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Master thesis

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An assessment of community-based monitoring in the Arctic

Cross-weaving local and Indigenous knowledge with scientific knowledge in environmental monitoring

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Abbreviations

CBM: Community-based monitoring
CS: Citizen science
TEK: Traditional ecological knowledge
LEK: Local ecological knowledge
FEK: Fishers' ecological knowledge
NORDECO: Nordic Agency for Development and Ecology
APN: Ministry of Fisheries and Hunting
GINR: Greenlandic Institute of Natural Resources
NAFO: Northwest Atlantic Fisheries Organization
ICES: The International Council for the Exploration of the Sea

GFLK: Greenland Fisheries Licence Control
PISUNA: Piniakanik sumiiffinni nalunaarsuineq (meaning opening doors to native knowledge)
KNAPK: Association of Fishers and Hunters
ICC: Inuit circumpolar council
KANUKOKA: The Greenlandic association of municipalities
TAC: Total allowable catch
CPUE: Catch per unit of effort

Definitions

Monitoring: Systematic measurement of variables over time, it is assumed that there is a specific reason for the collection of data, often related to research, conservation and sustainable use of habitats or species

Community-based monitoring: Monitoring method that involves community members in more than data collection, and the monitoring is done in relation to aims and objectives valued by the community members

Conventional monitoring (this term is used interchangeably with scientific monitoring, science-driven monitoring and conventional western science): Monitoring that is designed, executed, interpreted and used by scientists

Citizen science: A monitoring method and field of research where professional scientists design the research project and have volunteers/citizens help with the data collection

Indigenous: Peoples having historical continuity with pre-colonial and (or) pre-settler societies, strong links to territories and surrounding natural resources, distinct languages, cultures, and beliefs

Traditional ecological knowledge: The cumulative body of knowledge held by community members due to long affiliations to specific landscapes and generational transmission

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Abstract

Science-driven environmental monitoring is often challenged when trying to unravel the complexities of ecosystem dynamics, especially in the Arctic where field work is extraordinarily expensive and logistically difficult. Instead novel approaches are being developed to improve the monitoring of the Arctic environment. One of these approaches is community-based monitoring (CBM) which integrates or cross-weaves local and Indigenous knowledge with scientific knowledge.
CBM has been found to cost-efficiently strengthen conventional science-driven monitoring while at the same time resulting in advantageous co-benefits for the local participants and communities. However not much is known about the status, characteristics or results of Arctic CBM programmes.

This thesis aims to provide a detailed assessment of currently running CBM programmes in the Arctic. This was done in three parts 1) A hands-on investigation of the applied work of CBM alongside the first ever Saami led restoration project in Finnish Lapland. 2) A general characterisation of 30 currently running Arctic CBM programmes, and finally 3) An in-depth analysis of fish stock abundance CBM data from a "best-example" Greenlandic case study of two study species: Greenland halibut (*Reinhardtius hippoglossoides*) and Atlantic cod (*Gadus morhua*).
All in order to answer the following research questions:

1. What are the general characteristics of Arctic CBM programmes?
2. What are the most distinguishing features of CBM compared to scientific monitoring?
3. Is there a difference in the format and the results between CBM data and scientific data?

This study provides the following characterisation: CBM programmes are widely distributed across the circumpolar Arctic, the aim of the programmes varies greatly i.e. from monitoring of berry phenology, use of traditional practices, wild life inventories, mapping of traditional land use. Likewise, the programmes cover a wide biome range, though with a skew towards the coastal zones. The monitoring covers mainly biological attributes, however, also abiotic and socio-cultural attributes are well-covered and often the programmes are interdisciplinary. There are multiple reasons why community members wish to engage in a CBM programme, the primary ones being to help sustain health and abundance of wildlife and to protect the rights over land, sea and resources. CBM contributes to the local communities by enhancing pride and self-esteem, increasing participation in natural resource decision-making and improving education and learning skills.
The main distinguishing feature of CBM is the temporal coverage; where CBM is continuously conducted throughout the entire year, most science-driven monitoring is strongly limited by the academic calendar. Also the format of CBM and science-driven monitoring differs fundamentally, making direct comparison between the two difficult. Consensus in fish abundance trends was found to depend on the species in question and the resolution. Consensus was found for Atlantic cod, however only for Greenland halibut by downscaling the resolution from monthly to quarterly scale. Lastly, further complicating the analysis, considerable confusion exists regarding the term CBM which often is used interchangeably with citizen science (CS). Despite this being a survey explicitly targeting CBM programmes, 40% of the programmes turned out to be using CS methodology, underlining the need for clarification and improved knowledge about CBM.

Overall, this study concludes that CBM can provide strengthened reliable environmental monitoring, novel discoveries and information that are directly relevant for managers, while also making a significant difference in the local communities. However, in order to obtain the full potential of CBM it requires researchers to be able to work with various knowledge systems, adapting new interdisciplinary methods and establishing an equal and trustworthy collaboration.

Key words: Community-based monitoring, Arctic environmental monitoring, Traditional ecological knowledge, Indigenous Knowledge, Natural resources, Greenland fisheries, Greenland halibut, Atlantic cod

1. Introduction

It can be argued that the field of environmental monitoring in the Arctic is facing a paradigm shift. Collaborative monitoring methods, such as community-based monitoring (CBM) mean that professional scientists no longer are being viewed as the only true experts in environmental monitoring in this region. Today, there is an increased reliance in having local or Indigenous peoples carrying out the monitoring activities (Wells & Mcshane 2004; Conrad & Hilchey 2011; Reed 2008; Kimmerer 2002; Ford 2000; Usher 2000; Danielsen et al. 2010; Johnson et al. 2014; Huntington 2011; Brook & Mclachlan 2008).

There are several reasons for this shift. Firstly, earlier pilot studies have demonstrated the many advantages of integrating local and Indigenous knowledge with scientific knowledge. There is now a general agreement that, if designed properly, CBM has the potential to improve conventional monitoring, while at the same time addressing community concerns (Pierotti & Wildcat 2000; Berkes 2004; Gadgil et al. 1993; Cuthill 2000; Zdor et al. 2011; Huntington 2000; Whitelaw et al. 2003; Conrad & Hilchey 2011; Dyck 2007; Ferguson & Messier 1997; Eckert et al. 2017; Chanda 1998; Danielsen et al. 2007; Danielsen et al. 2014). Secondly, the scientific community has realised that new measures are necessary in order to fully unravel the complexity of the ecosystem dynamics (Conrad & Hilchey 2011; Whitelaw et al. 2003; Callaghan et al. 2013; Vaughan et al. 2001). Thirdly, the legislative development within this field has been an important factor. For example international laws and policies, such as the as the Indigenous and Tribal Peoples Convention No. 169 from 1989[1], the signing of the Convention on Biological Diversity in 1992, the formation of the UN Permanent Forum on Indigenous Issues in 2000 and latest the UN declaration on the Rights of Indigenous Peoples in 2007. These changes have underlined the necessity of acknowledging Indigenous peoples ’ rights and encourage/require that local communities are consulted and involved in decision-making processes concerning local natural resource issues. Finally, all these changes coincide with a present strong wish from local and Indigenous communities in the Arctic, to be involved in the ongoing research happening on their lands (Ferguson & Messier 1997; Wayvey et al. 1993).

Recent decades struggle for equity and recognition by the peoples of the Arctic region, have today, albeit slowly, begun to be recognised within both governments, science communities, the international councils and institutions (Mauro 2000; IPES 2015; IUCN 2017; Conservation International 2010; IPCC 2014; CAFF 2013; ACIA 2004; Ford et al. 2016). Leading influential Arctic institutions like the International Panel on Climate Change (IPCC) and especially the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) are highlighting the need for integration of local and Indigenous knowledge with scientific knowledge.

"*(...) Indigenous, local, and traditional knowledge systems and practices, including Indigenous peoples' holistic view of community and environment, are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts. Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation."*(IPCC 2014)

[1] which in the Arctic has been ratified by Norway and Denmark

"IPBES aims to promote effective engagement with Indigenous and local knowledge holders in all relevant aspects of its work. (...) Indigenous and local people are often better placed than scientists to provide detailed information on local biodiversity and environmental change, and are important contributors to the governance of biodiversity from local to global levels" (IPBES 2013b)

1.2 Environmental monitoring

Monitoring is defined as systematic measurement of variables over time (Spellerberg 2005). When using the term monitoring, it is assumed that there is a specific reason for the collection of data, often related to research, conservation and sustainable use of habitats or species (Lein 2011).

Monitoring of the environment is one of the most important tools in nature management and climate research (Spellerberg 2005). Collected data provides the information which scientists base their research and develop their climate models on, and serves as the foundation upon which decision-makers decide their management interventions and policies. It is thus highly relevant to continuously improve existing monitoring and adapt innovative methods, in order to make sure that the environmental monitoring is as reliable and correct as possible.

The Arctic is a favoured region for environmental monitoring, in particular in relation to climate research. Here the climate is changing faster than anywhere else on the planet. As such, the changing ecosystem dynamics investigated and discovered here, are used as a harbinger for change to come in other parts of the planet (Elmendorf et al. 2012; IPCC 2014).

However, monitoring of the environment was not invented by scientists. The first monitoring in the Arctic was performed thousands of years ago by hunters, fishers, reindeer herders and gatherers of natural resources, who through their everyday work noted down, either systematically or by recognition, the trends in the changing environment. For these people, life depended on accurate environmental knowledge in order to secure safe travel and successful hunting and harvesting activities (Gadgil et al. 1993; Johnson et al. 2014). Rigorous and reliable methods were thus crucial for survival.

Even though Arctic communities have adapted to the modern way of life, today, many Indigenous communities across the Arctic continue to depend on the harvesting and use of living terrestrial, marine, and freshwater resources. Hence, local monitoring remains extremely important in today's Arctic communities, especially with climate changes altering the environment at an unprecedented rate. The local communities recognize that the changing climate is having profound impact on everything from their resources, infrastructure, community services to the well-being of residents (Bell 2010; Farhan Ferrari et al. 2015; Danielsen et al. 2010; Huntington et al. 2004).

Many Arctic peoples through lifelong practice and experience, possess an extraordinary knowledge about their surrounding nature and environments (IPBES 2013b). A growing number of case studies show examples of CBM supplementing or even surpassing scientific knowledge of key components of the environment, such as snow and ice conditions (Riseth et al. 2011) sea-ice (Laidler 2006), the sun and ultraviolet radiation (ACIA 2004) weather patterns (Weatherhead et al. 2010), fish and marine mammals (Johannes et al. 2000), caribou (Ferguson et al. 1998), Arctic fox (Gagnon & Berteaux 2009), see box.

Box 1: Example of the power of community-based monitoring in the Arctic

One of the most famous examples of the power of CBM in the Arctic, is the example of the ban on bowhead whale harvest put in place by the International Whaling Commission in 1977 in Alaska. The ban was put in place due to a scientific survey claiming that the bowhead whale population was decreasing. However, the Eskimo (Eskimo in this region is not perceived as a derogatory term, as it is in most other Arctic regions) whalers in the area knew that this was not an accurate statement, and that the assumptions upon which the census was based were not valid. The ban strongly affected the traditional hunting of the Alaska Eskimos. After a long and hard struggle for the hunters to get the authorities and politicians to listen, the Eskimo whalers finally where allowed to make a new census. The Eskimo whalers used their knowledge about the bowhead whale biology and migration patterns and suggested to monitor also when the sea was ice-covered (the researchers had assumed that no whales where passing by during this time) and also looking further offshore than in the original study. The results of the new census were clear. The population turned out to be much larger than the researchers first had claimed, and the reduction in the hunt was not needed (Huntington 2000; Freeman 1989).

1.3 Limitations to scientific monitoring in the Arctic

Conventional monitoring (this term is used interchangeably with scientific monitoring, science-driven monitoring and conventional western science) in the Arctic faces many challenges:

1. Scientific researchers are bound by the academic calendar, meaning that the field season is mainly limited to a few months every summer. This results in very limited temporal coverage, leaving a lot of factors unknown to science (Conrad & Hilchey 2011; Ford 2000).
2. The logistics and infrastructure of working in the Arctic region are extraordinary difficult and very expensive. Thus planning and conducting research in the Arctic is extremely costly and time consuming. Field sites are often constrained by what is easily accessible logistically, impeding the spatial coverage (Hockley et al. 2005; Danielsen, Burgess, et al. 2005; Dyck 2007).
3. By itself, conventional monitoring often do not suffice in order to fully unravel the complex dynamics of the ecosystems (Conrad & Hilchey 2011; Whitelaw et al. 2003; Callaghan et al. 2013; Vaughan et al. 2001). These systems are composed of a myriad of short and long-term interconnections and feedback mechanisms, often exceeding the scope of individual scientific research projects.
4. Tight budgets and substantial cuts in funding to environmental programs are constraining science-driven monitoring in the Arctic (Conrad & Daoust 2008; Dyck 2007).
5. Science-driven monitoring is criticized for not being inclusive and accessible to the people who need it (Berkes et al. 1993).
6. Conventional monitoring is often strictly "data-driven" instead of management-driven, meaning that it often does not meet the needs of managers and is ineffective in integrating information into decision-making. This results in the findings being communicated to the right institutions too late to avoid or mitigate problems in a timely manner. (Danielsen, Jensen, et al. 2005; EMAN 2013; Vaughan et al. 2001; Nicholson & Jennings 2004).

1.4 New approaches

Many researchers and conservationists are aware of the limitations of conventional monitoring and have been seeking alternative approaches, especially in remote regions like the Arctic. Following this realisation, novel holistic and collaborative methods have been developed. Such as citizen science (CS), and later Community-based monitoring (CBM) that was spawned from this field.

1.5 Citizen science and Community-based monitoring

CS and CBM are two distinct collaborative monitoring methods but the terms are unfortunately frequently used interchangeably, despite having distinct definitions. CS is a monitoring method and research field where professional scientists design the research project and have volunteers/citizens help with the data collection (Bonney et al. 2009). The structure and framework can vary, ranging from few or occasional volunteers and data input to highly coordinated network of volunteers, reporting continuously. For example, as seen in a big project from the Natural History Museum of Denmark, where citizens are encouraged to collect ants from all over the country, which will be determined to species by researchers at the museum to provide the first Danish exhaustive ant inventory (http://snm.ku.dk/skoletjenesten/grundskole/materialer/myrejagten/). Or the nationwide Danish Project Biodiversity by the Danish Society for Nature Conservation where 30 different species are registered over the whole country using a mobile application, so that researchers obtain data on exactly where nature conservation is most needed (http://www.biodiversitet.nu).

In the 1990's the need to involve stakeholders in planning and management processes was recognized. This together with a growing endorsement of collaborations with Indigenous and local communities, catalysed stronger engagement between the scientist and community members. Hence new programmes quickly evolved with the aim of involving non-professionals not just in the data collection but in the entire design process, the execution and the interpretation of the results, hereby CBM emerged. CS can be said to be the umbrella, and CBM is a distinct branch hereunder.

1.6 Community-based monitoring definitions

Several definition of CBM exist, amongst others: **CBM encompasses monitoring of natural resources of relevance for the local community members and the monitoring is in relation to aims and objectives valued by them** (Danielsen et al. 2014) And **CBM is a process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track, and respond to issues of common community concern** (EMAN 2013) (the definition used in this thesis is explained in section 1.8). Adding to the confusion about the distinction of CS and CBM is the fact that several terms are used inconsistently as synonyms for CBM, such as: community citizen science, extreme citizen science, participatory monitoring, collaborative management, locally based monitoring, hunter self-monitoring. There is a clear need for a clarification of exactly what the term CBM encompasses and how it differs from other participatory approaches such as CS.

1.7 Different CBM frameworks

Several different structures or frameworks exist for CBM. It is important to be aware of these when evaluating the CBM programmes (Pollock & Whitelaw 2005). Although not exhaustive, I here distinguish between a "documentation" and an "instrumental" approach, which are modified terms from Thornton and Scheer, 2012, who use these terms to describe different types of traditional ecological knowledge (TEK, see section 2.5) studies (Thornton & Scheer 2012). "Documentation" are CBM programmes initiated in collaboration with scientists with the aim of collecting data in order to document environmental conditions and changes. "Instrumental" CBM programmes are often initiated by governments or NGOs with the aim of directly addressing management concerns or providing developmental aid. In this thesis when advocating that scientific monitoring can be directly strengthened by CBM, I especially refer to the "documentation" approach.

1.8 CBM background

Long before CBM officially emerged, much had been written about collaborative research approaches. Arnstein, 1969 made one of the first widely used characterisations of citizen participation programs. Arnstein uses “the Ladder of Citizen Participation” based on the redistribution of power as an essential element in meaningful citizen participation. Arnstein arranged the categories on a ladder with eight rungs: Manipulation, therapy, informing, consultation, placation, partnership, delegated power and citizen control. The last three top rungs of the ladder I argue can be defined as CBM. Here citizens have an advisory position, delegated power and control to make decisions, independently and in partnership with “powerholders”, see (S. Arnstein 1969) for details. A lot of papers have since elaborated on Arnstein’s ladder theory (Hurlbert & Gupta 2015; Choguill 1996; Connor 1969; Maier 2001; Shirk et al. 2012), i.e. Danielsen et al. 2008 made another graduation of local participation in natural resource monitoring. This characterisation consists of five different categories, following a progression of the relative degree of involvement by the locals in relation to professional researchers (Danielsen et al. 2008)

Box 2. Categories of local participation by Danielsen et al. 2008

1. **Externally driven, professionally executed monitoring:** No involvement of local stakeholders. Design of the scheme, analysis of the results, and management decisions derived from these analyses are all undertaken by professional scientists funded by external agencies.
2. **Externally driven monitoring with local data collectors:** Only involves local stake-holders in data collection. The design, analysis, and interpretation of the monitoring results are undertaken by professional researchers - generally far from the site.
3. **Collaborative monitoring with external data interpretation:** Involves local people in data collection and management-oriented decision making, but the design of the scheme and the data analysis are undertaken by external scientists.
4. **Collaborative monitoring with local data interpretation:** Involve local stake- holders in data collection, interpretation or analysis, and management decision making, although external scientists may provide advice and training.
5. **Autonomous local monitoring**: The whole monitoring process—from design, to data collection, to analysis, and finally to use of data for management decisions—is carried out autonomously by local stakeholders.

Looking at the categories listed in Box 2, it can be argued that category 1 and 2 correspond to conventional monitoring and CS respectively. For the purpose of this thesis, I will use categories 3-5, together with the definition stated by (Danielsen et al. 2014) to define CBM. Thus CBM is defined as*:* **monitoring where community members are involved in more than “just” data collection, and the monitoring is done in relation to aims and objectives valued by them.**

1.9 Need to improve environmental CBM efforts

There is a general need to improve environmental CBM efforts in the Arctic. Earlier studies have found that despite increasing recognition of the advantages of CBM and the necessity to integrate local and scientific knowledge in the Arctic. There is still a gap in the empirical knowledge about the characteristics, the state of and how far the CBM programmes in the Arctic have come (Huntington 2011; Johnson et al. 2014; Kouril et al. 2016; Johnson et al. 2016). This study aims to address this knowledge gap in order to bring together CBM and science-driven monitoring.

1.10 Aim of the thesis

The aim of this thesis is to provide a detailed assessment of the depth and breadth of currently running CBM programmes in the Arctic. I here define assessment as an evaluation of both: The applied work, the general characteristics and the actual data from Arctic CBM programmes.

I aim to answer the following three research questions:

1. What are the general characteristics of Arctic CBM programmes?
2. What are the most distinguishing features of CBM compared to scientific monitoring?
3. Is there a difference in the format and the results between CBM data and scientific data?

2. Background

2.1 The Arctic

The Arctic region spans 40 million km^2, covering three continents and eight countries; Canada, the United States, Russia, Finland, Sweden, Norway, Iceland and Denmark (Greenland and Faroe Islands). All of the Arctic countries except Iceland and The Faroe Islands (part of the Kingdom of Denmark) have populations of Indigenous peoples. The proportion of Indigenous people in the Arctic countries varies greatly. In Greenland the great majority are Indigenous, while in Norway, where the majority of the Saami people lives, Indigenous people make up less than 1 % of the total population. (Fondahl et al. 2015). In this report I use the borders of the Arctic region outlined by the Arctic Monitoring and Assessment Programme (AMAP). AMAP uses a holistic definition which take into account several physical, geographical and ecological characteristics (see (AMAP 1998) for details).

Figure 1 The Arctic can be defined in many ways, such as: the Arctic Circle (66°32'N), on the basis of temperature (the 10°C July isotherm) or the tree line. These definitions are often too simplistic to cover the whole range of local variations. AMAP uses a holistic definition which take into account several physical, geographical and ecological characteristics. The AMAP area is highlighted in purple on the map. For reference also the arctic marine boundary, the Arctic circle and the 10°C July isotherm is depicted.

2.2 The Indigenous people of the Arctic

About 10 percent of the 4 million people inhabiting the Arctic are considered to be Indigenous (AHDR (Arctic Human Development Report) 2004). However, due to the varying definition of Indigeneity and different definitions of the boarders of the Arctic region, the true number of Indigenous people in the Arctic is difficult to establish definitely.

During the 1950s and 1960s, the number of people living in the Arctic started to grow rapidly because of improved living standards and also due to a large influx of immigrants moving to the region because of discoveries of rich natural resources. Recently the population growth in the Arctic has slowed down in general and in some cases (e.g. Russia) the total population has declined. (ACIA 2004; Arctic Centre University of Lapland n.d.).

Indigenous peoples have inhabited the Arctic since time immemorial. More than 40 different Indigenous ethnic groups are living in the Arctic. It has been difficult for Indigenous peoples to keep their traditional way of living in close contact with nature, amongst other reasons due to the political marginalization by the national governments and missionary work by the church, aiming to assimilate the Arctic Indigenous peoples into mainstream modern culture. These struggles have often been violent and deadly, and it is today a dark chapter in the Arctic Nations history. Presently there is an uprising of the Arctic Indigenous communities, who rightly demand to be involved in the policy-making processes that affect their lives, lands, and communities.

2.3 Who is Indigenous?

Indigenous, Natives, Aboriginals, Indians, First Nations, Tribal; whichever word you use, these people are as their names suggest the original inhabitants of their lands. Who is Indigenous is not a simple question, there exist no general or jurisdictive definition for when someone is considered Indigenous. Mostly the international norm is that people are considered Indigenous if they self-identify as such, as seen in Greenland. However, Arctic countries employ a variety of definitions: According to US legal protocols dating back to the Euro-American colonizers, Indigeneity in Alaska is based on blood quantum. The Indigenous peoples of Canada are collectively referred to as Aboriginal peoples, they are defined as "all of the original peoples of Canada and their descendants". The Canadian Constitution Act, of 1982 recognizes three groups of Aboriginal peoples: Indians (more commonly referred to as First Nations), Inuit and Métis. Based on the degree of descent, First Nations can furthermore be divided in three categories: Status Indians, Non-Status Indians and Treaty Indians. Only Status Indians are entitled to certain rights and benefits under the law. In Norway, Sweden and Finland, speaking Saami, or having a parent, grandparent or great grandparent who spoke it, together with self-identification serves as criteria for determining who has the right to vote in the Saami Parliament. The Russian Federation on the other hand does not as such recognize Indigenous peoples, however the constitution and national legislation set out rights for the 40 Indigenous groups under one unified term: "Indigenous numerically small peoples of the North". To be recognized as such, the criteria include; self-identification, numbering less than 50,000 persons, living in the regions of the North, Siberia and the Far East on the territory of traditional occupancy of their ancestors and maintaining traditional ways of life (Fondahl et al. 2015; Rohr 2014; IWGIA 2015).

