design or interpretation). Since only one party benefits (the scientists or associated government agency), such programmes are unlikely to be sustained over time.

**Intervention**

Possible interventions include:

- Involving representatives of community members and CBM programmes in the planning and evaluation of observation programmes (further discussed in Section 3.1);
- Relying on a broader knowledge co-production and resource co-management framework to guide CBM implementation and use CBM-derived information (Inuit Circumpolar Council-Alaska 2015; Lovecraft *et al.* in review).

## Challenge: Sustaining community members' long-term commitment to CBM efforts

Beyond the challenges identified under 4.1 and 4.2, maintaining long-term interest and involvement by community members and thereby ensuring continuity of CBM activities can be challenging. A problem related to this is frequent staff turnover at the management authority level (discussed in Section 3.3).

**Extent**
Fatigue among community members and participant turnover at the community level were considered significant challenges for around one in five of Arctic CBM programmes surveyed (Chapter 2).

**Causes**
One major reason for a loss of motivation and engagement among community members is a poor fit between the design of the CBM programme and the local context, in particular community interests and concerns. Further problems can result from observing protocols that consume too much time or resources. Insufficient feedback on CBM results and outcomes also contributes to participant fatigue and disengagement. When designing CBM programmes, it is also important to be aware that not all community members and communities are likely to be equally interested and capable of participating. For instance, CBM programmes aimed at protecting rights to land and resources and sustaining the health and abundance of wildlife have proved suitable where community members are heavily dependent on living resources for their livelihoods and culture. In other communities, it may not be meaningful to establish such programmes. Finally, it is important that all parties involved in a CBM programme feel their effort "amount to something", and that they are recognised for the contributions they make, including use of CBM information for actual management decisions at higher levels. Intellectual incentives are not sufficient.

**Effects**
A loss of motivation among community members and other hurdles to participation at the community-level may lead to rapid and frequent turnover of CBM observers and contributors. Such turnover potentially jeopardizes the long-term sustainability of the CBM programme, including the continuity of the resulting data records (Conrad and Hilchey 2011).

**Intervention**
Possible interventions include:
- Involving representatives of community members and CBM programmes in the planning and evaluation of observation programmes (see also Section 3.1);
- Using tools and approaches for data collection that can easily be incorporated into the day-to-day activities of the community members and that allow the CBM-results to be incorporated into decision-making;
- Providing regular feedback to community members with the findings and results of the CBM programmes and examples of how these findings are being used for decision-making (see Section 3.2);
- Motivating all parties in the CBM programmes, from community members to the authorities involved. Consider carefully what each party gains from participation. For many participants, there is a strong incentive if the concept of her/his voice in society has changed as a result of the effort;

- Different incentives may need different methods of communication, varying from social media and gamification (employing game design elements) to more tangible benefits such as caps, rubber boots or financial compensation.

## Challenge: Lack of compatibility between data formats of scientist-executed monitoring and CBM programmes

In CBM programmes, where community members and facilitators are keen to connect with scientist-executed programmes, lack of mutual visibility and compatibility between the two kinds of datasets generated is a major hurdle.

**Extent**

The incompatibility of the data formats among scientist-executed and CBM programmes in the Arctic is reported as a challenge but the extent of this problem is poorly explored (e.g., Pulsifer *et al.* 2012). Further, there may be CBM programmes (and certain information) that are not intended to connect with scientist-executed programmes (Fidel *et al.* 2017), and *vice versa*, and for such programmes differences in data formats are not a concern at present, though they may prove problematic down the line were the situation to change. CBM programmes are also not often visible to scientist-executed programmes and *vice versa*.

**Causes**

Scientist-executed and CBM programmes are usually developed independently of each other. They are based on different realities and epistemologies or world views. They may be connected to each other yet not directly comparable. They often have different aims and use different tools and approaches. For example, CBM programmes are typically user driven with a local focus and a single intended application. In contrast, global and regional data management programmes attempt to integrate data arising from multiple sources holistically such that they can be utilised in a range of applications.