2.4 Indigenous definition

In this study, I define Indigenous using the definition from the UN Permanent forum of Indigenous people: Peoples having historical continuity with pre-colonial and (or) pre-settler societies, strong links to territories and surrounding natural resources, distinct languages, cultures, and beliefs (UN

Permanent Forum on Indigenous issues 2006)

2.5 Implementation of traditional ecological knowledge

When involving local and Indigenous peoples in the design, execution and interpretation of monitoring, their unique knowledge will be included as well. Local and Indigenous peoples display an exceptionally detailed knowledge about the natural environment they reside in. This knowledge is termed local ecological knowledge (LEK) and traditional ecological knowledge[2] (TEK). LEK represents a lifetime of accumulated ecological observations, while TEK is composed of similar observations, embedded within an explicit belief system. For simplicity, I have in this thesis chosen to use the overall term TEK to describe knowledge held by both Indigenous and non-Indigenous peoples.

TEK can be defined in many ways, here I use the definition that TEK is the cumulative body of knowledge held by community members due to long affiliations to specific landscapes and generational transmission (Berkes et al. 1993). The term *knowledge* in this case refers to the myriad intertwined components, such as experiences, rituals, worldview, social and family institution, language, traditional land and natural resource use etc. making TEK a holistic approach (Kimmerer 2000). TEK comes in many forms, including oral, written, song, dance, art, rituals and ceremonies. TEK can be described as a *knowledge-practice-belief* complex (Berkes et al. 1993). It enables the possibility for new interpretations, innovative solutions and adaptive management to complement the static synchronic worldview of conventional science.

2.6 Traditional ecological knowledge versus scientific knowledge

It is important to be aware of the fundamental differences that distinguish TEK from conventional scientific knowledge. TEK and conventional western science belong to two different epistemologies (worldviews). TEK observations tend to be qualitative and create a diachronic database, i.e. a record of observations from a single location over a long time period. This knowledge is said to be tested and validated through trial and error methods through generations. The observers tend to be the resource users themselves – hunters, fishers, and gatherers who are intimately linked to the land. In contrast, scientific observations made by professional researchers tend to be quantitative and represent synchronic data, i.e. "value-free" short-term observations from a range of sites. Scientific ecological knowledge often makes use of abstractions, yielding generalized models. Conclusions are often based on reductionist reasoning (Kimmerer 2000).

2.7 Benefits of CBM

CBM can provide a measure to address the limitations to science-driven monitoring listed in section 1.3.

1. Local communities are distributed more widely in the Arctic region than the scientific field stations and the peoples of the Arctic monitor the environment year-round as part of their everyday lives, thereby strongly extending the scientific understanding of the spatial and temporal dynamics (Danielsen et al. 2014).
2. CBM has been shown to be a cost-effective alternative to science-driven monitoring (Danielsen, Burgess, et al. 2005).
3. Local knowledge has been shown to extend the scientific understanding of ecosystem dynamics (Sutherland 2013; Eckert et al. 2017).

[2] Also know under other terms such as: Indigenous knowledge, Indigenous science etc.

4. The local and Indigenous peoples are often the first to spot even subtle changes in the environment, therefore CBM has been found to lead to effective and timely response to immediate threats to the environment while threats are still small.
5. CBM will by its nature focus on issues of greatest concern to the community, and is thus more management demand-driven, resulting in management decisions being taken more promptly (Danielsen et al. 2008).
6. CBM can be used to guide bottom-up management of fish stocks and other wildlife (Ferguson et al. 1998; Eckert et al. 2017)
7. CBM can lead to easy targeting of the most serious threats to the local ecosystems, suggest new research questions or reveal gaps in the scientific knowledge where further research is needed (EMAN 2013; Danielsen et al. 2014).
8. Besides the apparent advantages in improving the monitoring results, CBM additionally yields a lot of social co-benefits for the participants and the community. E.g. training and education, employment opportunities, increased local networks, data to support the local augmentation in management conflicts, building trust and credibility between locals and the authorities, a sense of ownership, self-esteem and pride (EMAN 2013; Wiber et al. 2009; Danielsen, Jensen, et al. 2005; Danielsen et al. 2008; Bertelsen 2016).
9. CBM can promote a change in attitude of locals towards more environmentally sustainable resource management (Danielsen, Jensen, et al. 2005).
10. CBM can make contributions to global assessments and play an important role in monitoring progress towards reaching international goals, for example the Aichi biodiversity targets (Farhan Ferrari et al. 2015).

2.8 Challenges of CBM

However, like all research methods CBM is not universally applicable, it is therefore crucially important for the successful implementation to follow best practices and recommendation and carefully investigate whether CBM is a suitable approach. Several challenges, pitfalls and critics (both justified and not) exist within CBM.

Firstly, opponents particularly question the validity of CBM data and note that since the observers often are the same people as the resource users CBM entail a conflict of interest (Fernandez-gimenez et al. 2007; Brandon 2003; Penrose & Call 1995; Farhan Ferrari et al. 2015; Root & Alpert 1994). This credibility issue is one of the main reasons why many scholars clearly distinguish between the quality of CBM and conventional science data, leading to the claim that CBM data need to be verified before being accepted as reliable (National EPA–Tribal Science Council & Integration 2011).

Secondly, another criticism regards the concept of community. Since CBM views communities as a unified entity, often there is a risk of neglecting the fact that communities also are composed by various peoples with various interests possibly affecting the quality of the monitoring outcomes (Degnbol et al. 2006). Thus as The Ecological Monitoring and Assessment Network (EMAN) states: *"since communities are unique, any approach to CBM should be appropriate to the local context, and a continually evolving process, flexible to change. In other words, CBM needs to be versatile, iterative and adaptive*" (EMAN 2013).

Thirdly, Indigenous knowledge monitor on a local scale why some scholars question whether CBM can be extrapolated and applied to larger scales (Maier 2001; Duerden et al. 1998). This is however often refuted, and CBM is increasingly being used to inform large scale monitoring (IPBES 2013b).

Leading to the fourthly challenge; making CBM available at scales beyond the local level raises challenges related to intellectual property and free, prior and informed consent (FPIC). Separating knowledge from its local, cultural, and epistemological context can involve significant risks for Indigenous peoples and local communities (IPBES 2013a).

Furthermore, a fifth and important challenge is the qualitative nature of CBM data, often the monitoring data is in ordinal scale (increase, decrease, stable) or the information can be in oral forms or in dance, movies, symbols, art-pieces or song, which is sometimes perceived as a nuisance by conventional scientists. While quantitative data is easily analysed by familiar statistical tools, a significant difficulty exists in finding appropriate means to manage qualitative data resulting from CBM. Often 1:1 comparison between local and scientific data is not possible. The socio-cultural context of CBM requires a cross-disciplinary approach, thus this demands improved skills by the scientists and decision-makers (Wayvey et al. 1993; Sillitoe & Marzano 2009; Mellado et al. 2014). Finally, perhaps the greatest challenge for CBM is the willingness and readiness of scientists, decision makers and management institutions to work collaboratively with community members. To respect and absorb the cultural, spiritual and social context of TEK (Brook & Mclachlan 2008; Day & Litke 1998; Wayvey et al. 1993).

3. Use of CBM in fisheries monitoring

One area where local and Indigenous peoples' knowledge especially is being used is in the fisheries. In this thesis I will focus on the use of CBM in Greenlandic fisheries, through analysis of fish stock abundance data from a Greenlandic CBM programme for the two study species: Greenland halibut (*Reinhardtius hippoglossoides*) and Atlantic cod (*Gadus morhua*) (see details in the method section).

CBM is especially relevant in the fisheries since often information on population dynamics, required to ensure a sustainable use of the fish stocks, is lacking and is both difficult and expensive to obtain. Especially from coastal areas, where big research vessels cannot be used, or in cases like in Greenland, where logbooks are not mandatory (see section 3.1), CBM can be used to provide essential information on population trends (Neis et al. 1999). In fact, this knowledge is termed fishers' ecological knowledge (FEK) (Leite & Gasalla 2013; Johannes et al. 2000).

Local fishers have been shown to provide crucial information related to a myriad of factors affecting the ecology of both commercial and non-commercial species such as: abundance dynamics, behaviour, spawning grounds, juvenile habitat, spatial and seasonal occurrence, habitat preferences, feeding behaviour, fish morphology, age and population structure, proportion of mature females and juveniles, stock structure, fishing areas, bycatch species, fishing practices, the performance of gear, and other factors affecting abundance, such as timing, wind direction, currents, water temperature, water clarity, bottom characteristics (Neis et al. 1999; Leite & Gasalla 2013; Eckert et al. 2017; Johannes et al. 2000).
Another important aspect of FEK, is the suggestions for local fisheries management (e.g. mesh and size of gillnets, closure seasons, gears restriction by fishing area), often provided by the fishers. Identifying management measures that are both scientifically valid and at the same time accepted by fishers is of utmost relevance for the long-term success of ensuring sustainable use of the natural resources (Himes & Carolina 2003; Bundy et al. 2008; Eckert et al. 2017).

However, due to scepticism about the accuracy and credibility of CBM data, scientists and managers are not always willing to incorporate FEK into their considerations (Johannes et al. 2000). Nonetheless presently FEK is incorporated more and more frequently due to a worldwide increasing number of case studies that have demonstrated consensus between FEK and conventional scientific data (Eckert et al. 2017; Leite & Gasalla 2013; Silvano & John 2008; Neis et al. 1999; Chanda 1998). In fact, FEK has been shown repeatedly to go beyond consensus, several examples of CBM data surpassing scientific knowledge can be found in the scientific literature. E.g. Johannes et al. 2000, in the article with the telling title "Ignore the fishers knowledge and miss the boat" presents a review of five cases, both Arctic and tropical, where marine biologists and managers underestimated the knowledge of local and Indigenous peoples resulting in serious consequences (Johannes et al. 2000).

3.1 Fisheries in Greenland background

3.1.1 The importance

Due to the vast inland ice sheet covering the majority of Greenland, life in Greenland has always been centred along the coast. The rich Arctic Ocean is the cornerstone of Greenlandic culture, economy and livelihoods. Today life in Greenland relies heavily on the fisheries. It is the one sole most important sector in the Greenlandic economy, accounting for more than 90 % of the total export (Bertelsen 2016; grønlands statistik 2016; Government of Greenland 2017) and the main employer of both men and women (grønlands statistik 2017). In many small communities a job in the fisheries sector is often the only option of employment (Bertelsen 2016). Moreover, many communities still live subsistence lives, with fish accounting for the main diet. Thus the coastal fishery has immense socio-economic importance for the livelihood of the locals, regional development and the national economy.

During the 20th century Greenland transitioned from a hunting society to a fishing society. This was especially due to the decreasing prices for seal products coinciding with a rapidly increasing stock of Atlantic cod. Later, when the Atlantic cod population crashed (explained in section 3.4.7), the fishery switched to focus on deep sea fishery of shrimp *(Pandalus borealis)* and Greenland halibut, which to this day are the main commercial species.

3.1.2 The Greenlandic fisheries - Description

The waters around Greenland are influenced by cold water masses from the Polar ocean and more temperate water masses from the Atlantic Ocean, making this a particularly biologically productive area. In 2010 DTU updated the Greenlandic fish species list, and concluded that 269 fish species are found in Greenlandic waters (Rask et al. 2010). Nonetheless the Greenlandic fishery is characterised by dependence on very few species, many of which have been found to be strongly impacted by climate change and interspecies interactions (Møller et al. 2010). Today the most important species are shrimp, Greenland halibut, Atlantic cod, lumpfish (*Cyclopterus lumpus*) and snow crab (*Chionoecetes opilio*).

When describing the Greenlandic fishery, one of the main characteristics to mention is the large regional differences. This is apparent both in relation to the distribution of fish stocks, the locations and capacities of the processing plants and the size and composition of the local fishing fleets.
Coastal fishing primarily takes place on the West coast, there are almost no commercial interest in coastal fishery on the East coast - also almost no landings and processing capacities are found here.
The offshore fishery however, takes places on both coasts. The offshore Greenlandic fishing fleet consists of few highly equipped huge trawlers, owned by big companies (or the government as with Royal Greenland), mostly with their own processing and packing facilities on board.
The coastal fleet is comprised of a mosaic of many small-scale or single person fishers in dinghies and small boats (<9,4m). Also, snow scooters and dog-sledges are used when the sea is ice-covered. In 2011 the coastal fleet consisted of 525 small boats and between 1500-2000 dinghies (grønlands statistik 2016).

3.1.3 The fisheries management

The fisheries sector is one of the areas that the Greenlandic home-rule government took home from Denmark, after ending the colonial period in 1979 with the establishment of the home-rule referendum. Thus, Naalakkersuisut (the Greenlandic government) has the full legislative responsibility for the fisheries (Government of Greenland 2017).

The Greenlandic fishery is regulated by TACs (Total allowable catches), quotas and licenses to ensure a sustainable use of the natural resources (Landstingslov nr. 18 af 31. oktober 1996 om fiskeri Government of Greenland 1996).

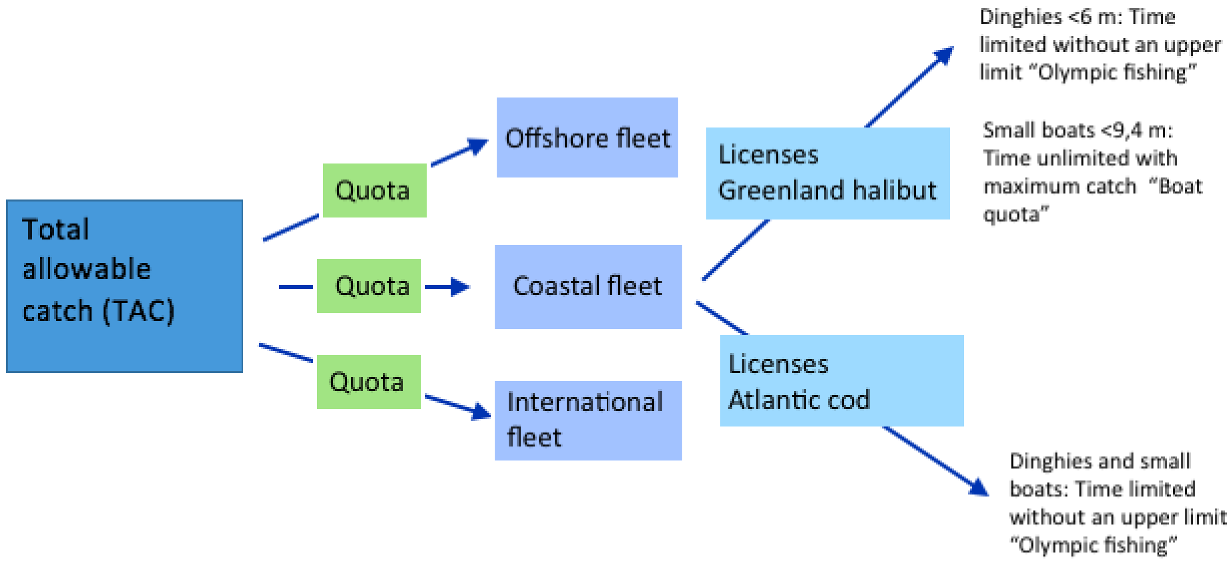


Figure 2 Model showing the Greenlandic fisheries management system regulated by TAC (total allowable catch), quotas and licenses. The model depicts an example of coastal Greenland halibut and Atlantic cod licenses.

The Greenlandic fishing waters range 200 nautical miles from the coast, within the so-called EEZ (exclusive economic zone). The management areas are divided in coastal and offshore fishing; coastal fishing is from the coast out to three nautical miles from the baseline (appx. 5.6 km from the coast), and includes all internal waters such as bays and fjords. Everything beyond this is characterized as offshore fishing. Coastal fishing is conducted using boats below size class 75 GRT/120 GT[3] (a measure of the cargo-carrying capacity of a ship), whereas offshore fishing is permitted for vessels bigger than 75 GRT/120 GT. However, some exceptions exist, e.g. for Greenlandic halibut where the maximum size for coastal vessels is 19,99 GRT/31,99 GT, due to limitations on the coastal processing plants (Greenland Government 2012). Additionally, since 2016, Atlantic cod vessels below 75 GRT/120 GT has been allowed to fish outside the 3nm limit.

[3] GT = Gross tonnage (Simply put a measure that equals the internal volume of the boat in cubic feet, it has nothing to do with the weight). GRT = Gross register tonnage (which is gross tonnage minus the volume of space that cannot be used for cargo or passengers).

Certain species are licensed[4], all commercial fishers need to apply to the Ministry of Hunting and Fishing (APN) for licenses to be permitted to fish for these species. Most licenses are valid for a period of one year and have to be re-applied for every new season. Non-commercial fishers do not need license for own consumption or subsistence fishing (Selvstyrets bekendtgørelse nr. 8 af 8. april 2016 om licens og kvoter til fiskeri Government of Greenland 2016).

Three types of licenses exist:

1. Time limited with maximum catch quantity
2. Time limited without maximum catch quantity, also called "Olympic fishing"
3. Time unlimited with maximum catch quantity, also called "Boat quota"

APN each year[5] decide a TAC for each of the licensed species. This process includes receiving biological advice from the Greenlandic Institute of Natural Resources (GINR) in collaborating with NAFO (Northwest Atlantic Fisheries Organization) and ICES (the International Council for the Exploration of the Sea). The biological recommendation is given based on all known scientific knowledge about the fish populations and using the precautionary principle in order to secure that the impact of the fishery does not cause harm to the species. Furthermore, before setting the TAC, the Fishery Council, consisting of representatives from KNAPK (the Association of Fishers and Hunters) and the employers' associations will be consulted.

To keep track of the quotas and to monitor the stocks all commercial catches are registered. All offshore fishers and coastal fishers with vessels > 9,4 m are obliged to fill out a logbook comprising detailed information about area, size, weight, numbers, fishing hours etc. Additionally, all trades are registered by the landing plants and information about weight, species, area of fishing, gear used etc. is registered (meaning that the small coastal boats' landings will be registered here and the offshore boats will have two types of registrations). It is the Greenland Fisheries Licence Control (GFLK) who receives and handle this information and perform patrols to ensure that the rules are followed accordingly.

3.1.4 International fleet

Besides the Greenlandic fishing fleet, Greenland also has special international fishing agreements with Norway, Russia and The Faroe Islands who gets a share of the TAC in exchange for opening op their waters to Greenlandic vessels. Furthermore, since Greenland exited EU in 1985 in order to gain more control of its own fishery management, Greenland has had the status of an EU oversea country and territory (OCT). Now Greenland has an extraordinary agreement with EU comprising a fishing and a partnership agreement. Today the EU funding makes up an important share of the Greenlandic budget and at the same time secures Greenland access to the EU free trade area, permitting Greenlandic products to enter the EU internal market. The agreements bring in substantial income to the fisheries sector and through the partnership agreement money is targeted at the sustainable development of the whole country. In the period of 2014-2020 the partnership funding is targeted at the Greenlandic school system and amount to 217,8M € (1,6B DKK) (the fisheries agreement is

[4] The offshore fishery licensed species are: Shrimp, Greenland halibut, Snow crab, Atlantic cod, Redfish (Sebastes spp.), Atlantic halibut (*Hippoglossus hippoglossus*), Capelin (*Mallotus villosus*), Grenadier (Macrouridae). The coastal fishery licensed species are: Shrimp, Greenland halibut, Atlantic cod, Snow crab, Atlantic salmon (*Salmo salar*), lumpfish, scallop (*Chlamys islandica*)

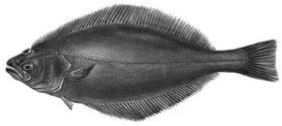
[5] There are exceptions, some TACs are set for longer periods

around 20M €/year (150M DKK)). This is in return for Greenland allocating quotas for commercial fishing to EU fishing vessels.

3.2 Coastal fishing for Greenland halibut (*Reinhardtius hippoglossoides*) and Atlantic cod (*Gadus morhua*)

This thesis focuses on the two study species Greenland halibut (*Reinhardtius hippoglossoides*) and Atlantic cod (*Gadus morhua*), in the following a description of the species biology, history and management is presented.

3.3 Greenland halibut (Reinhardtius hippoglossoides, Walbum 1792)



3.3.1 Distribution

The Greenland halibut is only found in the cold waters surrounding Greenland, Iceland, the Faroe Islands, Newfoundland and in the Barents Sea.

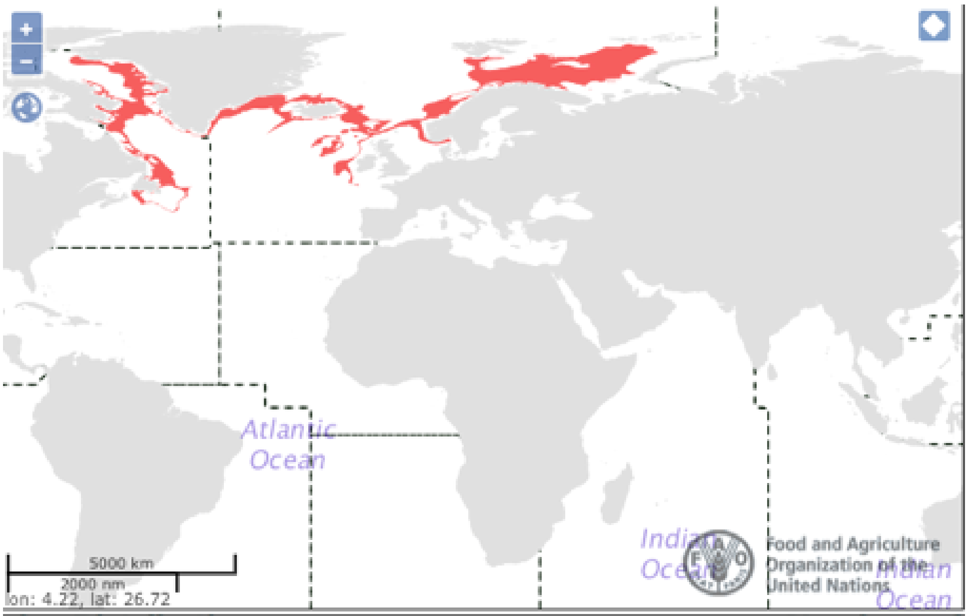


Figure 3 distribution map for Greenland halibut source: http://www.fao.org/fishery/species/2544/en

Greenland halibut is widely distributed in Greenland. It is found at great depths both offshore and coastal. It can be found from Ittoqqortoormiit on the East coast, south on Cape Farewell and up to Qaanaaq on the NW coast of Greenland.

3.3.2 Species biology

The Greenland halibut belong to the *Pleuronectidae* family (the right eye flounders), it is a demersal deep water fish, found at depths of 200-2000m. It is mainly found in waters with temperatures from 1-4°C, but has also been observed at sub-zero temperatures down to -2.1°C (Jørgensen 1987). Due to low water temperatures, the growth rate is slow. Females reach maturity at 10 years of age, when they are approximately 60 cm long. Males mature at 7 years of age or approximately 50 cm long. The sexes grow at the same speed but vary in size and longevity, females have a maximum seize of 125 cm and 45 kg and live around 25 years, while males have a maximum size and 80 cm and live around 11 years. The Greenland halibut is unusual for the order of *Pleuronectiformes* (the flatfishes) because it is a fast swimmer, an effective hunter, and an unusually mobile flatfish (Fisheries and Oceans

Canada 2008). It feeds primarily at the ocean floor on fish and crustaceans. However, it also feed on squid and polar cod in the pelagic zone. The Greenland halibut itself, is a preferred prey for several marine mammals, especially the narwhal who at their wintering grounds in Baffin Bay and Davis Strait can have a significant impact on the population. Also, The Greenland halibut is a popular fish for human consumption, the meat is white and has a high fat content, making it rich in flavour. Furthermore, due to the slow growth rate the meat is extraordinarily firm. Greenland is the leading supplier of halibut to the world market. Most of the catch is exported to China and Japan for fillets, sushi and sashimi.

3.3.3 The population

A lot of uncertainties about the populations dynamics still exits. It is believed that Greenland halibut throughout the North Atlantic can be viewed as one meta population with a group of spatially separated sub-populations/stocks[6] which interact at some level (Stenberg 2007). In Greenland two of these sub-populations exits: The Eastern Canada and West Greenland stock complex (From which the stock on the West coast originates) and the Eastern Greenland, Iceland and Faroe Island stock (From where the East Greenlandic stock is believed to originate from) (Simonsen & Gundersen 2005; Stenberg 2007).

3.3.4 Spawning

Knowledge of Greenland halibut spawning is limited. The main spawning areas are believed to be in the deep waters (>1500m) in the Davis strait and on the Canadian shelf between Disko Island and Baffin Island. The Greenland halibut is a batch spawner, it migrates from the northern part of Davis Strait and Baffin bay, south to the spawning grounds (Gundersen et al. 2010). From the spawning areas the eggs and larvae drift to the banks of the west coast of Greenland or are transported to the banks of Baffin Island and Labrador by the current. The East Greenlandic stock is thought to originate from the spawning area west of Iceland (Jensen 2003).

Eggs and larvae of Greenland halibut drift in the water masses for more than half a year before they settle to the bottom. At first the larvae are pelagic and like round-fish larvae, has eyes on either side of the head. But as the larvae gradually grow and flatten, the left eye starts to move and will in the adult fish be placed in the forehead (in other species in this family the left eye wanders further, all the way on to the right side). At this stage the fish settle at the bottom. Important nursery areas are found at Store Hellefiske Banke and Disko Banke, SW of Disko Island. Probably some also settle further north on the banks in Baffin Bay, depending on the drift of the West Greenland Current (Stenberg 2007). The fish spend the first years of their lives in these nursery grounds, before they migrate towards greater depths either in Davis strait, central Baffin Bay or in the fjords along the West coast of Greenland. Some fish may migrate across the Davis Strait to settle on the Canadian shelf.

It is assumed that spawning does not occur in coastal waters, if spawning occurs here it is believed to be sporadic and not sufficient to maintain the population (Simonsen & Gundersen 2005; Simonsen & Boje 2000; Boje 1994; Simonsen & Boje 1999; Jørgensen 1987). Once the small Greenland halibut have migrated from the offshore nursery areas to the fjords, they become resident but do not reproduce, possibly because the water in the fjords are too warm for the eggs to develop (Boje 2001).

[6] 1) Norwegian and Barents Sea; 2) The waters off East Greenland, Iceland and Faroe Islands; 3) Newfoundland area, Grand bank, Labrador, West Greenland; 4) The Gulf of St. Lawrence

Thus the coastal stock is consequently depended on inflow of fry and juvenile Greenland halibut from the offshore stock.

3.3.5 Management

Management considerations for coastal Greenland halibut are therefore different from other stocks under fisheries management since it is not considered a spawning stock. The management areas for Greenland halibut are divided into:

Offshore

1. Davis strait (the TAC is shared 50/50 with Canada)
2. Baffin Bay ((the TAC is shared 50/50 with Canada)
3. East Greenland

Coastal

4. Disko bay
5. Uummannaq
6. Upernavik
7. Remaining Greenland

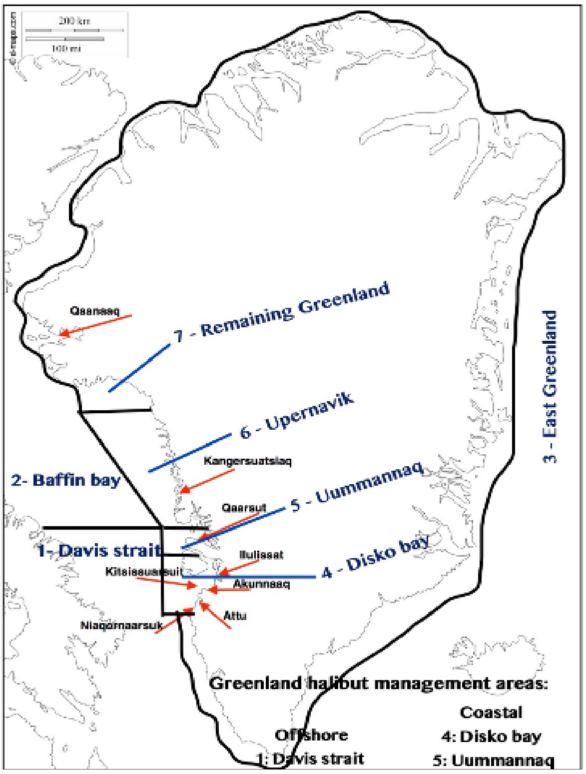


Figure 4 Map showing the offshore and coastal management areas for Greenland halibut, for reference the communities participating in PISUNA is marked by red arrows

The area of Disko bay, Uummannaq and Upernavik, have been managed by TACs since 2008. The Greenland halibut fishery in this area is in value the most important fishery in the whole coastal fisheries industry. A coastal Greenland halibut license is valid for both Disko bay, Uummannaq and Upernavik, but the fisher cannot at the same time possess a license for any of the other management areas (Selvstyrets bekendtgørelse nr. 11 af 28. august 2014 om kystnært fiskeri efter hellefisk Government of Greenland 2014).

A change in management was implemented in 2012. Now half of the coastal Greenlandic halibut quota is distributed to small boats (> 6m < 9,4 m) as time unlimited with maximum catch (called "boat quota", since every single boat is assigned a maximum catch amount). The other half is distributed to dinghies (< 6 m) as time limited without an upper limit (no individual limit, everybody shares the quota, this is called Olympic fishing, since it is "a race" to get the most fish before the quota is closed). Also the quotas for small boats were transformed into individual transferable quotas

(ITQs), meaning that it is now allowed for small boats to trade the coastal Greenlandic halibut quotas (the same way as with the shrimp quotas). This was implemented by the previous government as a mean to restructure the coastal fishery to make it more profitable. The goal was that the quotas would be accumulated on fewer bigger boats, thereby phasing out small scale fishing. The plan was to do the same with the dinghy licenses, however, in 2014 the new government came to power and reversed this plan.

3.3.6 The history of Greenland halibut fishery

Coastal Greenland halibut fishing has a long history in Greenland as a traditional fishery, first with single hooked lines, then later in the beginning of the 1900's, the long-line tradition started with 100 -2.500 baited hooks are attached to a main line that is anchored to the sea bottom. Greenland halibut is fished all year, in open waters from boats during summer and from the ice with dog sledges or snow scooters in winter. Fishing with longlines is considered as a non-destructive method, as the sea bottom is left unharmed and the fish are detached by hand, causing only minimal damage to the fish meat. The method is very labour intensive, however.

After the collapse of the Atlantic cod stock in 1960's (see details section 3.3.7), the commercial fishery for Greenland halibut took off rapidly and today it is the second most important commercial fishery in Greenland (after shrimp).

In 2017, the offshore Greenland halibut fishery in Greenland, achieved the Marine Stewardship Council (MSC) certification. This is the first Greenland halibut fishery in the world to receive a MSC, which is only appointed to sustainable and well-managed fisheries. This is a great success both environmentally and economically. The world market is demanding sustainable products and the Greenland Greenlandic halibut can now be sold globally carrying the blue MSC label.

3.3.7 Today

Even though the offshore Greenland halibut population is highlighted as a success, the coastal Greenland halibut stock has been subject to much heated debate recently. In particular, the most important fishing grounds at Disko bay. Stakeholders have for the last 4-5 years been discussing whether this population is decreasing and at risk of collapsing or not.

The landings have been gradually decreasing, from 12.500t in 2005 to now 7.268t in 2017. GINR have from their surveys found the size of Greenland halibut in Disko bay to be getting smaller and smaller, thus the catch per unit of effort (CPUE) is decreasing see figure 5. Meaning that today the fishermen need to invest greater efforts in order to maintain the same quantity. GINR interpret the declining sizes as a sign that the larger residential fishes in the fjords of Disko bay have been overexploited and now the fishers are catching the recently recruited smaller fish. Biologists are very worried that if the fishery continues as it is now, the population risk collapsing. Due to the slow growth rate of Greenland halibut, it would take several years to re-establish the population if a potential collapse should happen

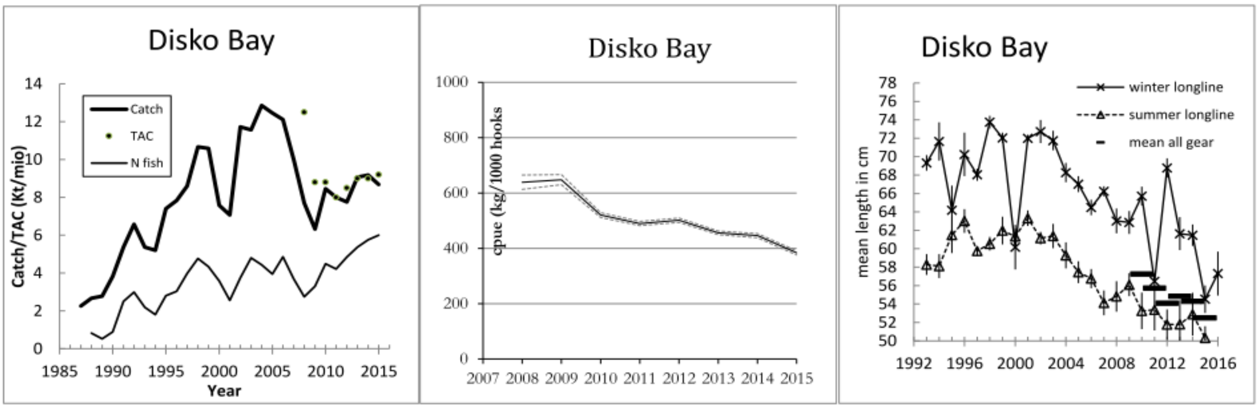


Figure 5 Data from Greenland Institute of Natural Resources (GINR) to support their biological advice. The first graph show catch, TAC and numbers of fish caught over the year. In the middle, the graph show catch per unit of effort (CPUE) over the years and the last graph to the right show mean lengths of Greenland halibut divided on winter longline, summer longlines and a mean for all gear. (Greenland Institute of Natural Resources/ ICES/ NAFO 2018)

3.3.8 The biological advice is not followed

During the last years, the TAC has generally been set significantly higher than the biological recommendations. In 2017 and 2018 the TAC for the total coastal area was almost 50 % higher than the biological recommendations.

Table 1 Table showing the difference between the biological advice and the TACs for the coastal management areas for Greenland halibut

	Disko bay		Ummaanaq		Upernavik		Remaining Greenland	
Year	Biological recmmendation (t)	Tac (t)	Biological recmmendation (t)	Tac (t)	Biological recmmendation (t)	Tac (t)	Biological recmmendation (t)	Tac (t)
2012	8000	8000	5000	6000	No recommendation	6500	No recommedation	No TAC
2013	8000	9000	6000	7450	6300	7950	No recommedation	No TAC
2014	8000	9000	6000	8379	6300	9015	No recommedation	No TAC
2015	8000	9200	6000	9500	6300	9500	No recommedation	No TAC
2016	8000	9200	6000	9500	6300	9500	No recommedation	No TAC
2017	6400	9200	6500	9500	6300	9500	No recommedation	No TAC
2018	6400	9200	6500	9500	6300	9500	No recommedation	No TAC

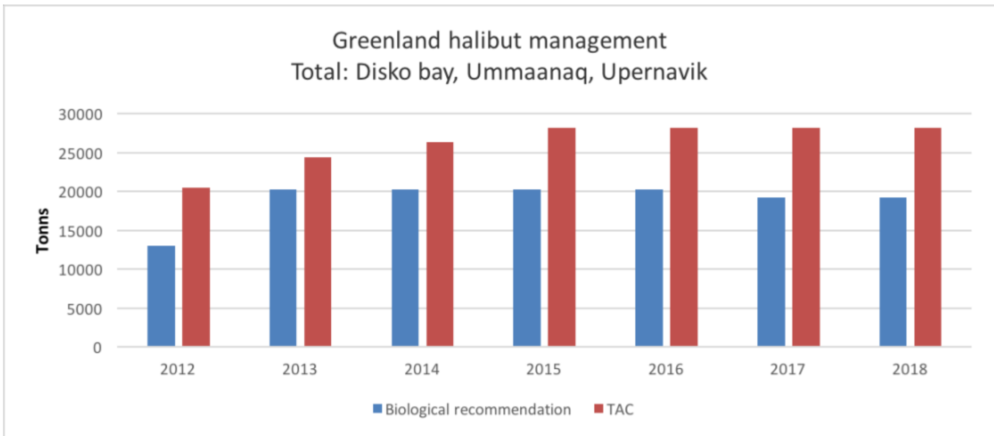
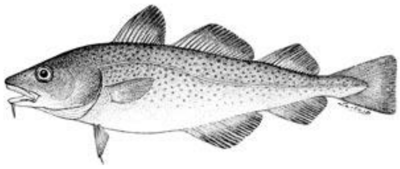


Figure 6 Graph showing The difference between the biological recommendation from GINR and the TAC determined by APN for the three management areas: Disko bay, Ummaanaq and Upernavik in total

3.3.9 The condition of the Greenlandic stock

Except for the coastal area of Disko Bay, the overall Greenlandic Greenland halibut stock appears to be stable. However, biologist have expressed concerns that a tendency to decreasing average size is now also seen at Uummaanaq. There is a worry that the declining catches in Disko Bay will result in many fishers from Disko area going to Uumannaq or Upernavik, thus increasing the fishing pressure here too. Already in 2011 local dinghy fishers from Upernavik expressed their frustration about fishers coming from the south in boats and catching a significant proportion of their total quota (GINR 2011).

The public debate is often heated when it comes to the coastal Greenland halibut stock, numerous stakeholders are affected by the Greenland halibut fishery and the stakes are high both for the livelihoods of the local fishers, political power, the national economy and for the environment. TAC policies remain a cause of conflict between scientists, fishers and decision-makers.



3.4 Atlantic Cod (Gadus morhua, Linnaeus, 1758)

3.4.1 Distribution

Atlantic cod has a wide distribution; it is found along the North American coast in the West and North Atlantic Ocean into the Arctic region, where it is distributed on the East and West coast of Greenland, around Iceland, in the Barents Sea. It is also distributed throughout Europe

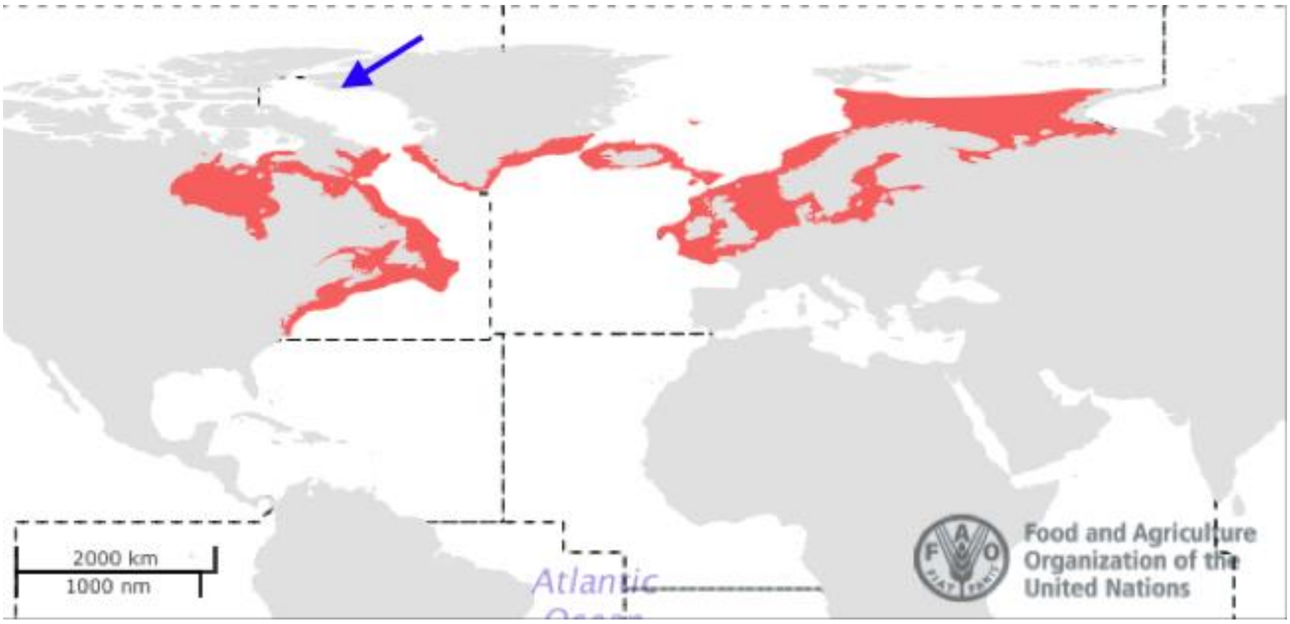


Figure 7 Distribution map of Atlantic cod source: http://www.fao.org/fishery/species/2218/en, the blue arrow indicate the new range of distribution discovered in the PISUNA data analysed for this thesis.

In Greenland Atlantic cod is described in the literature to be found on the West coast up to Qeqertarsuaq and on the East coast up to Tasiilaq (ICES 2005), however as shown in this thesis, the Atlantic cod is now also found as high North as Qaanaaq.

3.4.2 Species biology

Atlantic cod belong to the Gadidae family, it is a benthopelagic fish, meaning it inhabit the water just above the bottom but is also found in the pelagic zone. It is found at temperatures from 2 to 8°C, at depths of up to around 600m. Juveniles prefer shallow waters (less than 30 m depth). Atlantic cod reach maturity when they are around 2-3 years, or equivalent to 31-74 cm, and it can live to around 25 years. Atlantic cod feed on various prey, both benthic and pelagic, crustaceans and fish (including cannibalism) are usually the main diet.

Atlantic cod is very sensitive to temperature changes and have rapidly increased or decreased according to the water temperature (Wieland 2015). The increasing water temperatures due to climate change is thus thought to benefit the Atlantic cod (Buch 2000; Wieland 2015).

3.4.3 Spawning

The Atlantic cod spawn in batches. The larvae are pelagic at first and prey on zooplankton, but after a few months the juveniles become more benthic. Previously major spawning grounds were found at the shallow (< 350 m) banks along the West coast and the offshore areas in south Greenland, however since the collapse of the stock in the 1970's, Atlantic cod almost disappeared from the offshore waters. Instead the coastal spawning grounds in the fjords on the West coast have become the most important. Here the cod spawn in shallow parts of the fjord with warmer waters (0,5-4°C) (Storr-paulsen 2006; Storr-paulsen et al. 2004).

3.4.4 The Greenlandic Atlantic cod stocks

Four separate stocks with distinct spawning grounds are found in Greenlandic waters, they however do intermingle outside the spawning period (Storr-paulsen et al. 2004).

1. A relatively stationary coastal West Greenlandic stock which spawn in the fjords along the Westcoast.
2. An offshore stock that spawn on the banks along the West coast and in the offshore waters of Southwest Greenland.
3. An offshore stock which spawn in East Greenland
4. A stock originating from Iceland.

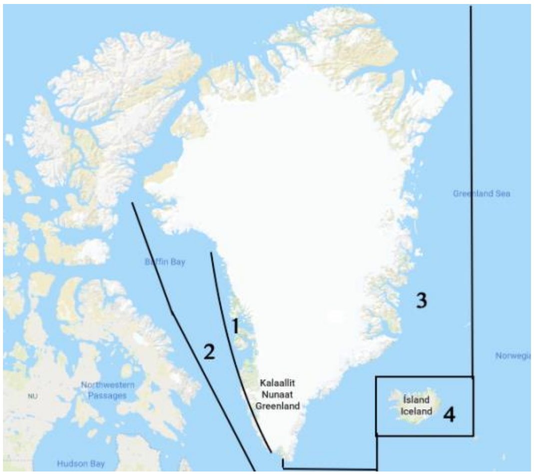


Figure 8 Map showing the 4 distinct stocks of Atlantic cod in Greenlandic waters

3.4.5 Management

The management for Atlantic cod is divided in three management areas:

- Coastal West Greenland,
- Offshore West Greenland
- Offshore East and Southwest Greenland

It was not until 2013, that the coastal population was identified as a separate population and received a separate management area. Also before 2016 the management area for East and West Greenland was combined, since the population depended on the Icelandic contribution and could not be distinguished.

Due to limited knowledge about the stock estimates and population structure, for long a time, the biological advice has been to not conduct any commercial fishing (in any of the management areas). With the identification of a distinct offshore and coastal population, and the increasing stock GINR was able to recommend a TAC for the coastal Atlantic cod fishery and the East Greenlandic offshore population. Still it is recommended to avoid offshore fishing in West Greenland.

3.4.6 The biological advice is not followed

The TACs are however not following the biological recommendations, in 2017 a trial fishery of 5000t was decided for the West Greenlandic offshore population, and the last three years the TACs have been set 2-3 times higher than the recommendations for the two other management areas.

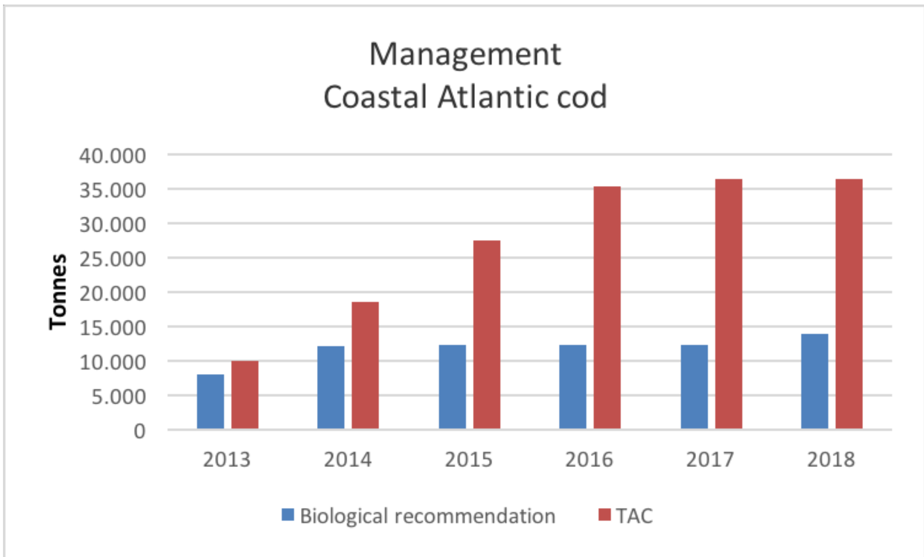


Figure 9 Graph showing the difference between the biological recommendation by GINR and the TAC decided by APN for coastal Atlantic cod

Biologists are concerned that the coastal TAC is too high, and that it is too soon to open up for fishing in the offshore waters on the west coast. They argue that even though the population is increasing, it is still at very low levels compared to previously, the spawning stocks might not have built up yet, meaning that the same year classes are being caught. This could lead to a risk of overfishing and population collapse.

The big discrepancies between the recommendations and the TAC are partly a result of the local fishers' strong requests for higher TACs. The fishers view the population to increased enough to start implementing higher TACs (Hedeholm et al. 2016).

3.3.7 The history of Atlantic cod fishery

The Greenlandic Atlantic cod population has fluctuating greatly. This is assumed to be due to both overfishing and the changing climate with varying air and sea temperatures.