There would be clear value in incorporating CBM programmes into global and regional data programmes, given that measurements tend to be useful to multiple applications, but there are typically several obstacles to doing so, including:
- Relevant global and regional archival facilities are not visible or accessible to CBM programmes and vice-versa;
- Format and modality of data entry, transmission, archival and related restrictions enforced by regional and global data centers exclude CBM contributions;
- Intellectual Property Rights, licensing, acknowledgement and citation concerns.

Scientists incorporating CBM programmes and CBM tools into their work have found that their science has become better (e.g., Mercer *et al.* 2010; Eerkes-Medrano *et al.* 2017). It is particularly important that CBM programmes store data in their most disaggregated form and with details of how they were collected, and that the raw data in the CBM programme are kept for checking and re-interpretation.

**Effects**

When the data formats of scientist-executed and CBM programmes (including international scientific data repositories) are incompatible, it may be difficult or impossible to connect the different kinds of programmes at the data level. Even when they are compatible, mutual limitations in knowledge mean that synergies go unrealized. Opportunities for obtaining a larger-scale understanding of environmental questions are thus lost.

**Intervention**

Possible interventions include:
- Encouraging managers of scientific data repositories to adjust their data formats so they become receptive to data from CBM programmes;

- Highlighting examples of the successful incorporation of both CBM and scientists' program data into publications to encourage further cooperation;
- Undertaking awareness raising (meetings, outreach, education) with international scientific organisations on the usefulness of incorporating local peoples' information into scientific data repositories in order to obtain a better basis for future decision-making;
- Identifying CBM programmes that are keen to connect with international scientific data repositories and which are not currently connected, and encouraging them to identify suitable scientific data repository partners and develop further cooperation (see Section 3.5).

## Challenge: Intellectual property rights, Free Prior and Informed Consent (FPIC), respect and reciprocity

Respecting the rights of participating Indigenous and local communities are important aspects of all CBM programmes; additionally, those that engage Indigenous knowledge must be rooted in an awareness of sensitivities specific to the management of data related to Indigenous knowledge. This will have an impact on how the programmes are implemented.

**Extent**

Many CBM programmes collect sensitive information, for example information about harvest locations of particular species (which hunters may not want to share with others), as well as information about sites that may be considered sacred or sensitive in some way and therefore requiring special protection. Most programmes work carefully with community members to identify and address these sensitivities. In some cases, disrespect for intellectual property rights and proper consultation has been reported (Fidel *et al*. 2017); however, little is known as to the actual extent of this challenge.

**Causes**

CBM programmes operate within a broader context of research practice in which communities are often approached by well-intentioned outsiders interested in collaboration but without a long-term commitment to understanding the local context of knowledge production and use. Many Arctic Indigenous community members can name multiple instances in which they have shared their knowledge with visiting researchers and have not received any tangible final product or benefit from the collaboration. As a result, communities are increasingly asking for greater awareness and sensitivity to ethics in research practice from the Arctic research community at large. This includes the need for awareness of and respect for existing protocols and frameworks for meaningful engagement of Indigenous peoples based on Indigenous rights, such as Free Prior and Informed Consent (FPIC). Some guidelines exist that describe how to promote the use of indigenous and local knowledge (e.g. the Tkarihwaié:ri Code; CBD 2011). However the process described in the guidelines is very time consuming and the guidelines are difficult to implement in practice. Indigenous communities and organizations have raised the need for regionally appropriate and specific ethics protocols and research agreements.

Some research and CBM programmes have unclear agreements on data ownership and data use. It is important that the communities maintain control over data, that data is accessible to community members, and that a long-term data storage solution is identified as part of CBM programme design. If the community wants to delegate data management to other organisations, then that should be their choice.

CBM can be a very important step in Indigenous and local communities' efforts to claim their rights to knowledge and their share of any benefits accruing from this knowledge through, e.g., the Access and Benefit Sharing Mechanism of the CBD. This, however, requires that FPIC is fulfilled and that there are clear agreements on data ownership and data use.