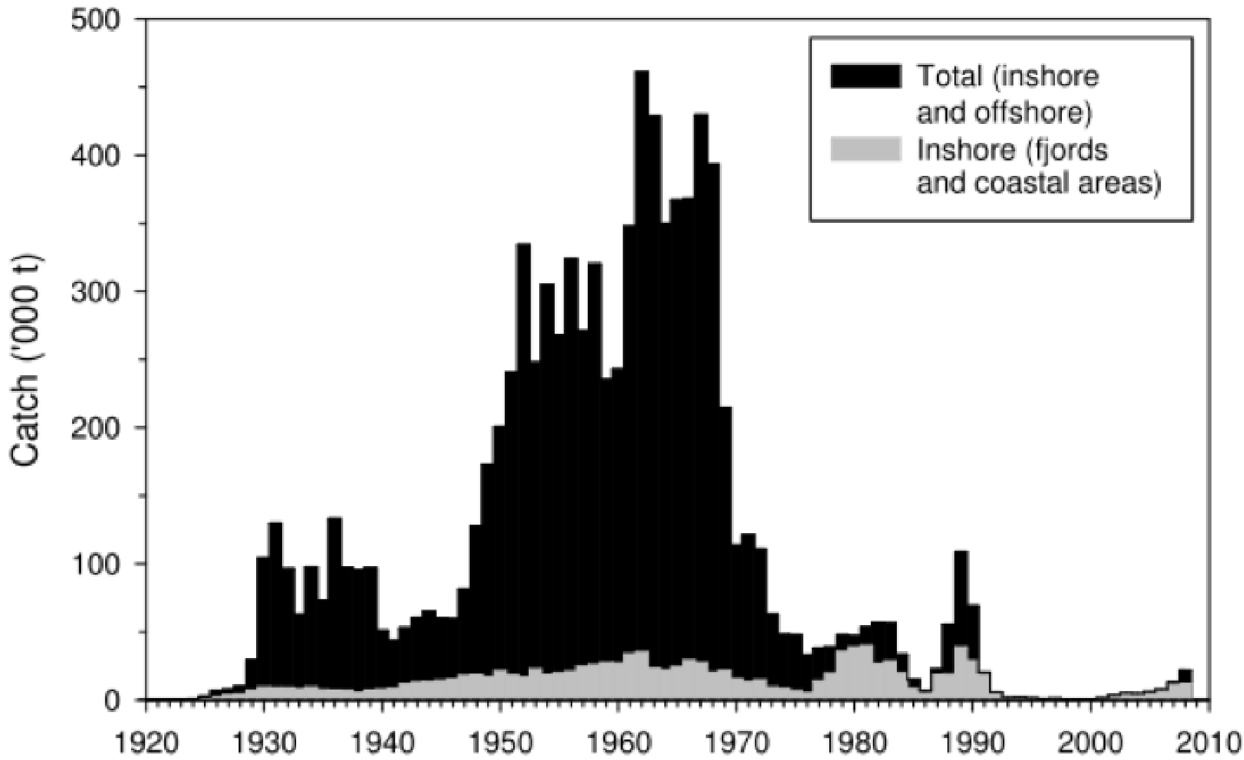


Figure 10 Graph showing the historical catch quantities for Atlantic cod. The black graph show the total (inshore and offshore) catch and the grey graph show the inshore catch separately (Wieland 2015).

The commercial coastal fishing for Atlantic cod started around 1910, with catches around 1000t. Then in the 1920's a general warming of the northern hemisphere resulted in a strong increase in the offshore stock, shifting the main effort to offshore fishing instead. It was the beginning of a large offshore fishery, resulting in Atlantic cod replacing seal hunting as the most important commercial sector in the 1930's.

The catches kept rapidly increasing until peaking in the 1960's, with catches of around 450.000t. The industry was booming and a lot of efforts in optimizing the capacity in the cod fishery were initiated. However, during the 1960s, the conditions changed, the West Greenlandic waters were cooling and Atlantic cod began appearing later each year and retreating further south. The Atlantic cod catches declined drastically and the stock collapsed around 1969. The commercial fishing for Atlantic cod was more or less stopped, expect for a few years (e.g. 1973, 1984, 1985), where strong year-classes gave rise to periodic commercial fishery. This happens since periodically Atlantic cod egg and larvae are passively transported to Greenland with the ocean currents from Iceland.

3.4.8 Today

After the offshore Atlantic cod fishery stopped, instead the relatively small coastal fishery took over, and still to this day the coastal fishery constitutes the largest proportion of the Atlantic cod fishery. However, since the beginning of the millennia, there have been signs that the Atlantic cod stocks are increasing once again. More Atlantic cod is being landed both in the coastal and offshore fishery, in 2015, the highest amount in 25 years was caught (25.272t coastal and 20.615t offshore). Furthermore, improved year-class composition and increased average sizes are suggesting improved conditions. However, the current catches are still only a fraction of the historical high 450.000t.

4 Methodology

4.1 Overview

In order to assess the depth and breadth of CBM in the Arctic, 3 different methods were used:

1. A practical hands-on investigation of the applied work with Näätämö river restoration project, a successful CBM programme in Sevettijärvi, Finland. Which was used as personal background experience in order to gain knowledge and insight to satisfyingly assess CBM programmes based on theoretical reviews.
2. A questionnaire survey used to provide a detailed characterisation of key features describing Arctic CBM programmes, and at the same time creating the foundation for an Arctic CBM meta-data base.
3. An in-depth analysis of abundance trends for Greenland halibut and Atlantic cod from PISUNA - a "best-example" Greenlandic case study, used to conclude differences in the format and the results between CBM and scientific monitoring data.

The questionnaire survey and in-depth analysis entail comparative analysis against corresponding scientific data. However, it should be noted that the aim with this, is not to try and verify the CBM monitoring - CBM is here considered valid in its own right. Rather the comparison is used to underline distinguishing features separating CBM and science-driven monitoring.

The details of the three methods are described in the following.

4.2 Field work - Näätämö river restoration project

Since I did not have any prior experience working with CBM programmes I joined Snowchange Cooperative for 3 weeks in the summer 2017 with the aim of gaining knowledge and experience within this field.

4.2.1 Study site

The fieldwork was conducted in the area of Sevettijärvi, Finish Lapland, approx. 400 kilometres north of the Arctic circle. Here the local Skolt Saami people in collaboration with Snowchange Cooperative have managed a CBM program since 2011.

Figure 11 Map of Finland, showing the location of the field site

Box 3 The Näätämö river restoration project

The aim of the project is to improve the conditions for the culturally important Atlantic salmon (*Salmo salar*) by restoring the river channels, changed by Metsähallitus ("Finish Forestry Agency") in the 1960s back into their natural states. At the same time the aim is to advance the Skolt Saami participation in issues of nature management and to reform the dialogue with the state authorities.

The Skolt Saami people are a minority within the minority of Saami's. They are Europe's smallest, oldest and most original Indigenous people. Originally the Skolt Saami's were living of the rivers especially from salmon fishing. The Skolt Saami have preserved their traditional lifestyle to an even higher degree than most other Saami people. However, their language, culture, traditions and TEK is at risk of going extinct. The Näätämö programme also addresses these issues by mapping traditional land uses and oral histories and bringing back pride and self-esteem regarding the local traditional practices in the community.

With the help of Snowchange cooperative facilitating the contact to the local authorities, the Skolt Saami have initially set up monitoring of the condition of the river. Two groups of local fishermen (the first team led by a male elder in mid-60s, the Second team led by a reindeer herder-fisherman in mid-40s), documents observations of fish resources, harvest, uses of the basin, etc. during the season by using a simplified field sheet adapted from the Greenlandic PISUNA project. Local fishermen and women have added to the data through interviews conducted in their Skolt language about the salmon, place names and past environmental change, helping to record traditional knowledge.
After the season the forms are collected and data and observations are discussed in informal group interviews. Furthermore, an added blank space in the field sheet, allows for further observations considered important by the Skolt Saami. Here unusual observations about weather, water quality, new species etc. is recoded.

The Näätämö river, which is a cross-border river between Finland and Norway is the second most important salmon river in Finland. This river is the cornerstone and home of the rich cultures of the Indigenous Skolt Saami. However, several factors are now threatening the Näätämö river salmon population, and as a result, the Skolt Saami way of life. These are: severe climate fluctuations affecting habitats, water temperature, oxygen levels and water levels, discharges from the close-by mining activities in Kirkenes[7], salmon farming along the coast of Norway, fish parasites, man-made alterations and tourism development.

The restoration measures are something the local people have hoped for the last 50 years. In the 1960's, Metsähallitus, widened part of the river channels using explosives. The alterations of the river flow had a drastic impact on the area which lost the suited spawning grounds. This had devastating effects on the culture of the Skolt Saami, who through millennia have fished as part of their culture and subsistence. In 2013 the Skolt Saami adapted, the first collaborative management plan for Finland (Mustonen & Feodoroff 2013). Based on this work the Skolt Saami have decided on the restoration efforts which was initiated by the Näätämö river programme. All restoration activities are designed and decided by the Skolt Saami themselves and the initiative is then co-managed by Snowchange and the stakeholders. The collaboration includes several stakeholders such as Metsähallitus, the Finish Natural Resources Institute, the Ministries for salmon management, the municipality of Inari, the Sevettijärvi Skolt Saami village Council, the local Skolt Saami as well as local Finns.

[7] Which is along the way for the migrating salmons coming from the Barents Sea going towards Näätämö river

Participatory observation was used during the river restoration, where a team of around 10 Skolt Saami together with a restoration consultant and Snowchange Cooperative, manually restored the flow of the river at distinct locations by relocating rocks and boulders in the river and afterwards distributing spawning gravel at suited locations.
In addition, informal interviews of informants and key informants were conducted throughout the whole period. Key informants were: Tero Mustonen and Kaisu Mustonen in charge of Snowchange Cooperative and Stina Roos, Northern Saami who were filming the whole restoration process in order to make it in to a documentary later. Free-listing of the most important aspects when designing, executing and assessing CBM was done.

Since this field work was used to gain initial experience with CBM in general, no actual results will be presented from this, instead I have drawn on the immense experiences and insights I obtained during the field trip throughout the entire thesis process.

4.2.2 Snowchange Cooperative

Snowchange Cooperative is an independent, non-profit organization based in North Karelia, Finland. The organisation was founded close to 20 years ago and has specialized in ecological monitoring in the Boreal and Arctic. Snowchange Cooperative are today undertaking large-scale Indigenous and local-driven ecological restoration activities to combat negative impacts of climate change. The organisation is devoted to keeping alive and aiding the rebirth of traditions and cultures of local and Indigenous Communities. This is for example done by building on Indigenous and local knowledge-based cultural indicators, oral histories, science assessments and CBM tools. The main purpose of the organisation is to address environmental change from the view of Indigenous communities. Snowchange Cooperative collaborate with an extensive network of local and Indigenous communities around the world including Saami, Chukchi, Yukaghir, Inuit, Inuvialuit, Inupiaq, Gwitchin, Icelandic, Tahltan, Maori, Indigenous Australian and many others to help them face the ongoing climatic and anthropogenic changes. The organisation is led by Tero Mustonen together with Kaisu Mustonen, but the Snowchange International Steering Committee includes 25 people, 20 of them being recognized as leaders in their respective communities.

4.3 Characterisation of Arctic CBM programmes

In the second part of my thesis I characterised and determined the distinguishing features of Arctic CBM programmes using a questionnaire survey.

4.3.1 The Questionnaire survey

A review of peer-reviewed and grey literature on the topic of Arctic CBM was conducted to identify currently running CBM programmes in the Arctic. Likewise, internet search, and the knowledge from NORDECO's long-term work within the field provided the identification of the target group for the questionnaire survey. 170 Arctic CBM programmes were identified in this process. The programmes were then selected from criteria ensuring a representation of the widest possible set of characteristics, such as: representing all Arctic countries and representing all types of attributes (what is monitored). 45 suited Arctic CBM programmes were identified through this process and the organisers of these were forwarded the questionnaire and asked if they would be willing to participate in the survey. The ambition was to gather a representative subsample of minimum 20 currently running Arctic CBM programmes. 30 out of the 45 CBM programs accepted and filled in the questionnaire, see appendix 1 for the list of respondents.

4.3.2 Meta-database

In addition to providing direct information for this thesis, the questionnaire survey feeds into the big EU funded project INTAROS (Integrated Arctic Observation System). INTAROS is an interdisciplinary project, running from 2016- 2021, it involves experts from 49 organisations in 20 different countries in Europe, North America and Asia. The overall aim is to improve the coordination and collaboration within observing systems and databases existing in the Arctic. I have been collaborating with the team at NORDECO and with one of the INTAROS' working groups, led by polar scientist Roberta Pirazzini. This group has completed a questionnaire survey from which they will create a meta-database[8] comprising "all" science-driven monitoring programs in the Arctic. Pirazzini's group is furthermore subsequently responsible for creating an interactive map featuring meta-data from all the responding projects.

Together with NORDECO I created an identical meta-database of a representative section of currently running CBM programmes in the Arctic, to feed into Pirazzini's work. This way the final meta-database will result in an easy accessible overview of both conventional and CBM monitoring programmes in the Arctic. Thus bringing together these two approaches.

4.3.3 The questionnaire design

The CBM questionnaire was created on the basis of several criteria and considerations. Firstly the CBM characterisation builds on the work of the only other Arctic CBM assessment which was made by the Sustainable Arctic Observing Networks[9] (SAON) in 2016 (Johnson et al. 2016). The questionnaire was then designed to provide an updated list of programmes and enhance the meta-data information level of the SAON meta-database. In addition, the questionnaire was designed to make sure the CBM programmes would be an integral part of the final INTAROS database. Therefore, the structure was created similar to the one used for the science-driven programmes' questionnaire. Most importantly, the questionnaire was designed to be as simple and functional as possible, in order to yield answers that would be appropriate for direct reliable analysis. On this augmentation, the CBM questionnaire was designed primarily from multiple choice options with an additional open-ended question in each section, providing the option of elaborating or commenting on anything the respondent judged important. The questionnaire consists of 33 questions, divided into 4 sections (central questions, general information, question on the community members and questions regarding the data) concerning key features of the CBM programme such as aim, links to management, degree of involvement of community members, outcomes for the community, monitored attributes, method, and data handling, see appendix 2 for the full questionnaire.

4.3.4 NORDECO

The Nordic Agency for Development and Ecology (NORDECO) is a Danish enterprise conducting interdisciplinary research within social and natural sciences. NORDECO work close together with local communities to build capacity, connect people and help facilitate and initiate interventions on-the-ground, such as environmental monitoring programmes. NORDECO was founded in 1990, the enterprise is owned by the non-profit Nordisk Fond for Miljø og Udvikling (www.nfmu.org), which

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[8] Meta in the way that it contains detailed information about the projects, but not the actual data results

[9] The purpose of the Sustaining Arctic Observing Networks (SAON) is to support and strengthen the development of multinational engagement for sustained and coordinated Pan-Arctic observing and data sharing systems. In 2009, the Arctic Council launched SAON in response to the recognised need to enhance arctic monitoring. 81 Arctic CBM programs were identified and metadata hereof was presented on the Online Atlas of Community-based Monitoring in a Changing Arctic http://www.arcticcbm.org/

promotes development and protection of natural resources through support of local, innovative initiatives. NORDECO does work worldwide: in Africa, Latin America, Asia, the Arctic and Europe. NORDECO is led by Martin Enghoff, anthropologist, Finn Danielsen, ecologist, and Michael Køie Poulsen, social ecologist, the team also counts Huong Lee, who is working with rural development. Additionally, NORDECO has several associated researchers and specialist that regularly are in contact with the company.

4.3.5 Comparative analysis against science-driven monitoring

Scientific attribute and biome coverage was analysed with data from the International network for Terrestrial Research Monitoring in the Arctic (INTERACT). INTERACT is a circumpolar network comprised of 78 scientific research stations, see (INTERACT 2015) for details. It should be noted that since INTERACT only include terrestrial research, the comparison is not directly applicable for marine and limnologic biomes. Likewise, since the INTERACT meta-data do not correspond directly to the categories used in the CBM questionnaire, a best possible fit was made by merging relevant categories.

The scientific temporal coverage was analysed using data from Arctic station, Disko Island, Greenland and Zackenberg research station, NE Greenland. Data on numbers of researchers visiting the field station per month, for the last 3 years was used to identify when scientific monitoring is undertaken in the Arctic. This give a proxy for temporal coverage.
Arctic Station is an example of a widely used research station in the Arctic, and the only one on Disko Island, the stations is open all year round. During the last 3 years approximately 1680 researchers visited the station per year. Zackenberg research station is much more isolated in the far NE of Greenland, with no close by community besides the Sirius dog sled patrols headquarter Daneborg, which is located 25 km NE of the station. During the last 3 years approximately 68 researchers visited the station per year. Special flights need to be arrange to reach the research station and the station is only open April to October. As opposed to Arctic station, Zackenberg represents the most logistically difficult and expensive Arctic scientific monitoring. Together, the number of scientists visiting Arctic Station and Zackenberg during the year can be assumed to be a reliable proxy of yearly monitoring activity for science-driven projects in the Arctic.

Figure 12 To the left: Arctic Station, Disko Island, Greenland (Photo by author), to the right Zackenberg research station, NE Greenland (photo Zero-Zackenberg).

4.4 In-depth analysis of CBM data from a Greenlandic case study

The third part of the thesis moves from meta-data to actual data level. An in-depth analysis of trends in the coastal stocks of Greenland halibut and Atlantic cod, was performed using data from Piniakanik sumiiffinni nalunaarsuineq (PISUNA), a Greenlandic CBM programme.

PISUNA was chosen as case study, since to my knowledge, this programme entails all the main characteristics of a successful and well-established CBM programme, hereby including: involvement of community members in all stages of the programmes, a relatively long-term monitoring series of numerous natural resources generating a large database, cooperation between locals, authorities and scientist and already small indications that the programme is leading to management actions. A so-called "best example" CBM programme. I wanted to test whether this, rather subjective, evaluation could stand scrutinizing by an in-depth analysis of the actual data.

Box 4. PISUNA programme description

In 2009 The Greenlandic Ministry of Fisheries and Hunting (APN) in collaboration with selected Greenlandic municipalities, KANUKOKA (The Greenlandic association of municipalities), KNAPK (Association of Fishers and Hunters), ICC (Inuit circumpolar council) and NORDECO initiated the CBM programme called Piniakanik sumiiffinni nalunaarsuineq (PISUNA) meaning Opening Doors to Native Knowledge.

The aim of PISUNA is to enable Greenlandic fishermen and hunters to document trends in living resources, to propose management decisions themselves and to take an active role in the management of the living resources and environment. This is done by local people and local authority staff collaborating in data collection, interpretation and resource management recommendations.

The communities that take part in the monitoring and management activities are spread out over most of the inhabited coastal area of Western Greenland. Initially PISUNA was implemented in four communities in the area around Disko Bay and Uummannaq Fjord (Akunnaaq, Kitsissuarsuit, Qaarsut and Ilulissat). Later in 2012 the programme expanded to the high North, as the communities of Kangersuatsiaq and Qaanaaq had heard about the programme and strongly wished to participate, this trend has continued over the years and today a total of 8 communities[10] participate in the monitoring, covering 1200 km of the NW Greenlandic coast.

In each of these communities, a Natural Resource Committee (NRC) has been established, selected through village meetings, consisting of six to ten of the most experienced and interested local hunters, fishermen and other people with knowledge of the environment and resources. Initially the hunters and fishermen noted down observations of animals, this however turned out to be too tedious work. In 2012 the system was revised, so that the trend over time of the natural resources was registered instead, as increasing, decreasing or stable compared to previous year same period. The hunters also fill out information on what gear is used and number of trips. Additionally, the fishers and hunters fill out a comments section noting down what they judge important about trend, the importance and possible explanation of the observed trend and recommendations for management decisions (see appendix 5 for the complete field sheet). The hunters and fishermen are each payed 500 kr. quarterly in compensation for their work. The NRC each year decide what natural resources will be observed based on the relevance for the community. Observations from PISUNA primarily focus on terrestrial and marine mammals, fish and birds, but also include shipping and trawling activity and sea ice cover. Between 20-30 hunters and fishers in total participate on a regular basis. The programme has been designed in a way that local observations and perceptions of trends are being triangulated between

[10] Niaqornaarsuk, Attu, Akunnaaq, Kitsissuarsuit, Ilulissat, Qaarsut, Kangersuatsiaq and Qaanaq

several hunters and fishermen within the communities, so to ensure that the locally obtained information is valid and that potential local biases are reduced.

At quarterly meetings the local NRC's meet and summarise all field sheets into one document. The findings are discussed, interpreted and the general trend and management recommendations of each attribute is determined. Hereafter the group coordinator sends this to the village council for endorsement before being forwarded to the municipal and national authorities, who decides if the management actions can be implemented. Once a year, the NRC members present their monitoring results at a community meeting to obtain inputs and feed-back from the entire community.

All data is publicly available at PISUNA-net (https://eloka-arctic.org/pisuna-net/en/) so that everybody with an interest, scientist or not, can gain insight in the changing trends of the natural recourses on the west coast of Greenland. Before accessing the data, users most accept the use agreement stating: *"I understand that the observations compiled in this product were made by recognized local natural resource experts and are shared generously by the observers and their communities to help further resource governance, education, scientific research, and communication between holders of local and Indigenous knowledge and decision-makers and research scientists. I also understand that the observations were made in the context of natural resource knowledge and use specific to the different communities that are part of this project; any interpretation of the data should respect this context."*

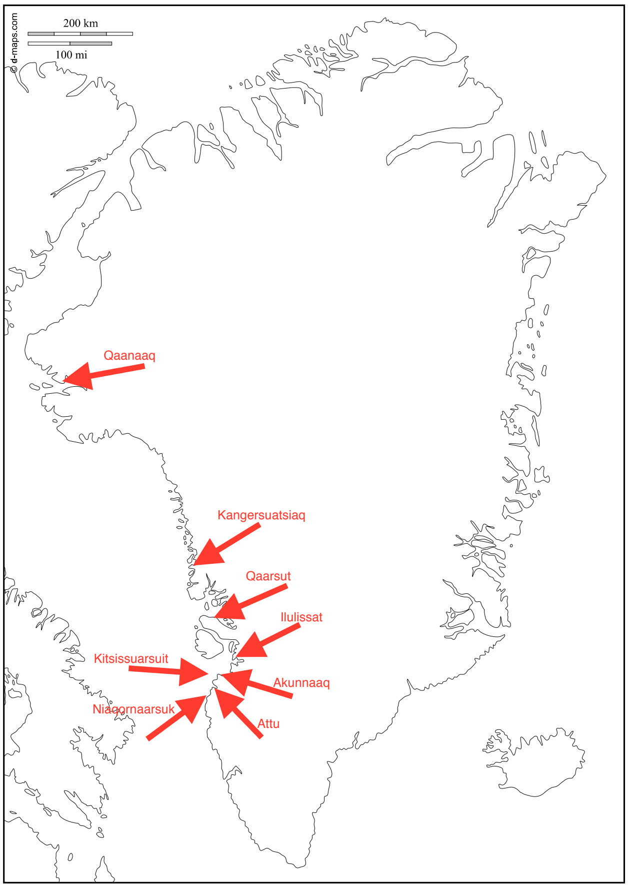

Figure 13 Map showing the location of the 8 cities and communities that are participating in PISUNA

4.4.1 The PISUNA data

The PISUNA database 2009–2016 (Danielsen et al. 2016) contains 736 data entries, corresponding to monthly data observations. Data is collected for 36 different natural resource and environmental attributes. This includes both abiotic phenomena like sea-ice, weather, climate and trawling activities, in addition to populations trends for 13 species of mammals, 8 species of fish and 11 species of birds.

Table 2 Overview of the PISUNA database

PISUNA data 2009-2016

Communities	Number of local participa nts	Attributes	Number of observations n= (total 736)	Additional comments, n= (total 632)	Importance and possible explanation concerning the trend n= (total 426)	Management suggestions n= (total 401)
Akunnaaq	5	Arctic char	25	6	6	6
Attu	9	Arctic Fox	10	10	10	10
Ilulissat	4	Arctic Tern	5	6	2	2
Kangersuatsiaq	6	Atlantic Cod	81	76	41	54
Kitsissuarsuit	1	Beluga	29	20	11	16
Niaqornaarsuk	6	Black Guillemot	3	3	3	0
Qaanaaq	4	Bowhead Whale	3	1	1	3
Qaarsut	8	Canada Goose	37	30	21	24
	43	Caribou	16	14	8	13
		Climate and weather	13	13	12	0
		Common Eider	71	61	44	47
		Fish	8	8	4	3
		Geese	9	9	7	8
		Greenland Halibut	48	36	26	20
		Greenland Shark	1	1	0	0
		Grenadier	1	1	0	0
		Habour Porpoise	5	14	6	0
		Humpback Whale	49	42	32	29
		Killerwhale	3	0	3	0
		Kittiwake	18	18	12	9
		Large Gull	19	18	10	13
		Little Auk	3	1	0	0
		Lumpfish	15	13	12	6
		Minke Whale	13	11	9	10
		Muskox	17	17	15	17
		Narwhale	35	21	5	28
		Polar Bear	11	8	5	5
		Raven	6	6	0	3
		Redfish	1	1	0	0
		Sea ice	3	3	3	0
		Seal(harp, hooded, ringed, bearc	87	87	59	30
		Thick-billed Murre	47	34	28	17
		Trawler	8	8	4	4
		Walrus	20	19	13	17
		White-tailed Eagle	1	1	0	1
		Wolffish sp.	20	18	6	7

In addition to the observations the database also contains 632 additional comments elaborating on the observed trend and 426 comments on the importance and possible explanation concerning the trend. Lastly the database includes 401 suggestions or recommendations for management decisions, emanating from the quarterly discussions and summaries on the monitoring. These encompass both concrete suggestions applicable for direct implementation and suggestions for areas of improvement.

The comments section is an open ended data collection method, where the community members can freely comment on they find noteworthy. Thus the comments are covering a wide range of areas: such as ecological dynamics, behaviour, population structures, interrelations between species, information on body conditions, unusual events and traditional ecological knowledge etc.

4.5 Study species

Greenlandic halibut and Atlantic cod was chosen as study species, since these species (and the fishery sector in general) constitute key resources for the Greenlandic society and culture. Greenlandic halibut and Atlantic cod are of vital importance both locally, in relation to livelihoods and subsistence, and nationally for their value in the commercial fishery and source of employment. Furthermore, since the Greenlandic fishery has experienced a transition, from an initial focus on Atlantic cod, to now depending heavily on Greenland halibut, these two species are interlinked in the description of the Greenlandic fisheries. Last but not least, Greenland halibut and Atlantic cod are currently highly debated species due to disagreements between biologist, politicians and the local fishers about the stock estimates and the management.

4.6 Analysis of Greenland halibut and Atlantic cod abundance trends

4.6.1 CBM data

The data used to analyse the CBM trends for Greenland halibut was the 48 trends observations, 36 additional comments, 26 comments on the importance and possible explanation concerning the trend and 20 management suggestion from the PISUNA database. Likewise, for Atlantic cod the 81 trend observations, 76 additional comments, 41 comments on the importance and possible explanation concerning the trend and 54 management suggestions from PISUNA was used.
The trends where compared to corresponding scientific data and analysed for correspondence using statical analysis while the comments were analysed for overall topics, and correspondence between the content being commented on within and amongst the communities.

4.6.2 The scientific fisheries data

The data used to represent scientific abundance trend data was landings data (caught and sold fish) obtained from GFLK (Greenland Fisheries Licence Control). Since landings data together with logbook data and field surveys make up the foundation for the biological recommendations provided by GINR, this was chosen as a suitable proxy.

The landings data was sorted, to only contain coastal landings from fishers residing the eight communities participating in PISUNA. "Estimated living weight" is used as estimate for quantity in this thesis. Greenland halibut and Atlantic cod can be sold as various types of products, the most common being "with head without intestines (MHUI)" or "without head without intestines (UHUI)", thus when sold, the weight does not represent the actual whole fish. GFLK uses a conversion factor to estimate the living weight.

Trends (increasing, stable or decreasing) for the same dates and communities, as in the PISUNA database, was calculated. A difference of ≥ 5% was considered a change in trend.

4.6.3 Analysis

Statistical analysis was performed using SAS Institute 9.4 (Statistic Analysis Systems). Data was tested using the Fishers' Exact test for independence with the Freeman-Halton extension. This test is suitable for categorical data in RxC contingency tables with expected values < 5, it is assumed that the individual observations are independent. Two-tailed P values were used, $\alpha = 0{,}05$.

5. Results

5.1 Questionnaire survey

In the following results from the questionnaire responses by the 30 Arctic CBM programmes are presented. The questionnaire consisted of 33 questions, to be used as data both for the INTAROS meta-database and the characterisation for this thesis. Here selected questions have been chosen in order to describe the main features of Arctic CBM programmes, these are: Distribution, latitudinal distribution, attribute coverage both specified and by scientific discipline, biome coverage, temporal coverage, frequency of data collection, stages of involvement, type of methodology, sources of motivations, contributions to the community and main challenges.

5.1.2 Distribution

Figure 14 Map showing the distribution of the 30 CBM programmes participating in the questionnaire survey. The programmes are numbered after date of reply.

1. Fávllis
2. Piniarneq
3. Federation of Icelandic River Owners information on all aspects of Icelandic sport fishing
4. Tromsø bird phenology programme
5. Húsavík Whale observation programme
6. Traditional ecological knowledge by summer farmers and Saami reindeer herders
7. LEO (Local Environmental Observer Network)
8. The great seal count programme
9. Reindeer husbandry plan programme (Renbruksplan)
10. Skolt Saami river restoration of Näätämö river
11. BuSK (Katersaatit Building Shared Knowledge)
12. Alaska Arctic Observatory and Knowledge Hub (AAOKH)
13. Moose observations by hunters (Älgobs)
14. Sea Ice for Walrus Outlook (SIWO)
15. wildlife triangle scheme
16. Snow depth measurements for the Finnish Meteorological Institute
17. Centre for Support of Indigenous Peoples of the North (CSIPN)
18. Birdlife Iceland (Fuglavernd)
19. Winterberry programme Citizen Science for Understanding Berries in a Changing North
20. Arctic and Earth SIGNs community-based monitoring
21. Evenk and Izhma peoples Programme
22. Nordland eider duck Programme (Ærfugl)
23. PISUNA (Piniakkanik sumiiffinni nalunaarsuineq)
24. Arctic Borderlands Ecological Knowledge Society (ABEKS)
25. Yukon River Inter-Tribal Watershed Council (YRITWC)
26. Walrus Traditional knowledge monitoring Program in Chukotka
27. Collaborative environmental monitoring program in the George River watershed, Nunavik
28. Faroese hare citizen science programme
29. Monitoring of Pilot whales on the Faroe Islands since 1584
30. Marian Watershed Stewardship Programme

The 30 CBM programmes are distributed across the circumpolar Arctic and sub-Arctic, covering all the 8 Arctic nations. 9 programmes are located in Canada and North America, 3 programmes in Russia and 18 programmes in the European Arctic. The assigned numbers do not correspond to any characteristics; it merely follows the order of date of reply.

5.1.3 Latitudinal distribution

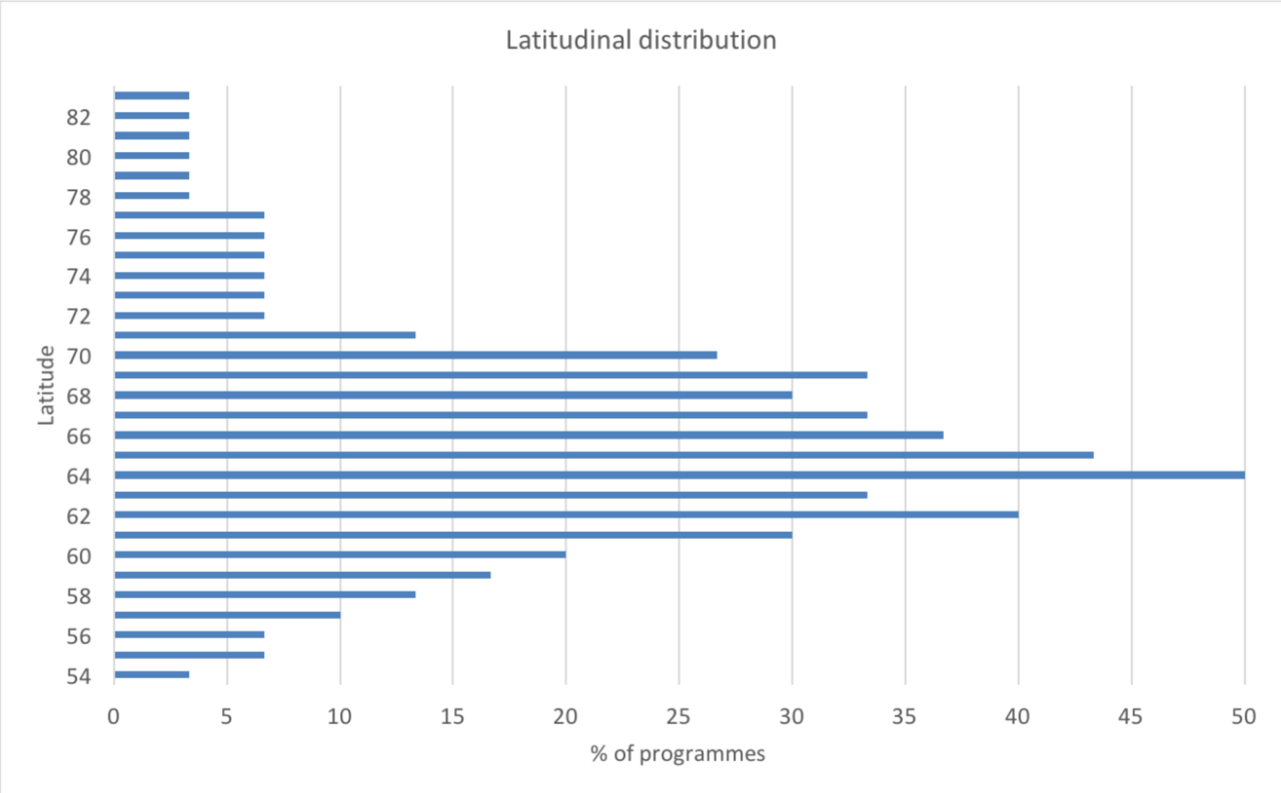

Figure 15 latitudinal distribution of the CBM programmes (n=30). Many programmes (n=15) cover several latitudes, thus the total percentage exceeds 100.

The latitudes ranged from sub-Arctic 54°N to high Arctic 83°N. The majority of the programmes conducted monitoring between 61-70°N. Many of the programmes (n=15) span several latitudes, covering whole biomes or countries. For an interactive map, depicting the approximate area covered by the programmes, visit: https://www.google.com/maps/d/edit?mid=1s411z_FN09jJRbXe6kdK-so1kijGpgAM&ll=31.749411048705014%2C0&z=2

5.1.4 Attribute coverage - What is monitored

The programmes spanned wide from water quality monitoring, berry monitoring, inventories of wild life populations, gathering of TEK and mapping of traditional land use, measurements of climate variables etc.

The three most monitored attributes were mammals (67%), birds (40%) and local knowledge transmission (37%). Most programmes (n=19) covered several types of attributes in their monitoring.

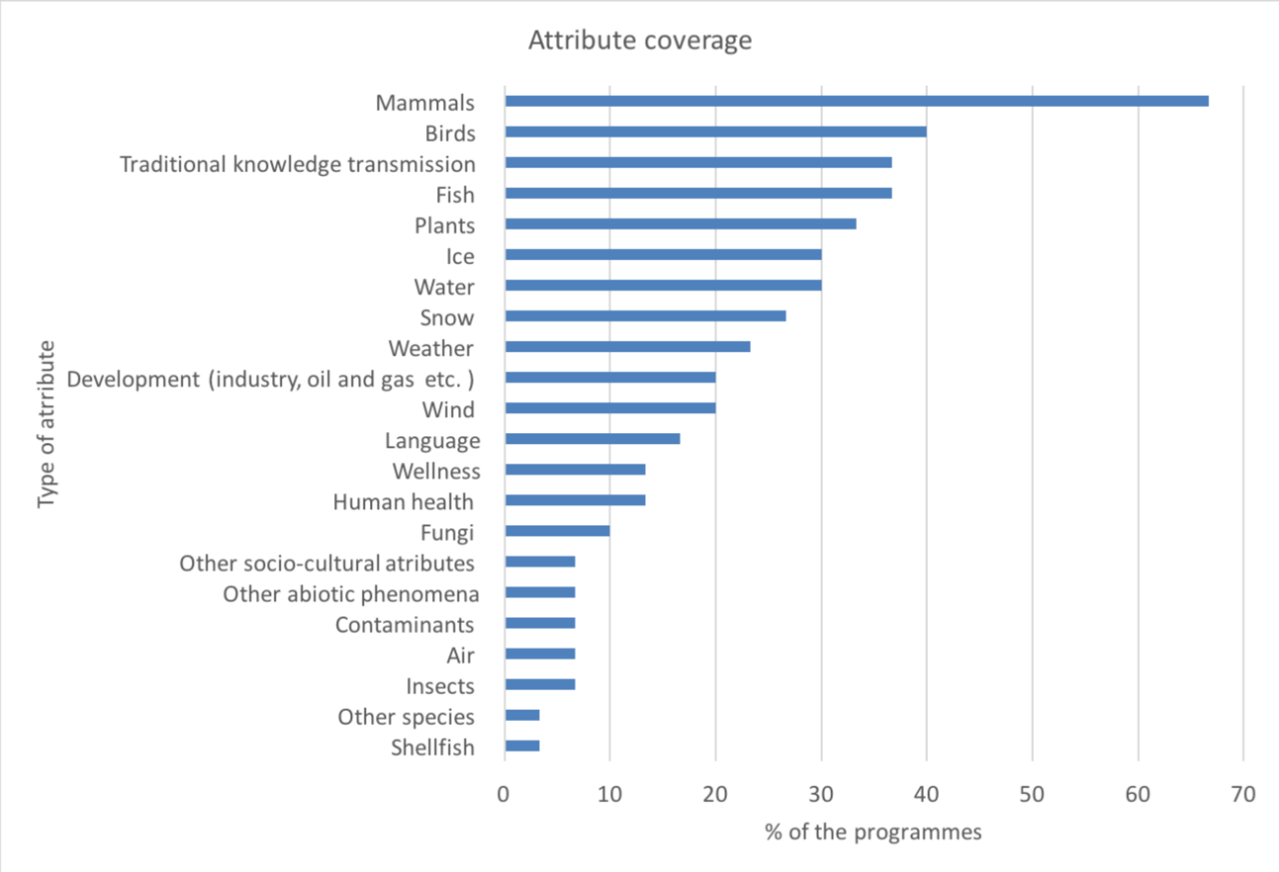

Figure 16 Attribute coverage (n=30). Most programmes monitored several attributes, explaining why the percentage exceeds 100%

5.1.5 Attribute coverage by groups of discipline

The monitored attributes can be aggregated into overall discipline groups of: Biological, abiotic and socio-cultural attributes. All discipline groups were well-represented; none being monitored by less than 40% of the programmes. Biological attributes, was noticeably the most monitored group with 90% of the programmes covering this discipline. 53% of the programmes monitor abiotic attributes and 40% monitor socio-cultural attributes. Most of the programmes (n=16) monitor attributes in more than one group of discipline.

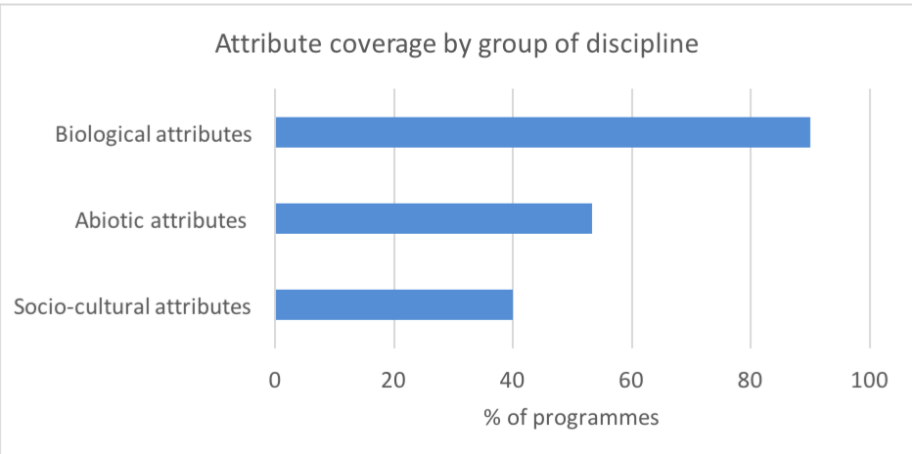

Figure 17 Coverage of attributes by groups of discipline (n=30). Most programmes monitor attributes in several disciplines thus the percentage exceeds 100%.

5.1.6 Biome coverage – what biomes are monitored

All biomes, defined in the questionnaire survey, were quite evenly monitored, resulting in a high spatial coverage. Most CBM programmes monitor the coastal biome (50%), hereafter followed: taiga (boreal forest) (47%), tundra (43%), freshwater (43%) and sea (37%). Most programmes (n=17) covered several biomes in their monitoring.

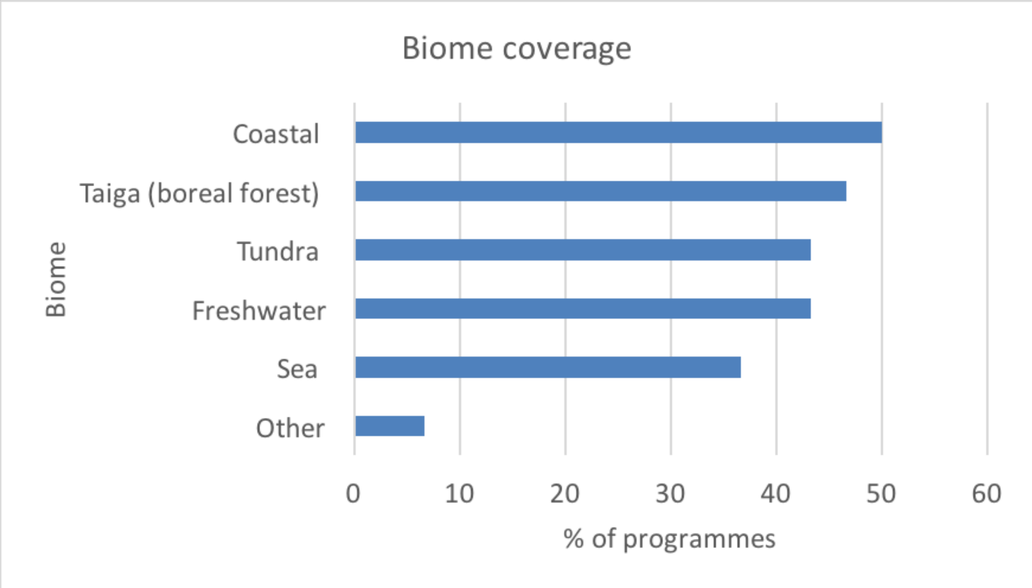

Figure 18 Biome coverage (n=30), most programmes monitored several biomes thus the percentages exceeds 100%.

5.1.7 Temporal coverage- what time of the year is the monitoring conducted

The monitoring activity by the Arctic CBM programmes was spread out evenly over the cause of the whole year. High monitoring activity (approx. 50-60%) is present consistently throughout the year, resulting in very high temporal coverage. It should be noted that for programs with no distinct monitoring period (n=11) all months were registered.

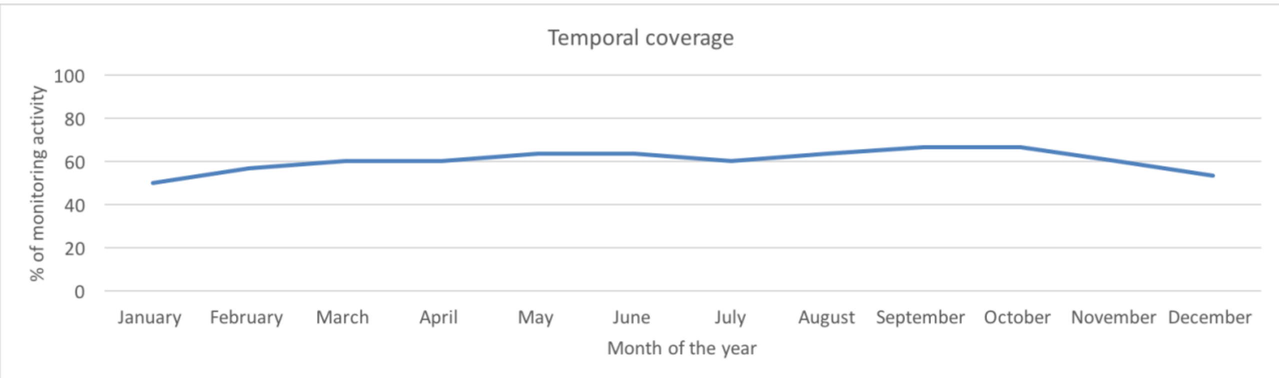

Figure 19 Graph showing when during the year monitoring is conducted by Arctic CBM programs (n=30).

5.1.8 Frequency – how often is monitoring conducted

Data was mostly collected at yearly frequencies (37%), but also daily data collection was common (30%). It should be noted that this question caused some confusion for the respondents filling in the questionnaire. It is assumed that some programs have answered the frequency of results reporting instead. For the purpose of this thesis, the answers are used as an indication of frequencies between intervals of monitoring, i.e. yearly is interpreted as monitoring being done "at a regular basis" during a field season, every year. This is based on comments such as "Yearly, 7-30 days during the hunting period", "Yearly, (on daily activities)". Further analysis, is needed in order to clarify the actual data collection frequency.

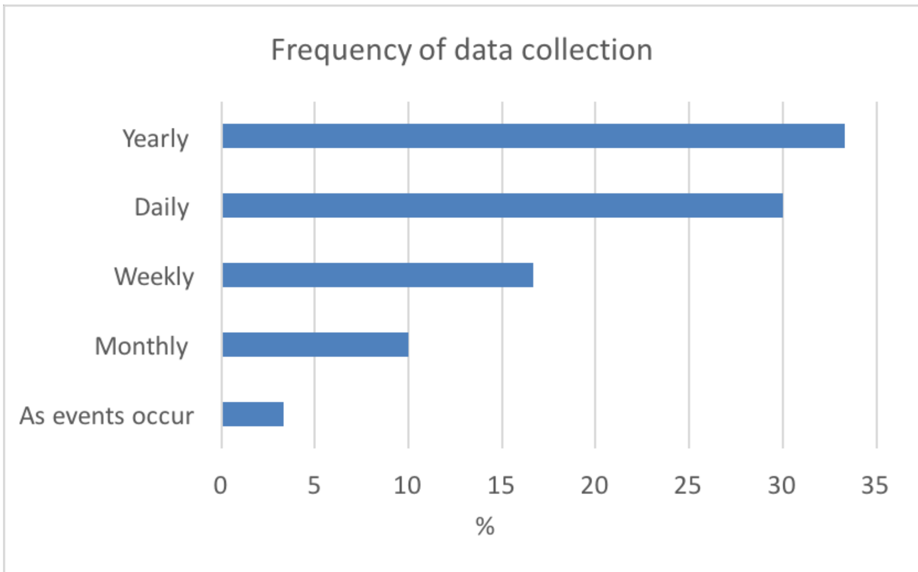

Figure 20 Frequency of data collection (n=30)

5.1.9 Stages of involvement

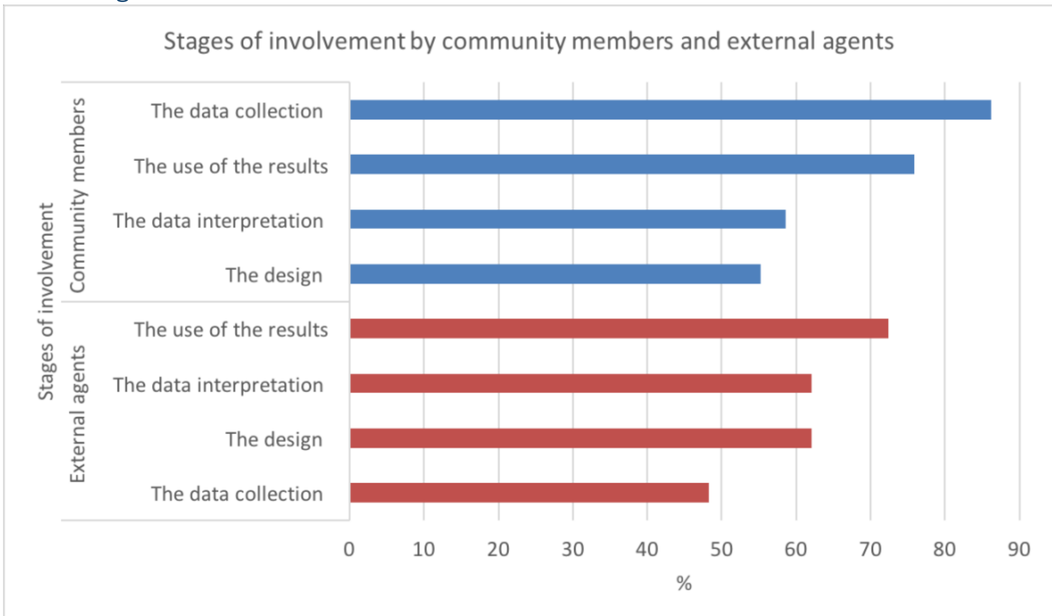

Figure 21 Stages of involvement of community members and external agents (n=29, one programme did not answer this question)

The most common division of involvement within each programme was that community members are involved in the data collection and the external agents (i.e. scientists, government staff etc.) were involved in the use of the results (this however in strong collaboration with the community members that to an even higher degree partake in this stage). It should be noted that two programmes (7%) answered that community members were only involved in the data collection, and hence did not meet the definition of CBM used for this thesis. The programmes were however included for the purpose of this thesis since they self-identify as CBM programmes.