**Effects**

In order to secure the full engagement of community members, CBM programmes must demonstrate awareness of and sensitivity to the importance of protecting Intellectual property rights and sensitive knowledge. Setting up CBM programmes without the consent of the Indigenous and local communities will mean that community members are unlikely to be happy with the results and the programmes will not be sustained. In the worst case, programmes set up without local consent may exacerbate conflicts between government agencies, scientists and community members.

CBM programmes are occasionally criticised for making data available for "mining" by outsiders. Internationally, there have been a number of examples of the misuse of Indigenous and local knowledge, Including examples where private companies have used this knowledge for their own benefit, without providing any compensation. For example, when in 1988 the National Geographic Magazine reporters described in their article the *tiki uba* plant used as an anticoagulant by the Amazonian Ureu-Wau-Wau tribe, the information attracted the attention of researchers working for the pharmaceutical company Merck. After successful testing, Merck commercialised the product, useful in heart surgery. The company used Indigenous and local knowledge without having any obligations to compensate the Ureu-Wau-Wau tribe (McIntyre 1989; Posey 1998).

**Intervention**

Possible interventions include:

- Highlighting examples of the successful use of Indigenous and local knowledge in sustainable CBMs;
- Further developing suitable protocols and procedures for enabling a respectful use of Indigenous and local knowledge;
- Clarifying data ownership and data use rights (further discussed in Section 3.7);
- Carrying out further training in CBM tools;
- Rewarding scientists that engage with community members in collaborative observation efforts.

## Challenge: Organisational and support structures for CBM programmes

The success CBM programmes and activities hinges on organisational and support structures that sustain the effort from the community level up to the government level.

**Extent**

Insufficient organisation and support structures (roles and responsibilities, communication lines, funding etc.) are recurrent challenges for some CBM programmes in the Arctic.

**Causes**

Several factors may result in insufficient organisation and support structures for CBM programmes. Programmes are sometimes established without any insight into the existing organisational or institutional landscape in the area. Programmes may therefore establish parallel "island" structures instead of properly incorporating the CBM activities into the organisations that already exist in the area and which will continue to do so. In some cases, CBM programmes have external support for too little time (e.g. a couple of years), so they are unable to institutionalise the CBM activities within existing organisations. Most natural resource management programmes require 5-10 years of external support before they can stand alone. Political priorities often change and can affect available funding for CBM.

**Effects**

Insufficient organisation and support in CBM programmes may result in the programmes being short-lived and unable to attain their objectives. CBM programmes may also be initially developed with

scientists in academic institutions that provide the organizational, administrative, or technological support, but then need to transition these support roles to an appropriate community-run entity over the long-term. Funding and support structures are needed to enable CBM programmes to contribute to decision-making, recognition, networks, scientific research, and advocacy.

**Intervention**

Possible interventions include:

- Including sustainability in the CBM programme from "Day 1". When developing the CBM programme, it is important to understand and respect the existing political and organisational structures in the area, and to build on and not undermine them (further discussed in Section 3.3);

- Developing international partnerships and funding structures to increase the support and collaboration options for CBM efforts at the local level;

- Being aware that institutionalizing CBM programmes within existing organisations is a capacity building process that takes time and must be based on trust and confidence;

- Building sustainable funding structures to support CBM.

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**Annex A. Arctic CBM programmes reviewed in Chapter 2.**