5.1.10 Investigation of overarching methodology – CS vs. CBM

The methods described by the respondents was together with background search on the programmes webpages used to extrapolate whether the overarching methodologies used by the programmes belonged in the category of citizen science or community-based monitoring.
The methodologies are defined using the characterisation described in table 3.

Table 3 Definitions used to characterise the overall methodologies (n=30)

General methodology	Description	Example
Citizen science method	Professional scientists design the monitoring project and have volunteers/citizens help with the data collection (adapted from Bonney et al. 2009 and Danielsen et al. 2008)	*"Hunters report observations of moose during the hunting period in relation to effort in hours of observation".* Answer by Älgobs programme, Sweden
Community-based monitoring method	Community members are involved in more than just data collection, and the monitoring is done in relation to aims and objectives valued by them (adapted from Danielsen et al. 2008 and Danielsen et al. 2014)	*"Community Indigenous experts collaborate with scientists to use instruments and protocols developed by scientists, but include community input on sampling locations of relevance to community interests and community observers provide narrative information deemed important by community observers not explicitly requested by scientists"* Answer by Alaska Arctic Observatory and Knowledge Hub (AAOKH)

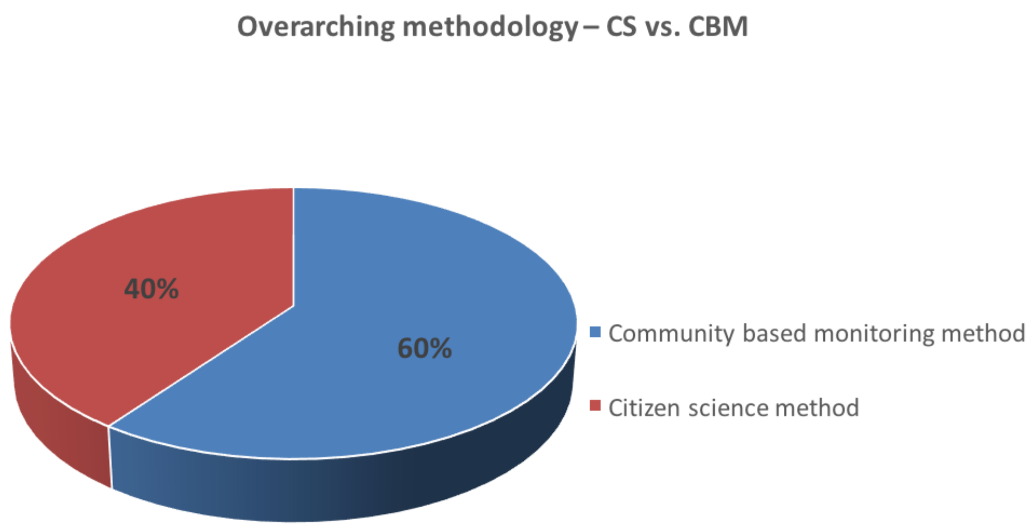

Figure 22 analysis of the overall methodology (n=30)

60% of the responding programmes made use of community-based monitoring methods, and can thus be considered "genuine" CBM programmes. The remaining 40% used citizen science methods, meaning that even though the programmes stated to be a CBM programme, when scrutinizing the methods, the community members only had influence on / participated in the data collection stage.

5.1.11 Sources of motivation

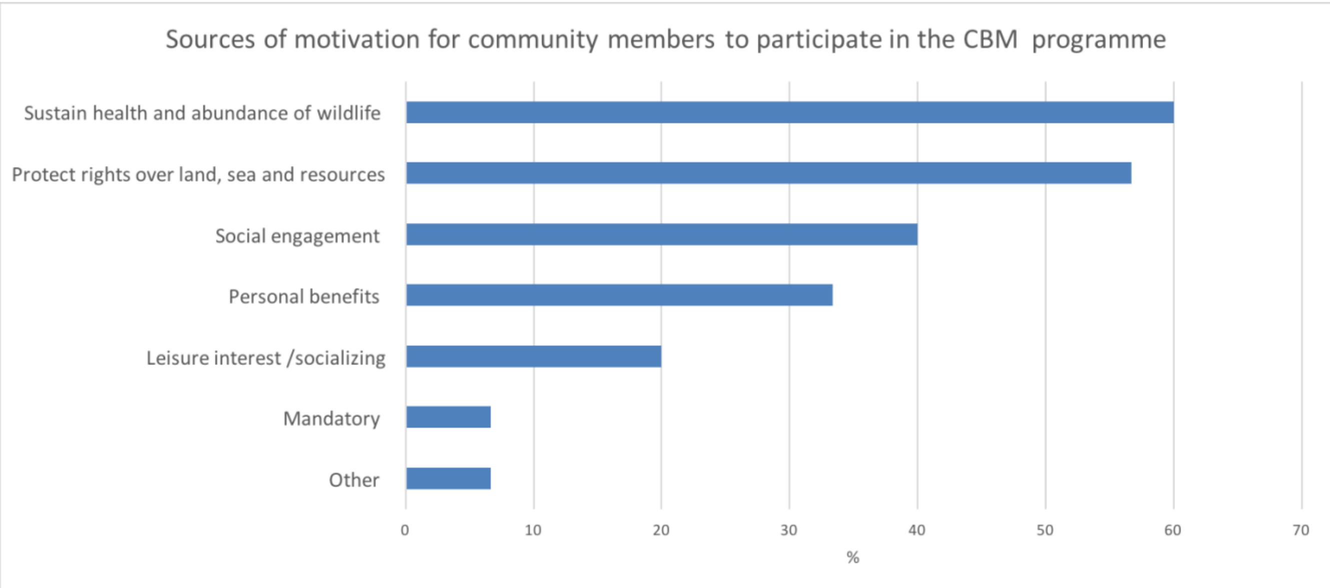

Figure 23 Sources of motivation for community members to participate in CBM (n=29, one programme did not answer). Several programmes noted more than one source of motivation, thus the percentage exceeds 100

For the majority of the responses (n=23) several reasons were listed for why community members chose to participate in the CBM programmes. Mostly community members participated because of a wish to contribute to the sustaining of health and abundance of wildlife (60%), likewise important was the wish to have their voices heard and influence the discussion of protection of rights over land, sea and resources (57%). The third most common motivation, was to participate due to the social engagement aspects of the participation (40%) (i.e. building local networks, get involved in issues of community concern). The 2 programmes that answered "other" mentioned "information sharing to support safer navigation" and "improve food security" as sources of motivation.

5.1.12 Contributions to the community

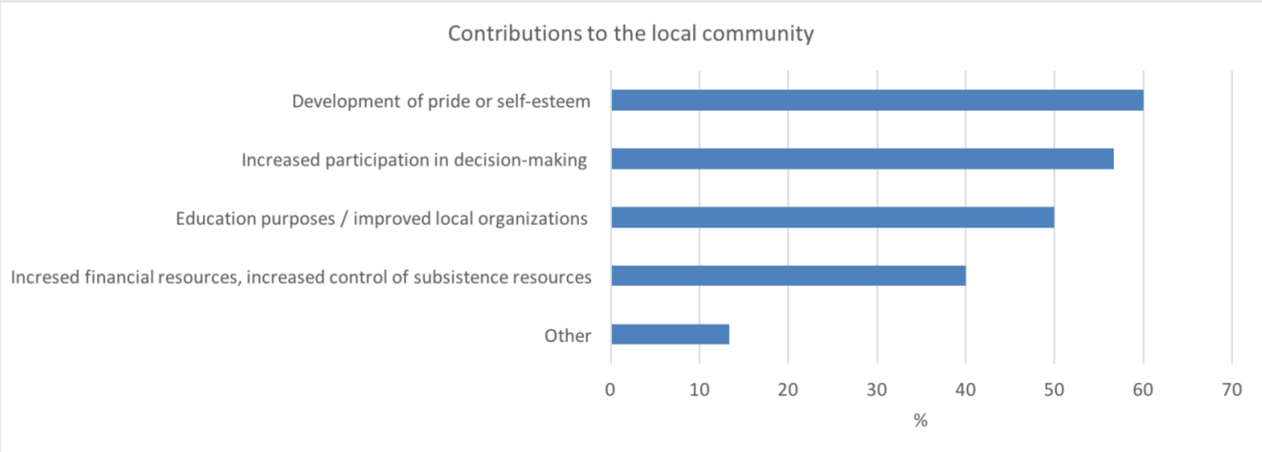

Figure 24 Contributions to the local community (n=28, (two programmes did not respond to this question)

Several positive effects were experienced in the communities by being involved in a CBM programme. Especially enhancements within psychological, political and social capacities was seen in more than 50% of the programmes. This specifically meant development of pride and self-esteem (60%), increased participation in natural resource decision-making (57%) and improved education and learning skills (50%). (n= 21) listed several benefits for the community. It should be noted that this question also entailed if there were any negative effects to the community by engaging in CBM, no programmes however reported any negative consequences. Two of the programmes that answered "other", specified why: "The participation is raising local awareness on sustainable use principles" and" The water quality data has contributed to the development of a Water Quality Management Plan, which was drafted by YRITWC and approved by Alaska Native Tribes and First Nations. This Plan is a coordinated effort by the Indigenous Peoples of the Yukon River to keep the river protected"

5.1.13 Challenges

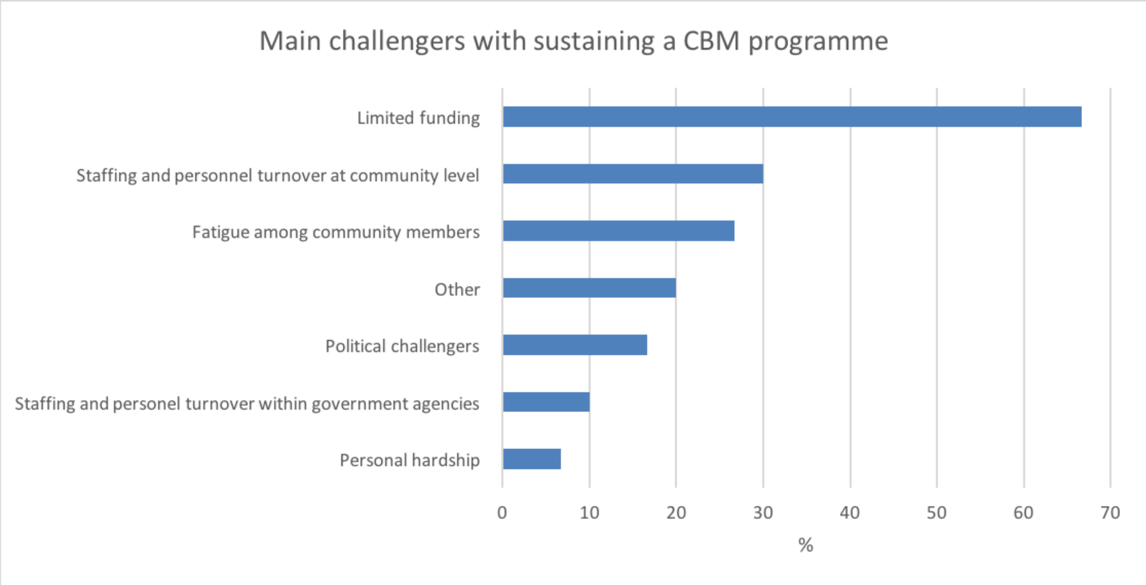

Figure 25 Main challenges by sustaining a CBM programme (n=27, three programmes did not respond to this), since several challenges are listed by each programme the percentage exceeds 100.

The sole most dominating challenge by running an Arctic CBM programme was limited funding, 67% of the responding programmes are challenged by this. Less common (30%) is staff and personnel turnover at community level (i.e. resulting in having to establish good collaboration repeatedly, or resulting in varying programme support prioritizing) and fatigue among community members (i.e. discontinuous interest/possibility to participate in the programme) (27%). The 6 programmes that answered "other" listed the following challenges: "Too high dependency on key individuals", "Needs new members, same old guys year after year", "By now it's a high average age of the bird tenders and it's necessary to get new recruits in a few years", "Limited interest among government agencies in changing government structures to listen to community members", "Lack of decision-making frameworks limits the effectiveness of the program", "The biggest challenge is to establish a long term monitoring program".

5.2 Scientific Arctic research stations – brief characteristic for comparative analysis

To clarify the distinguishing key features of Arctic CBM programmes where it was possible, analysis of similar characteristics for science-driven programmes was conducted, these were: Attribute coverage, biome coverage and temporal coverage. Data from the INTERACT terrestrial research station network and Arctic Station, Disko Island was used as examples of science-driven monitoring projects.

5.2.1 Attribute coverage - What is monitored

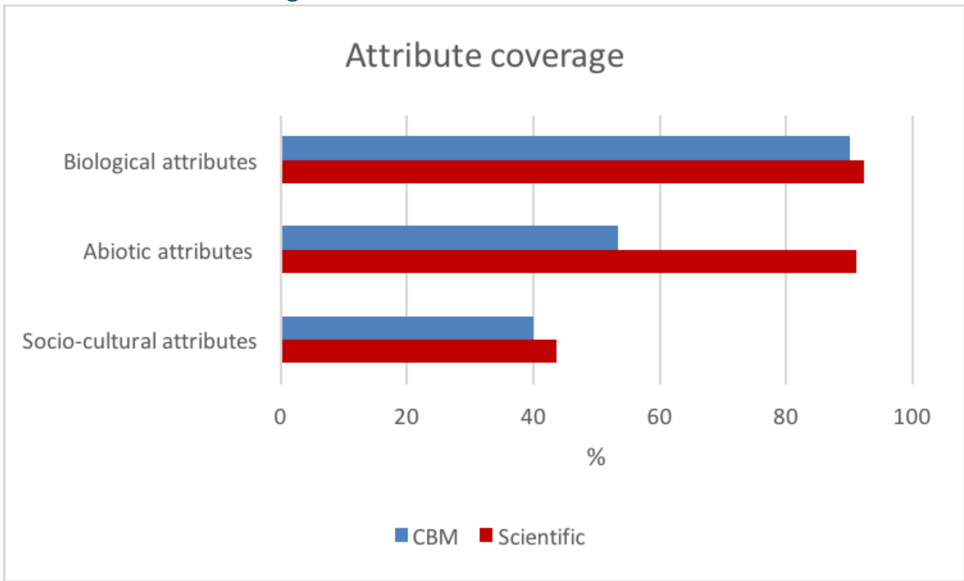

Figure 26 Comparison between attribute coverage for science-driven monitoring (n=78) and CBM programmes (n=30). Scientific data from the INTERACT Network is used. Since most programmes monitor attributes in more than one group, the total percentage exceed 100.

Compared to CBM, science-driven monitoring has a stronger coverage of abiotic attributes which are monitored to the same high extent as biological attributes. Biological and abiotic attributes are monitored each by 92 % and 91% of the scientific projects, while Socio-cultural attributes are monitored by 44 %. Most of the projects (n=71) monitored attributes in more than one group of discipline. Therefore, similar to CBM, science-driven monitoring is interdisciplinary and to a high degree monitor attributes within all disciplines.

It should be noted that since the categories used in the science database were different than the categories used in the CBM questionnaire, several categories were merged in the science dataset[11].

[11] The categories were modified from the scientific database in order to provide the best possible fit to the categories used in the CBM questionnaire.

Biological attributes: Ecosystem services, Human biology, Medicine, Marine biology, Microbiology, Oceanography, Fishery, Paleoecology, Paleo-limnology, Terrestrial biology – Biodiversity, Terrestrial biology – Ecosystem function

Abiotic attributes: Astrophysics, Atmospheric chemistry and physics, Climatology, Climate Change, Environmental sciences – Pollution, Geo-cryology, Geomorphology, Geodesy, Geology, Sedimentology, Geophysics, Glaciology, Hydrology, Isotopic chemistry, Limnology, Land-use change, Mapping, GIS, Soil Science

Socio-cultural attributes: Anthropology, Sociology, Archaeology, Community-based monitoring, Citizen Science

5.2.2 Biome coverage – what biomes are monitored

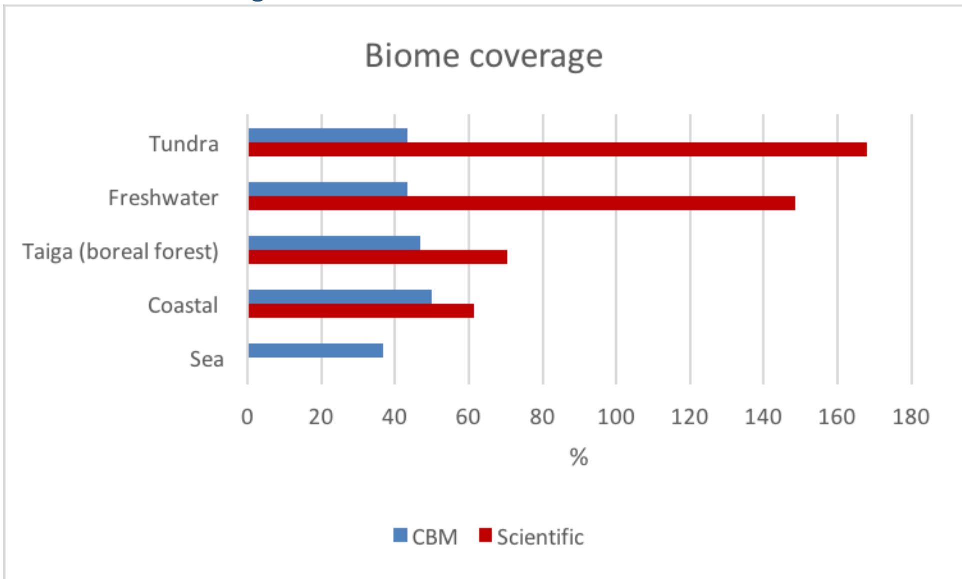

Figure 27 Comparison of biome coverage between science-driven monitoring projects (n=78) and CBM programmes (n=30). For the scientific data, a best possible fit to the categories used in the CBM questionnaire has been made by merging appropriate categories. For the sake of this analysis, all categories that could not be merged into the categories used in the CBM was excluded of the analysis. Thus the presentation of the scientific data is not optimal, this is a flaw in the questionnaire design. Since categories were merged, the total amount exceeded n=78, why the coverage exceeds 100%

Similar to the CBM programmes, the science-driven monitoring projects had a wide biome coverage and monitored a range of diverse biomes. Whereas CBM monitored all the biomes quite evenly, there was a great difference between the degree of monitoring by the scientific projects. Opposite CBM, the tundra and freshwater biomes was clearly the most monitored biomes for the scientific projects, these biomes were monitored more than twice as much as the taiga (boreal forest) and coastal biome. All scientific stations (n=78) monitored several biomes.

Since the categories used in the science database was different than the categories used in the CBM questionnaire, biome categories were merged where suited. Since more distinct biomes were included in the science database, not all categories could be merged into the biomes categories used in the CBM characterisation, this however, explain why the coverage exceeds 100%. For the sake of this thesis all categories that could not be merged into the categories used in the CBM was excluded of the analysis[12]. This constitute a flaw in the questionnaire design. However, it does not change the relative coverage of the remaining categories which can still be used for comparison.

Furthermore, it should be noted that INTERACT is a network only including terrestrial Arctic research stations, thus marine biomes are missing.

[12] Other covers: Human settlements, permanent ice and snow, mountain, valley and the "other category" from the INTERACT database

5.2.3 Temporal coverage- what time of the year is the monitoring conducted

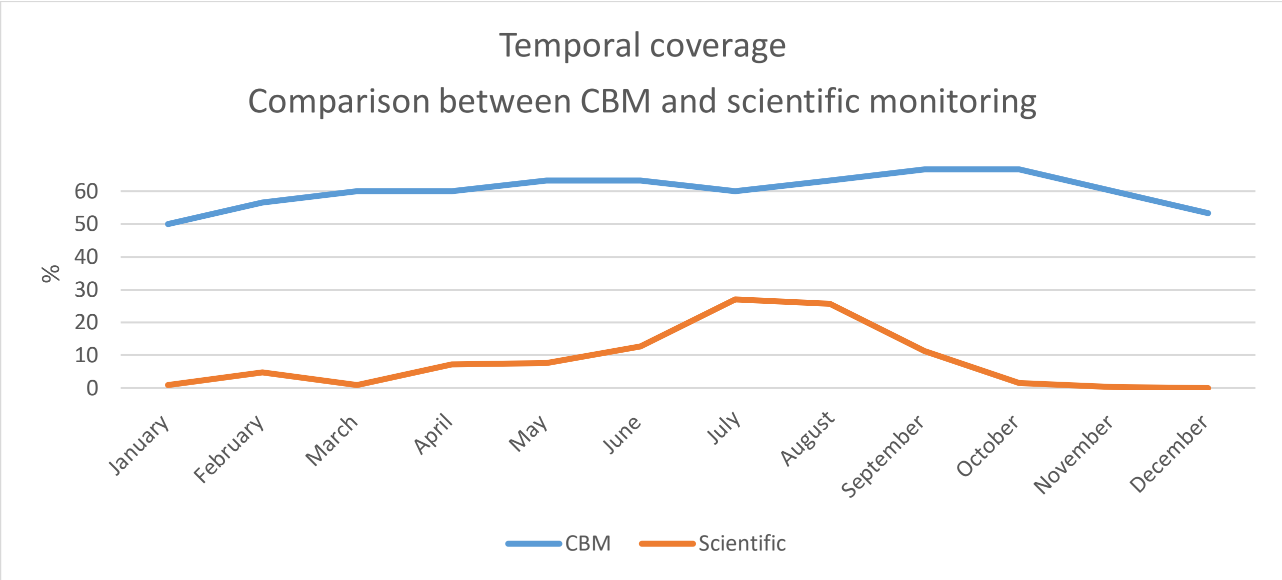

Figure 28 Comparison between the temporal coverage for CBM and scientific monitoring. Data from the last 3 years (2015,2016, 2017) from the numbers of researchers staying at Arctic Station, Disko Island and Zackenberg research station, NE greenland is used as a proxy for science-driven monitoring activity during the year.

Compared to CBM programmes, the temporal coverage was very limited for the scientific projects. There is a clear peak in the science-driven monitoring from June to September, with only very little activity during the spring and almost no activity over the winter. Thus only the summer season is covered.

It should however be noted that most research stations today have implemented automatic monitoring systems that monitor the environment all year round automatically independently of researchers are present or not. This type of monitoring is not covered in this comparison, and thus the scientific monitoring would be somewhat higher than showed here. Automatic year-round monitoring strongly strengthens the coverage of the scientific monitoring. However, these automatized measurements are primarily monitoring abiotic attributes, such as temperature, precipitation, gas fluxes and snow depths. Monitoring of biological attributes, such as abundance trends are not performed automatically.

5.3 PISUNA - Abundance trends for Greenland halibut and Atlantic cod

This section presents the results of the in-depth analysis of the PISUNA abundance trends and comments from Greenland halibut and Atlantic cod. The CBM trends were compared to scientific data obtained from GFLK (Greenland Fisheries Licence Control).
The comments were summarized and divided into ecosystem categories depending on the content and analysed for correspondence amongst the communities.

5.3.1 Greenland halibut – Comparison between CBM and scientific abundance trends on monthly and quarterly scale

PISUNA provides fine-grained data down to monthly resolution, however for identifying population changes often less detailed resolution is more suited. Thus, the PISUNA data was likewise analysed for quarters of the year, which can be argued to be a more commonly used resolution in fisheries abundance assessments.

Monthly trend - Grennland halibut				
Community	Year	Month	CBM trend	Scientific trend
Akunnaaq	2010	3	1	1
		4	1	1
	2011	9	1	-1
	2014	4	1	1
		5	1	1
	2015	3	1	0
		7	1	-1
	2016	2	1	1
		3	1	1
Attu	2016	6	1	1
Ilulissat	2010	5	1	1
		6	1	1
		7	1	-1
		8	1	1
		9	1	-1
Kangersuatsiaq	2016	7	0	1
		8	0	-1
		9	0	-1
Kitsissuarsuit	2015	7	1	1
		8	1	1
	2016	7	1	-1
		8	1	-1
		9	1	-1
Qaanaaq	2016	1	-1	-1
		2	-1	-1
		3	1	0
Qaarsut	2010	5	0	1
		6	1	1
		7	1	1
		8	1	-1
		9	1	-1

Figure 27 Comparison between CBM and scientific trend for Greenland halibut. The comparison is done for each month where trends were available from both the CBM and the scientific database. This yielded 31 (out of 48) corresponding observations, n=62. The trend is noted as -1: decreasing, 0: Stable, 1: Increasing

Quarterly trend - Greenland halibut				
Community	Year	Quarter of the year	CBM trend	Scientific trend
Akunanaq	2010	1	1	1
		2	1	1
	2011	3	1	-1
	2014	1	1	1
		2	1	1
	2015	1	1	1
		3	1	1
	2016	1	1	1
Attu	2016	2	1	1
Kangersuatsiaq	2016	3	0	1
Kitsissuarsuit	2013	3	1	0
Kitsissuarsuit	2015	3	1	-1
Kitsissuarsuit	2016	3	1	1
Ilulissat	2010	2	1	1
Ilulissat		3	1	-1
Qaanaaq	2016	1	-1	-1
Qaasut	2010	2	1	1
Qaasut		3	1	-1

Figure 28 Comparison between CBM and scientific trend for Greenland halibut. The comparison is done for each quarter of the year where trends were available from both the CBM and the scientific database. This yielded 18 (out of 48) corresponding observations, n=36. The trend is noted as -1: decreasing, 0: Stable, 1: Increasing

31 corresponding observations for monthly trends was found for Greenland halibut when comparing CBM and scientific monitoring (n=62). When looking at quarterly scale, 18 corresponding trends was found for each type of monitoring (n=36). CBM mainly reported the Greenland halibut population to be increasing. For monthly trends 25 (out of 31) months had increasing trends while 4 months were found to be stable and 2 months decreasing. The scientific monitoring likewise found most months to have increasing trends (16 out of 31), however notably more months (13) were found to be decreasing, 2 months were stable. Table 4 illustrate the frequencies (top value in the cells).

For quarterly trends CBM found 16 (out of 18) quarters of the year to had increasing trends, 1 quarter was stable and 1 was observed to be decreasing. The scientific trends found 12 quarters of the year to be increasing, 1 was stable and 5 was decreasing, table 5 illustrate the frequencies.

5.3.2 Statistical analysis

Monthly trend

Table 5 Table showing the monthly frequency of each trend (decreasing -1, stable 0, increasing 1 (top number in each cell) and the frequency that statistically would be expected if the different types of monitoring should be similar (bottom number in each cell). Below is the P value Pr<=P listed. α *= 0,05*

Frequency Expected	Table 2 of Type by Trend Controlling for Species=Halibut				
		Trend			
	Type	-1	0	1	Total
	CBM	2 7.5	4 3	25 20.5	31
	Science	13 7.5	2 3	16 20.5	31
	Total	15	6	41	62

Fisher's Exact Test	
Table Probability (P)	0.0003
Pr <= P	0.0034

Quarterly trend

Tabel 4 Table showing the quarterly frequency of each trend (decreasing -1, stable 0, increasing 1 (top number in each cell) and the frequency that statistically would be expected if the different types of monitoring should be similar (bottom number in each cell). Below is the P value Pr<=P listed. α *= 0,05*

Expected	Controlling for Species=Halibut				
		Trend			
	Type	-1	0	1	Total
	CBM	1 3	1 1	16 14	18
	Scientif	5 3	1 1	12 14	18
	Total	6	2	28	36

Fisher's Exact Test	
Table Probability (P)	0.0570
Pr <= P	0.4257

Looking at a monthly resolution, no consensus existed between the CBM abundance trends and scientific abundance trends for Greenland halibut (n=62, p=0.0034). This suggests that the observations from the two monitoring types significantly vary and do not show the same trend for the Greenland halibut abundance.

When instead comparing quarterly trends, no difference was found (n=36, p=0.1774), suggesting that there was indeed consensus between CBM and scientific data for Greenland halibut and that the abundance trends from the two different types of monitoring were telling the same story about the Greenland halibut population changes.

5.3.3 Atlantic cod – Comparison between CBM and scientific trends on monthly and quarterly scale

Monthly trend - Atlantic cod				
Community	Year	Month	CBM trend	Scientific trend
Akunnaaq	2010	11	1	1
		12	1	1
	2011	8	1	-1
	2014	5	1	1
		10	1	1
		11	1	1
		12	1	1
	2015	3	1	1
		7	1	1
		8	1	1
		9	1	1
		10	1	1
		11	1	0
	2016	10	1	-1
		11	1	1
Attu	2014	10	1	1
		11	1	1
		12	1	1
	2015	7	1	1
		8	1	1
		9	1	1
		10	1	1
		11	1	1
		12	1	-1
	2016	2	1	1
		3	1	1
		5	1	1
		6	1	1
		7	1	-1
		8	1	-1
		9	1	1
		10	1	1
		11	1	1
		12	1	1
Ilulissat	2010	5	1	-1
		6	1	1
Kitsissuarsuit	2013	7	1	-1
		8	1	1
	2016	7	1	1
		8	1	-1
		9	1	1
Niaqornaarsuk	2014	10	1	1
		11	1	1
		12	1	-1
Qaanaaq	2016	1	1	1

Figure 29 Comparison between CBM and scientific abundance trends for Atlantic cod. The comparison is done for each month where trends were available from both the CBM and the scientific database. This yielded 31 (out of 48) corresponding observations, n=62. The trend is noted as -1: decreasing, 0: Stable, 1: Increasing

Quarterly trend - Atlantic cod				
Community	year	Quarter of the year	CBM trend	Scientific trend
Akunnaq	2010	2	1	0
		4	1	1
	2011	1	1	1
		3	1	-1
	2014	1	1	1
		2	1	1
		4	1	1
	2015	1	1	1
		3	1	1
		4	1	1
	2016	4	0	1
Attu	2014	4	1	1
	2015	3	1	1
		4	1	0
	2016	1	1	1
		2	1	1
		3	1	-1
		4	1	1
Ilulissat	2010	2	-1	1
Kangersuatsiaq	2016	1	1	0
		2	1	1
		4	0	0
Kitsissuarsuit	2013	3	1	1
	2014	4	1	1
	2016	3	1	1
Niaqornaarsuk	2014	4	1	1
Qaanaaq	2016	1	1	0

Figure 30 Comparison between CBM and scientific abundance trends for Atlantic cod. The comparison is done for each quarter of the year where trends were available from both the CBM and the scientific database. This yielded 18 (out of 48) corresponding observations, n=36. The trend is noted as -1: decreasing, 0: Stable, 1: Increasing

For Atlantic cod, 45 monthly corresponding abundance trend observations existed for the two types of monitoring (n=90). Both CBM and the scientific monitoring found the Atlantic cod population to be increasing in most periods. In 41 out 45 months CBM reported that the Atlantic cod population was increasing, 2 months were stable and 2 months decreasing. The scientific monitoring found 35 out of 45 months to be increasing, 1 month was stable and 9 months decreasing, table 6 illustrate the frequencies (top value in the cells).

When looking at quarterly scale 27 corresponding trends existed for CBM and scientific monitoring (n=54). CBM found 24 (out of 27) quarters of the year to be increasing, 2 were stable and 1 decreasing. The scientific monitoring found 20 (out of 27) quarters of the year to be increasing, 5 were stable and 2 decreasing, table 7 illustrate the frequencies (top value in the cells).

5.3.4 Statistical analysis

Monthly trend

Tabel 7 Table showing the monthly frequency of each trend (decreasing -1, stable 0, increasing 1 (top number in each cell) and the frequency that statistically would be expected if the different types of monitoring should be similar (bottom number in each cell). Below is the P value Pr<=P listed. α= 0,05

Frequency Expected	Table 1 of Type by Trend				
	Controlling for Species=Cod				
		Trend			
	Type	-1	0	1	Total
	CBM	2 5.5	2 1.5	41 38	45
	Science	9 5.5	1 1.5	35 38	45
	Total	11	3	76	90

Fisher's Exact Test	
Table Probability (P)	0.0087
Pr <= P	0.0640

Quarterly trend

Tabel 6 Table showing the monthly frequency of each trend (decreasing -1, stable 0, increasing 1 (top number in each cell) and the frequency that statistically would be expected if the different types of monitoring should be similar (bottom number in each cell). Below is the P value Pr<=P listed. α= 0,05

Frequency Expected	Table 1 of Type by Trend				
	Controlling for Species=Cod				
		Trend			
	Type	-1	0	1	Total
	CBM	1 1.5	2 3.5	24 22	27
	Scientif	2 1.5	5 3.5	20 22	27
	Total	3	7	44	54

Fisher's Exact Test	
Table Probability (P)	0.0402
Pr <= P	0.1774

When analysing on a monthly scale, no difference between the results of the two types of monitoring was found (n=90, p= 0.0640). This suggests that consensus existed between the abundance trends observed by CBM and scientific monitoring for Atlantic cod.

The same is the case when analysing on quarterly resolution. No difference between the trends observed by the two types of monitoring was found (n=54, p=0.4257). This suggests that for Atlantic cod both the local fishers participating in PISUNA and the data registered by the GFLK show the same picture about the population development for Atlantic cod.

5.3.5 Content and correspondence analysis for the Comments from PISUNA

5.3.6 Greenland halibut

The PISUNA database contained 36 additional comments, 26 comments on the importance and possible explanation concerning the abundance trend and 20 management suggestion for Greenland halibut. Table 8 gives a summary and an overview of the content of the comments data, see appendix 3 for the full data.

In order to clarify the content of information provided by the comments, all comments were divided into ecosystem categories, see table 9.

The Greenland halibut comments provided information on 11 (out of 15) different categories within ecosystem dynamics. There is good correspondence between the categories commented on by the different communities. 86 % of the communities commented on body condition, Akunnaaq, Attu and Kitsissuasuit observed increasing body condition, while kangersuatsiaq and Qaanaaq observed the body condition to be unchanged. The second most commented topic is new spatio-temporal distribution, 43 % of the communities were experiencing some changes in the spatial and/or temporal distribution of Greenland halibut. In 2013 Kitsssisuasuit reported that Greenland halibut was found between Kitsissuarsuit and Maniitsoq in the summer, and in 2015 it was reported that this was the first year they fished for Greenland halibut in Kitsssisuasuit. Also in Qaanaaq new fishing areas was observed due to a change in the sea-currents and movement of icebergs. Lastly Qaarsut in 2010 reported an unusual event where Greenland halibut changed the commonly known distribution pattern and stayed in the waters around Qaasut, even after the time of arrival of Harp Seal in June-July which normally was the time Greenland halibut leave the area.

5.3.7 Additional knowledge from the comments – Greenland halibut

By analysing the comments, additional trends became apparent. Akunnaaq, Attu and Kitsissuasuit all observed increased body condition in 2016 (Akunnaq also in 2014,2015), whereas kangersuatsiaq and Qaanaaq observed unchanged body conditions in 2016. Hence there appeared to be a trend towards increasing body condition in the southern part of Disko bay, while the Greenland halibut further north maintained the same body condition.

Furthermore, several species interactions were found when analysing the comments, possibly explaining variations in the fish stock. E.g. Akunnaaq NRC in 2010 and 2015 described an interaction between sea-ice, seals and whales and Greenland halibut. "*When sea-ice departs, seals return, and Greenland Halibut disappears to avoid the seals,* (…) and *when Narwhale and Beluga arrive to the area, the Greenland Halibuts seem to disappear".* This link was also found in Qaarsut, where the NRC in 2010 explained that Greenland halibut disappeared from the area around June-July at the time of arrival of Harp seal, explaining why normally the fishers moved elsewhere to fish in this period, or shifted to hunting seals instead.

Moreover, the comments revealed that the direct effects from the big-scale commercial fishing industry have lessened during the last years. The NRC's of Akunnaaq, Attu and Ilulissat concluded that the negative effects, previously caused by the shrimp trawlers' large bycatches of small Greenland halibuts, had diminished since the implementation of grates in the shrimp trawls.

The comments likewise provided insight in the concerns of the fishermen. In Qaarsut the NRC was worried that many nets are set over their long-lines or are left at sea where they continue to catch fish, which then rot and attract Greenland sharks.

Table 8 Summary of the comments for Greenland halibut, for the full data see appendix

	Additional comments (n=36)	Importance and possible explanation concerning the trend (n=26)	Management suggestions (n=20)
Greenland halibut	➢ Increase in catch per unit effort (Akunnaaq 2010, 2011) ➢ Increase in size (Akunnaaq 2014, 2015, 2016, Attu 2016, Kitsissuarsuit 2016, Ilulissat 2010) ➢ New fishing areas (Kitsssisuasuit 2015, Qaanaaq 2016) ➢ Unchanged sizes (Qaarsut 2010, Kangersuatsiaq 2016, Qaanaaq 2016)	➢ Change in sea-currents and movement of icebergs opening up new fishing areas (Qaanaaq 2016) ➢ Greenland halibut has come back after the small shrimp fishing vessels has stopped trawling or have implemented grates. Before young Greenland halibut was caught as bycatch by the shrimp trawlers (Attu + Akunnaaq + Ilulissat) ➢ Good food basis is believed to be the reason for the increasing population and bigger fish (Akkunnaq + Kitsissuarsuit) ➢ It is believed that the fatty Greenland Halibuts come from the north (Qaarsut 2010, Ilulissat 2010) ➢ Greenland halibut seem to disappear, when there are large numbers of seals, Narwhale or Beluga whales in the area (Akunnaaq 2010) ➢ When sea-ice departs, seals return, and Greenland halibut disappears (Akunnaaq 2015) ➢ Greenland halibut disappears from the area at the time of arrival of Harp Seal in June-July, meaning that the community members have to move elsewhere to fish. However, an unusual event happed in 2010, here the Greenland halibut stayed in the area even into September (Qaarsut 2010) ➢ Many nets are being set over the long-lines and some nets are left at sea when the sea freezes over. This results in many rotting fish, which attract Greenland sharks (Qaarsut 2010) ➢ Due to strict management procedures concerning the processing plants, only low volumes are landed (Kangersuatsiaq 2016)	➢ It is recommended to establish local authority bylaw to restrict net fishing in Uummannaq Fjord (Qaarsut 2010) ➢ It is recommended that the acquisition of Greenland halibut license is made easier, and the rules about losing the license when you have not used it should be cancelled (Akunnaq 2014) ➢ It should be possible to get GHL 47 license (small vessel license for coastal Greenland halibut) (Kitsissuarsuit 2015) ➢ To further increase the population, it is recommended to limit the trawling during spring, summer and fall, and to establish closed areas in Isuamiut - Saattuarsuit - Agissat – Tussaaq (Akunnaq 2015) ➢ Unchanged management is recommended (Attu and Qaanaaq 2016).

Table 9 Table showing the categories covered by the Greenland halibut comments.

	CATEGORY	AKUNNAAQ	ATTU	KANGERSUATSIAQ	KITSISSUARSUIT	ILULISSAT	NIAQORNAARSUK	QAANAAQ	QAARSUT
GREENLAND HALIBUT	Behaviour								
	Body condition (size, weight)	X[1]	X[2]	X[3]	X[4]	X[5]		X[6]	X[7]
	Catch per unit of effort	X[8]							
	Food supply	X[9]			X[10]				
	Hazards								X[11]
	Industry impacts	X[12]	X[13]						
	New spatio-temporal distribution	X[14]			X[15]			X[16]	X[17]
	Population distribution dynamics					X[18]			X[19]
	Prey								
	Sea currents							X[20]	
	Sea ice								
	Species interactions	X[21]							X[22]
	Unusual events								X[23]
	Water temperature								
	Weather change								

The foot notes inform about the year of the comment and refer to the source of the original full comment in appendix 3, the row numbers are given

[1] In 2014, 2015, 2016. 2014: 9-11. 2015: 15-20. 2016: 21-23
[2] In 2016, 24
[3] In 2016, 32-34
[4] In 2016, 39-41
[5] In 2010, 12
[6] In 2016, 42-44
[7] In 2010, 45,47
[8] In 2010, 2011. 2010:2, 2011:6
[9] In 2015, 18-20
[10] In 2016, 39-41
[11] in 2010, 45,47
[12] In 2010, 2014. 2010: 2, 2014: 12-14
[13] In 2016, 24
[14] In 2016, 21-23
[15] In 2013, 2015. 2013: 35, 2015: 36-37
[16] In 2016, 42-44
[17] In 2010, 45, 47
[18] In 2010, 12
[19] In 2010, 45
[20] In 2016, 42-44
[21] In 2010, 2015. 2010: 2, 2015: 15-17
[22] In 2010, 45,47
[23] In 2010, 45, 47-48

5.3.8 Local suggestions for management decisions – Greenland halibut

By reviewing the proposals for management three overall suggestions were put forward:

1. Establishing a local authority bylaw to restrict net fishing in Uumannaaq Fjord
2. Making the acquisition of Greenland halibut license easier
3. Limiting the trawling during spring, summer and fall, and to establish closed areas in Isuamiut - Saattuarsuit - Agissat – Tussaaq

5.3.9 Atlantic cod

The PISUNA database contained 76 additional comments, 41 comments on the importance and possible explanation concerning the abundance trend and 54 management suggestions was made for Atlantic cod. Table 10 gives an overview of the comments.

The comments provided information on 12 (out of 15) different categories within ecosystem dynamics. Like the comments for Greenland halibut there was good correspondence in the topics and content of the comments between the different communities. Seventy-one % of the communities commented on body condition, the next most commented topic was catch per unit of effort (CPUE) and the food supply with each 43% of the communities mentioning these. Comments like" *This year Atlantic cods are larger and found 'everywhere'"- Akunnaaq 2014, "Long lines for Atlantic Cods are now placed for no longer than one hour as there are so many Atlantic Cods*"- Kangersuatsiaq 2016 and" *You catch Atlantic cod wherever you put a hook into the water*"- Kitsissuarsuit 2013 underlined the fact that a change towards bigger and more abundant Atlantic cod was observed in most communities.

Detailed insight into the food supply was observed in Attu, explaining that "*Food items such as wing-snails, jellyfish, sandeel, scallops and the presence of warmer sea-water make the conditions fine for Atlantic Cod*" - Attu 2015

5.3.10 Additional knowledge from the comments – Atlantic cod

Again, by analysing the comments, additional trends became apparent. The four southern most communities Akunnaaq, Attu, Kitsissuasuit and Niaqornaarsuk all observed increased body condition, three of these independently of each other, proposed increased food supply to be the reason for this change (Attu NRC likewise mention the increasing water temperature).

Novel insight on the distribution range was likewise revealed in the comments. Since 2016, Atlantic cod was observed in Qaanaaq. The previous northernmost distribution described in scientific literature, was Qeqertasuaq at Disko Island (Jensen 2003).

Likewise, the comments provided information on possible interactions affecting the Atlantic cod population. Atlantic cod was found to be negatively affected by the presence of seals and humpback whales observed by the NRC's of Attu and Ilulissat in 2015 and 2010 respectively.

Attu NRC in 2015 expressed concerns about the capacity of the processing plants. The NRC informed that due to capacity limitations, Atlantic cod is only caught in limited areas and no more than 5 % of the full potential is being caught.

Table 10 Summary of the comments for Atlantic cod, for the full data see appendix 4

	Additional comments (n=76)	Importance and possible explanation concerning the trend (n=41)	Management suggestions (n=54)
Atlantic cod	➢ Increase in catch per unit effort (Akunnaaq in 2010, Kangersuatsiaq 2016, Kitsissuarsuit 2013) *"long lines for Atlantic Cods are now placed for no longer than one hour as there are so many Atlantic Cods"*- Kangersuatsiaq 2016. *"You catch Atlantic cod wherever you put a hook into the water"- Kitsissuarsuit 2013* ➢ Increasing size (Akunnaaq 2014, 2015, 2016, Attu 2015, 2016, Kitsissuarsuit 2016, Niaqornaarsuk 2014) *"This year Atlantic cods are larger and found 'everywhere"- Akunnaaq 2014* ➢ Only few large individuals, most Atlantic cod are of medium size (Kangersuatsiaq 2016) ➢ Atlantic cod is now caught throughout the whole year, which is a change since earlier there has used to be times of the year where Atlantic Cod was not present (Akunnaaq 2015, Kangersuatsiaq 2016) ➢ Species that where not present before are now caught on the longlines in Qaanaaq; such as Redfish, Grenadier, Wolf Fish, Atlantic Cod and Greenland Cod. *"We enjoy eating these new fish"* (Qaanaaq 2016).	➢ The increasing stock (and the fact that the Atlantic Cod wander further north (Attu 2014)) is believed to be a response to good food basis (Kitsissuarsuit 2014 + Akunnaaq 2015 + Attu 2015, 2016), warmer sea temperatures and restrictions in fishing (Attu 2014). ➢ Food items such as wing-snails, jellyfish, sandeel, scallops and the presence of warmer sea-water make the conditions fine for Atlantic Cod (Attu 2015) ➢ Atlantic cod partly disappears when seals turn up (Attu 2015) ➢ Humpback Whales fed repeatedly in the Atlantic cod fishing area (Ilulissat 2010) ➢ The increasing food supply can be caused by a change in sea currents Attu (2016) ➢ Decreasing sea-ice, warmer sea temperatures and more humidity is observed (Attu 2016) ➢ In the summer when the sea is calm you can see schools of Atlantic cod perched at the water surface (Akuunnaq 2015) ➢ *"The presence of Atlantic cod is new. The last four to five years, the population has very much increased. During summer, fishermen who fish at Aappilaatoq have observed Atlantic Cod even in shallow water"*- Kangersuatsiaq 2016 ➢ Due to strict quotas, Atlantic cod is only fished in a small area and the fishermen only catch 5% of what is possible (Attu 2015)	➢ The 15,000 tonnes quota is not enough. Higher quota is recommended (Akunnaaq 2014 ➢ Larger quota is recommended (Kitsissuarsuit 2014, 2016). ➢ The quota is recommended set to 20-25.000 tons (Attu 2014). ➢ Same quota as last year is recommended (Akunnaaq 2015). ➢ Larger quotas are desirable. We recommend that the quota is increased to 30.000 tons. Quota allocation should follow the conditions in 'the real world' (Attu 2015). ➢ It is suggested that the quota is increased to 40,000 tons (Attu 2016) ➢ It is recommended to improve the processing plants (Akunnaaq 2015, 2016 +Attu 2016) ➢ It is recommended to control the substantial increase in Humpback whale population (Ilulissat 2010) ➢ If there is no Lumpfish to fish, it is recommended to open the Atlantic Cod trade (Attu 2016) ➢ It is recommended that thorough Atlantic cods studies are done in in this region to provide information to support the management (Attu 2016+ Kangersuatsiaq2016)

Table 11 Table showing the different categories covered by the Atlantic cod comments

	CATEGORY	AKUNNAAQ	ATTU	KANGERSUATSIAQ	KITSISSUARSUIT	ILULISSAT	NIAQORNAARSUK	QAANAAQ	QAARSUT
ATLANTIC COD	Behaviour	X[1]		X[2]					
ATLANTIC COD	Body condition (size, weight)	X[3]	X[4]	X[5]	X[6]		X[7]		
ATLANTIC COD	Catch per unit of effort	X[8]		X[9]	X[10]				
ATLANTIC COD	Food supply	X[11]	X[12]		X[13]				
ATLANTIC COD	Hazards								
ATLANTIC COD	Industry impacts								
ATLANTIC COD	New spatio-temporal distribution	X[14]		X[15]				x[16]	
ATLANTIC COD	Population distribution dynamics								
ATLANTIC COD	Prey		X[17]						
ATLANTIC COD	Sea currents		X[18]						
ATLANTIC COD	Sea ice		X[19]						
ATLANTIC COD	Species interactions		X[20]			x[21]			
ATLANTIC COD	Unusual events								
ATLANTIC COD	Water temperature		X[22]						
ATLANTIC COD	Weather change		X[23]						

The foot notes inform about the year of the comment and refer to the source of the original full comment in appendix 4, the row numbers are given

[1] In 2015, 9
[2] In 2016, 22
[3] In 2014, 2015, 2016. 2014:5-5, 2015: 9-10, 2016: 16
[4] In 2015, 2016. 2015: 13-14, 2016: 15-18
[5] In 2016, 21
[6] In 2013, 2016. 2013: 23, 2016: 25
[7] In 2014, 26
[8] In 2010, 2
[9] In 2016, 21
[10] In 2013, 23
[11] In 2015, 9,11
[12] In 2015,2016. 2015: 14, 2016: 16-17
[13] In 2014, 24
[14] In 2015, 8
[15] In 2016, 22
[16] In 2016, 27
[17] In 2015, 14
[18] In 2016 ,16
[19] In 2016, 15
[20] In 2015, 14
[21] In 2010, 19
[22] In 2014,2016. 2014: 12, 2016: 15, 18
[23] In 2016, 15

5.3.11 Local suggestions for management decisions – Atlantic cod

By reviewing the proposals for management four overall suggestions were put forward:

1. Significantly increase the TAC
2. Improve the processing plant capacities, hereunder the possibility to open up for the trade of Atlantic cod, if there is no Lumpfish to fish
3. Implement management procedures to control the increasing Humpback whale population
4. Conduct thorough scientific studies of the Atlantic cod population in the area around Attu and Kangersuatsiaq to provide information to support the management

6 Discussion

This thesis aimed to answer three research questions:

1. What are the general characteristics of Arctic CBM programmes?
2. What are the most distinguishing features of CBM compared to scientific monitoring?
3. Is there a difference in the format and the results between CBM data and scientific data?