| Title | Link | Content of the link |
|---|---|---|
| A-OK | https://eloka-arctic.org/sizonet/ | Access to all data via database search function. |
| Arctic and Earth SIGNs | https://www.globe.gov/web/arctic-and-earth-signs | Programme information. |
| Arctic Borderlands | https://www.arcticborderlands.org | Programme information about ABEKS and link to guidelines for requesting access to data. |
| Bird Phenology | https://dataverse.no/dataverse/uit | Large amount of open research data including Bird Phenology data. |
| | https://dataverse.no/dataset.xhtml?persistentId=doi:10.18710/4MCRQL | Data on first arrival dates of spring migrants. |
| BuSK | https://katersaatit.org/ | Programme information in Greenlandic and Danish language. |
| | https://asiaq.maps.arcgis.com/apps/View/index.html?appid=72a0b7241ef341b0af3fb3812eddb320 | Access to data. |
| CSIPN | https://www.uarctic.org/member-profiles/russia/8440/centre-for-support-of-indigenous-peoples-of-the-north-russian-indigenous-training-centre | Programme information in English language. Use http://www.csipn.ru for additional information in Russian language. |
| Evenk & Izhma Peoples | N/A | |
| Fávllis | http://site.uit.no/favllis/ | Link to a large amount of information in Norwegian language about the programme and Indigenous and local knowledge. |
| | http://www.meron.no/nb/loaklkunnskap/fjordokologi-og-ressurser | Data from Fávllis are/will become available via this link. |
| FMI Snow Depth | http://globefinland.fi/glofin/projektit.html | Programme information in Finish language with link to data form in English with some information on FMI Snow depth measurement campaign. |
| Fuglavernd | https://fuglavernd.is/verkefnin/gardfuglar/gardfuglahelgi/ | Programme information in Icelandic language. |
| George River | N/A | |
| ION-Yukon River | https://www.yritwc.org/science | Programme information in English language. |
| | http://staging.eloka-arctic.org/communities/snowy/atlas/index.html | Data - password needed. |

|  |  | Water quality data example: https://www.sciencebase.gov/catalog/item/573f3b8de4b04a3a6a24ae28 |
| --- | --- | --- |
| Local Environmental Observer | https://www.leonetwork.org/en/docs/about/about | Programme information in English language. |
|  | https://www.leonetwork.org/en/ | Access to data. |
| Marion Watershed | N/A |  |
| Nordland Ærfugl | http://www.eiderducks.no/?side=hjem&language=en | Programme information in English language. |
| Oral History | http://www.snowchange.org/efforts-in-the-skolt-sami-areas-of-naatamo-watershed-finland/collaborative-management-along-the-naatamo-watershed/ | Programme information in English language. |
|  | http://www.snowchange.org/pages/wp-content/uploads/2015/09/Snowchange-Discussion-Paper-9.pdf | Example on available reports |
| Pilot Whale | http://heimabeiti.fo/default.asp?menu=97 | Harvest data in Faroese language from 1584 to 2015. |
| Piniarneq | https://www.sullissivik.gl/Emner/Jagt_Fangst_og_Fiskeri/Jagtbevis/Fritidsjagtbevis_samlet? | Links to Piniarneq harvest reporting only (Greenlandic and Danish language). No information about how to get data, but data is likely to be available upon request. |
| PISUNA | www.pisuna.org | Programme information in Greenlandic, Danish and English language. |
|  | https://eloka-arctic.org/pisuna-net/kl/search | Access to all data via database search function. |
| Renbruksplan | www.renbruksplan.se https://www.sametinget.se/116236 | Programme information in Swedish and local language. Information on database under construction in Swedish and local language. |
| River Owners Iceland | http://www.angling.is/en/catch-statistics/ | Link to data in English and Icelandic language. |
| Sea Ice for Walrus Outlook | https://www.arcus.org/siwo | Programme information in English language. |
| Seal Monitoring | http://selasetur.is/en/research/557-2/the-great-seal-count/ | Programme information in English and Icelandic language. |
| Summer Farmers and Small Herders | https://www.slu.se/en/Collaborative-Centres-and-Projects/swedish-biodiversity-centre1/Research/projects/ongoing-phd-projects-/ | Some programme information in English. |

| Walrus Haulout Monitoring | N/A | |
|---|---|---|
| Wildlife Triangles | http://www.nrcresearchpress.com/doi/full/10.1139/cjfr-2015-0454#.WmodLZOdXBI | Programme information in English language. |
| Wild North | http://rannsoknasetur.hi.is/university_icelands_research_center_husavik | General information on the involved research centre |
| WinterBerry | https://sites.google.com/alaska.edu/winterberry/ | Programme information in English language. |
| Älgdata | http://www.algdata.se/Sv/Pages/default.aspx | Programme information in Swedish language. |
| | http://www.algdata.se/Sv/statistik/Pages/default.aspx | Link to data in Swedish language. |

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# INTAROS

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