These questions will be answered and discussed in the following sections.

6.1. The characterisation of Arctic CBM programmes

Research question 1) What are the general characteristics of Arctic CBM programmes?

In short, this study provides the following characterisation: Arctic CBM programmes are distributed across the circumpolar Arctic, the programmes vary greatly i.e. from monitoring of berry phenology, use of traditional practices, wild life inventories, mapping of traditional land use. Monitoring mainly covers biological attributes. However, abiotic and socio-cultural attributes are also relatively well-covered by the monitoring, and often the programmes are interdisciplinary and monitor attributes within several disciplines. Likewise, the programmes cover a wide biome range, the programmes are relatively evenly distributed across the different biomes investigated in this thesis, though with a skew towards programmes in the coastal zones. The temporal cover is very high, since monitoring is conducted continuously throughout the whole year. Monitoring is mainly conducted at yearly frequencies, however this question need further investigation.

There are several reasons why community members want to be involved in the CBM programmes, the primary ones being to help sustain health and abundance of wildlife and to protect the rights over land, sea and resources. CBM contributes to the communities by building psychological, political and social capacities seen by an enhancement of pride and self-esteem, increased participation in natural resource decision-making, improved education and learning skills.

Community members are mainly involved in the data collection whereas external agents mainly are involved in the usage of the results. However, an overall high degree of involvement in all stages of both groups exists, suggesting terms of equal collaboration.

It is clear that there exists confusion about the term CBM and that it is used interchangeably with CS. Despite this being a survey explicitly targeting CBM programmes, 40% of the programmes turned out to be using CS methodology (will be discussed in 6.1.2).

6.1.1 Previous Arctic CBM assessments

Only few national and regional assessments of CBM programmes currently exists e.g. ((EMAN 2013; Conrad & Daoust 2008; EUmon n.d.). To my knowledge, only one previous circumpolar Arctic CBM assessment has been done (Johnson et al. 2016). Thus knowledge concerning Arctic CBM programmes is critically lacking due to very little empirical data and analyses of these. This study was the first to provide a detailed characterisation of Arctic CBM programmes by also looking at both the motivations of the participants, the contributions to the communities, the biome coverage, the methodologies, and the challenges arising when establishing an Arctic CBM programme.

As mentioned in the introduction, the Sustainable Arctic Network (SAON) project did a similar study to this thesis, where they through questionnaire surveys and workshops compiled metadata from 81 circumpolar Arctic CBM programmes. The outputs were compiled in an online atlas (www.arcticcbm.org) and the scientific report *Community-Based Monitoring and Indigenous Knowledge in a Changing Arctic* (Johnson et al. 2016).

One of the more comprehensive national CBM assessments was done in Canada in 2001. Here, the Ecological Monitoring and Assessment Network (EMAN) in partnership with the Canadian Nature Federation (CNF), initiated the Canadian Community Monitoring Network (CCMN), which is the most detailed survey of CBM in Canada to date. The project explored 31 community approaches on how to implement demand-driven ecosystem monitoring and to create local capacity for action toward sustainability. This was done in order to better understand the issues related to CBM across Canada. EMAN used the individual characteristics of the 31 programmes and made a guide for identifying critical factors for successful "on-the-ground" implementation together with a conceptual framework (the CCMN Model) for how CBM is best accomplished see (EMAN 2013) for details.

A similar regional study of a similar scope was carried out in Nova Scotia, Canada. Here, using the same technique as this current study, a questionnaire filled out by local CBM programmes was used to compile information regarding the current state of CBM in the province. Additionally, working from the CCMN model, Conrad and Daoust, 2008 developed a functional CBM framework aimed to provide practical guiding for stakeholders wanting to initiate a CBM programme, see (Conrad & Daoust 2008) for details.

In the subsequent sections, the results from these three previous assessments will be related to the findings of this thesis.

Even though the study by Johnson et al. 2016 included fewer characteristics than this present study, the general overview of the corresponding features for the 81 programmes from the SAON project gave a very similar characterisation of Arctic CBM programmes as reached in this thesis, thus supporting and providing confidence in the results obtained. For instance, Johnson et al. 2016 found a similar distribution between both biological (80%), and abiotic attributes (79%), as well as socio-cultural attributes[13] (23%). Likewise, the majority of the programmes monitored attributes in two or more categories.

It is not surprising that most monitoring is done on biological attributes (e.g. mammals, birds, fish, insects, plants, fungi), since biological attributes represents natural resources utilized by the local communities. It is inherent in the CBM method to focus on attributes of common community concern. It is however, more surprising that also abiotic attributes (sea ice, water, snow, weather, wind,

[13] Johnson et al. 2016 divided the attributes into 5 categories, here I have aggregated them to fit the categories used in this thesis

currents, pollution, infrastructure) and socio-cultural attributes (TEK, language, human health, wellness) are monitored to a relatively high degree.
This clarifies the fact that CBM is often done on attributes within different scientific disciplines, making CBM a strong interdisciplinary approach. This is however, not a distinguishing feature; science-driven monitoring is also interdisciplinary and monitor attributes to a high degree within the different disciplines. Thus both methods can provide a socio-ecological interdisciplinary approach.

Contrary to my results, Conrad and Daoust, 2008 found that most of the CBM programmes in Nova Scotia, monitor attributes in relation to watersheds, testing for variables such as pH, temperature, dissolved oxygen, salinity, macro-invertebrates, and various bacteria, whereas fewer undertook terrestrial or wildlife monitoring. This was explained by freshwater being one of the most valued resources in the region (Conrad & Daoust 2008), underlining the fact that CBM addresses issues of greatest community concern.

It is often noted that CBM programmes have more recognition or at least are more distributed particularly in Canada and North America (Conrad & Daoust 2008; Johnson et al. 2013; Conrad & Hilchey 2011; Berkes et al. 2001). This may be due to the fact that these regions are significantly further ahead when it comes to land claims acts and autonomous territories. Moreover, the local and Indigenous authorities and organisations in this region have much stronger organisation and higher levels of self-governance than elsewhere in the Arctic. It is also from this region some of the first, and to this day, still most well-known examples of the power of TEK and CBM originate (e.g. the 1970's bowhead whale census case) (Huntington 2000; Freeman 1989; Johannes et al. 2000; Berkes et al. 1993).
However, CBM studies are not exclusive to the Canadian and North American territories. In the updated distribution map (figure 14, page 39) from this study it is seen that CBM in the European Arctic too is highly represented. Johnson et al. 2016 likewise found a wide circumpolar distribution with a high proportion of CBM programmes distributed outside Canada and USA: USA (19), Canada (15), European Arctic (38), Russia (9). Thus, it is time for a revision of the current notion regarding the distribution of CBM programmes. The first ever Saami led programmes in Finland are now being established, such as the Näatäamö river restoration. Collaborations are being carried out across Greenlandic government authorities, traditional fishers and hunters in the PISUNA programme, creating recognition of local knowledge. These are just some of the cases underlining how far the development of CBM programmes in this region has reached already. Even though the questionnaire survey is not exhaustive, in that it only comprises 30 programmes it is noteworthy that already a high degree of the Arctic region is covered.

It is important to relate the spatio-temporal coverage of the monitoring to the efforts of the data collection. In this thesis, effort is indicated by the frequency of data collection. The CBM programmes primarily monitor yearly, often the programmes will have campaigns during the hunting or fishing season, or make observations of a given resource at certain times of the year. This, is much like the frequency of most science-driven programmes relying on field seasons, although the CBM programmes' field seasons were distributed over the whole cause of the year. The second most used frequency, is daily observations, were local or Indigenous people observe during their everyday work for example as hunters, herders, gathers or fishers, this is for example seen in the PISUNA programme. It should however be noted that there have been some misunderstandings in the answering of the frequency question in the survey. Instead of answering data collection frequency, some programmes answered the frequency of the reporting of the results. This gives an uncertainty to the effort analysis, and further investigation into this is needed.

In this study CBM was found to promote development of pride and self-esteem together with increased participation in decision-making in the communities. Enhancement of these capacities can lead to more equal terms of collaboration and thereby improved communication between community members, scientists and decision-makers, as seen in the Näätämö river restoration programme.
Looking at the national assessment, EMAN likewise found that Canadian CBM programmes resulted in the development of trust, partnerships, and lines of clear communication in the communities (EMAN 2013). This together with the identification of early signs of ecological change led to an enhanced ability for local decision-makers to react in time when their management plans were going off track. The same has been proven for PISUNA in an earlier study by Danielsen et al. 2005, here it was found that greater involvement of the Greenlandic local hunters and fishers led to more rapid management action (Danielsen, Jensen, et al. 2005).

The main challenge by sustaining the Arctic CBM programmes is limited funding. This challenge is crucial, since monitoring programs by their very nature of providing time series data require long-term duration. Unfortunately, more often than not CBM initiatives struggle to find secure long-term funding, since most funding agencies often only fund projects for a few months to a few years at the time (Johnson et al. 2013). Communities that do manage to maintain monitoring programs long-term, often have to piece together funding from various sources. A lack of sustained funding may result in gaps in data collection and leave residents feeling frustrated and disheartened.

Another challenge identified by Conrad and Daoust, 2008 was the willingness and readiness of decision-makers and management institutions to include the data and work collaboratively with community members. This was also stated explicitly by one programme in the questionnaire survey conducted for this thesis.
However, Conrad and Daoust, 2008 found that this was a double-edged sword, since the reason why the data was not considered by the management institutions was thought to be caused by the fact that most programmes (73%) did not use any consistent monitoring method or standardized protocol, resulting in data being unsuitable for decision-makers. Pointing to an important fact, the format and the structure of the CBM data have implications for the wider use of the CBM data.

One of the critics often raised against CBM data, is the inability to scale up and use the data in national or global assessments and policy-relevant work (Fernandez-gimenez et al. 2007; Ferguson & Messier 1997). However, several implementing strategies to bridge this gap has been initiated. For example organisations such as IPBES, are working to create the institutional structures and capacity required to ensure that data from CBM and conventional scientific knowledge is effectively combined in the context of national and international assessments (Sutherland 2013; IPBES 2013b). Likewise, projects such as INTAROS are creating platforms such as larger data repositories and meta-databases to better access, use and integrate CBM knowledge on larger scales ((EMAN 2013; Pulsifer et al. 2012; Sutherland 2013; Farhan Ferrari et al. 2015). However, if this is to succeed it depends on careful attention to the way data is collected, like seen in PISUNA where long-term systematically collected time series data is available in a high resolution, down to monthly scale. Providing the opportunity to integrate the observations into broader observations networks and management information. Taking the time during the monitoring design phase to consider how methods relate to sharing and use of data at a larger scale may increase the project's long-term impact (Johnson et al. 2013).

6.1.2 Revealing the "true" involvement of community members

In relation to what stages community members and external agents (e.g. scientist or authorities) are engaged in, this study finds that there is a high degree of involvement by both community members and external agents in all stages of the CBM programmes. Looking at the two groups separately, a different division of involvement is seen. Community members are primarily involved in the data collection (86%) and this to a much higher degree than external agents (48%). The external agents are mostly involved in the use of the results (72%), this however in close collaboration with the community members, which to an even higher extent are involved in this task (76%). Thus suggesting that CBM contribute to collaboration on equal terms meaning a high degree of influence by the community members.

However, when scrutinizing the methods used by the Arctic CBM programmes in this study, the overarching methodology turned out to be a combination of CBM (60%) and CS methodology (40%). This is notable since it does not correspond with the fact that 93% of the programmes state that they involve community members in more stages than data collection. When applying the CBM definition used for this thesis, strictly speaking, these 40% should not be included in the CBM assessment.

However, for the sake of this thesis, I have chosen to view all 30 programmes as CBM programmes, as they self-identify as this. Also the categorisation of this overarching methodology was done on a very limited foundation of information, using only the brief description of methods provided in the questionnaire and follow-up internet search. In order to truly define the programmes as CS or CBM first-hand knowledge about the individual programmes is necessary.

Even though Johnson et al. 2016, initially excluded programmes that did not provide enough information to demonstrate involvement of community members (36 programmes were excluded). This challenge was also encountered in the SAON project. Where 20 % of the 81 programmes were found to use CS methods.

This strongly underlines the fact that substantial confusion about what defines a CBM exits and that CBM is used interchangeably with CS. Likewise it illustrates the necessity to thoroughly investigate the realities of each CBM project. This is crucial since it can hinder the implementation of genuine CBM programmes.

This point was made as early as in 1969 by Arnstein, who with the self-declared provocative landmark article wanted to illustrate that it was necessary to scrutinize proclaimed CBM programs, since experience showed that to a large extent the aim of collaboration was merely mentioned on paper but in reality community members were not allowed to influence the project process or have their voices heard (S. R. Arnstein 1969).

This is indeed provocative, but looking beyond that, Arnstein did prove an important point. One of the pitfalls with CBM is the paradox that the increasing political focus have made CBM become a buzz-word, at risk of being used as a promotion strategy. Arnstein note that this kind of tokenism can especially be seen where the use of traditional knowledge is required, even though this might not be the most relevant approach. Opening up the discussion, that like all other methods, CBM is not universally applicable and should only be used when this method is appropriate.

The literature often romanticizes participation without examining when participation is challenging or where policy making is more appropriately implemented by external decision-makers. It is essential to know the capabilities of the different methods and types of data provided by these, in order to choose the most suitable approach. The characterisation and assessment provided in this thesis can be used for exactly that purpose.

6.1.3 Limitations to the questionnaire study

It should be noted that several challenges exist when conducting a questionnaire assessment like this present study. Firstly, it is a limitation to the study that the analysis is based on others perceptions about the reasons of motivations and the contributions to the communities. Secondly, it can be assumed that only successful CBM programmes are interested in participating in the analysis, thus not all the nuances will be covered with this type of analysis. Thirdly, it is very difficult to include programmes that are not led by an organisation or scientists, since these autonomous programmes often do not have a webpage or other publicly available information. And fourthly by using multiple choice, the variation and unique details in the answers are lost since the answers are already constructed for the respondent. which might not agree with the provided options.

6.2 Comparison between CBM and science-driven monitoring

> Research question 2) What are the most distinguishing features of CBM compared to scientific monitoring?

Both CBM and science-driven monitoring was found to be wide-ranging with regards to attribute and biome coverage, monitoring all the disciplines and biomes investigated in this analysis.

On the other hand, the temporal coverage was a clear distinguishing feature for CBM compared to science-driven monitoring. Monitoring is undertaken consistently throughout the whole year, every season is evenly covered by the CBM monitoring. Whereas the science-driven monitoring is strongly limited by the academic calendar and monitoring is conducted in a peak season from June to September.

Thus CBM strongly strengthen the temporal aspect of Arctic environmental monitoring, providing a better foundation to unravel the ecosystem dynamics often interconnected across yearly processes and mechanisms.

6.2.1 Limitations to the temporal comparison

As mentioned however, a clear limitation to this analysis is the fact that it does not account for all the automatic monitoring that is conducted year-round by scientific monitoring equipment all around the Arctic. These automatic measurements strongly enhance the scientific monitoring period. These automatic year-round observations have during the last decade provided novel insight into the ecosystem mechanisms happening during the dark winter period (e.g.(Sturm et al. 2005). However, automatized measurements are primarily monitoring abiotic attributes, such as temperature, precipitation, gas fluxes and snow depths. Monitoring of biological attributes, such as abundance trends are not performed automatically.

6.3 Consensus or not? - Using CBM data in fisheries management

Research question 3) Is there a difference between CBM data and scientific data?

In this thesis consensus was found between science-driven monitoring and CBM for Atlantic cod. But for Greenland halibut, consensus was only found if the observations were summed to quarters of the year instead of monthly resolution. The explanation to this is that when summarizing to quarters, more registrations are included from the landings data, where before data was not available for all the exact same months as the CBM observations. This difference in resolution, or downscaling in accuracy, turned out to result in corresponding trends between CBM and scientific monitoring.

Thus to conclude whether there is consensus or not between the abundance trends provided by the two types of monitoring, is this not straight forward. The correspondence here depends on the species in question and the resolution used.

Here I argue that the PISUNA results can be regarded as consistent with the scientific findings, since quarterly resolution normally is best suited to identify abundance trends in fish stocks, since observations on monthly intervals often are too fine-grained to make out any significant changes.

There has been a general misconception that CBM is to be considered unreliable until validated within a scientific paradigm. While there is no doubt that traditional knowledge can be flawed and that it can entail a conflict of interest, distrust should not be the default assumption when regarding CBM data. Successful CBM programs, like scientific monitoring, should have triangulation and data validation processes build into them. E.g. as with PISUNA, where trends are triangulated between the different observers and quality checked by the NRC at the quarterly group discussions.

It is however important to understand that each monitoring approach represent different epistemologies. The comparison in this thesis is thus instead used to underline the fact that since direct comparison is not straightforward and often proves not to be a suitable method to gain additional information, not much come of comparing the methods 1:1. Rather when scientific observations and CBM observations correspond, this should be used to increase the confidence in both. And when they diverge, both should be re-examined, opening up for new and innovative research questions. One method might be as good/ valid/ close to the reality as the other, the two types of monitoring simply provide different formats of knowledge and different possibilities for analysis. Scientists have a responsibility not to dismiss such claims before investigating carefully what lies behind them.

When discrepancies are found these have been mostly explained by mismatch in spatial and temporal scale or errors in the research method (Hedeholm et al. 2016; Verweij et al. 2010; Neis et al. 1999). Neis et al. 1999, state that resource users develop a detailed, small-scale understanding of population complexes, while scientific management typically aims at a larger scale. This mismatch in spatial scale can lead to different assessments of stock status and apparent disagreement where none may exist. This is backed by for example Verweij et al, 2010 who talks about a tower of Babel in the fisheries, and found that differences in perceived status and trends of North Sea fish stocks among fishermen and scientists (and other stakeholders) were only related to the spatial and temporal extent of the specific data each group used to assess changes to fish stocks (Verweij et al. 2010).

6.3.1 The special context of fisheries monitoring

A growing number of case studies, both from the Arctic and the rest of the world show consensus between CBM and scientific fisheries data (Eckert et al. 2017; Rosa et al. 2014; Beaudreau & Levin 2014; Chanda 1998; Leite & Gasalla 2013; Brown & Pomeroy 1999; Ferguson & Messier 1997). For example, Neis et al. 1999, who did an investigation of the capelin fisheries with coastal fishers from Newfoundland, Canada and found the local data to be consistent with tagging data from the Department of Fisheries and Oceans (DFO). The local fishers knew about the complex distribution of the capelin fish, and the fishers possessed large amounts of information useful for fisheries assessment (Neis et al. 1999). Similar examples exist from Puget Sound, Washington (Beaudreau & Levin 2014), British Columbia, Canada (Eckert et al. 2017), the Bangweulu Swamps, Zambia (Chanda 1998) and the Caribbean (Brown & Pomeroy 1999).

However, despite the increasing consensus and the apparent advantages by including CBM in fisheries data, the methods of conventional and CBM monitoring is highly debated. Just to mention a few key points: Firstly, scientific knowledge has been critisised for being driven by what data is available, not by what data is needed. Often, like in Greenland, scientific knowledge is highly based on information directly obtained from the fisheries, such as landing data or loogbooks together with yearly trawl surveys. Because external market factors strongly influence the distribution, effort and behaviour of commercial fishers, this data may not necessarily reflect biological changes to species sizes or abundance (Eckert et al. 2017). Also analyses show that the ability of trawl surveys to detect short-term (<10 years) trends is generally poor. Thus while conventional fisheries monitoring do provide good long-term indicators of changes in fish community structure, they are unlikely to provide an appropriate tool to support short-term management decisions (Nicholson & Jennings 2004).
Secondly, it can be difficult to compare scientific monitoring and CBM, since often community members use different indicators than identified by visiting researchers to assess and understand stasis and change (Huntington 2000). Thirdly, when conducting these comparisons, it is very important to collaborate with the right participants. As Johannes et al. 2000 state: *Those who doubt the value of local marine ecological knowledge may find evidence to reinforce their doubts if they simply interview fishers at random* (Johannes et al. 2000). In order to access reliable and valid data from TEK, it is essential to identify the most qualified and experienced fishers (Moreno et al. 2007). I will not go into further details here, since this opens up for a whole additional characterisation study, however usually the most suited informants are among the older fishers (Beaudreau & Levin 2014).
Finally, the fisheries can be determined to be a special context to evaluate the use of CBM. The European research project JAKFISH (Judgement and Knowledge in Fisheries Involving Stakeholders) use the term *post-normal* to describe the management situation in fisheries. A situation can be considered post-normal when stakes are high and scientific knowledge is uncertain. In such situations, it is not sufficient only to rely on textbook knowledge, and trust that scientists alone will be able to give the answers - because there is not one single answer due to the uncertainties and decision stakes involved (Christine et al. 2012).

Due to the *post-normal* circumstances strong tensions have grown in some fisheries between scientists, locals, industry, decision-makers and/or politicians, in particular around questions of credibility and legitimacy of the statements put forward by the different stakeholders in relation to abundance trends (Christine et al. 2012). Local people often perceive the scientific knowledge to be incorrect, due to unsuitable field surveys, too little data or not inclusive enough data. Which is thought to lead to management decisions being taken based on strictly speaking no more than educated guesses.

On the other hand, many fishery officials and scholars still accept "the tragedy of the commons" model, that assumes that the individual fishers are biased by their own self-interest and behave contrary to the common good of all users by depleting or spoiling the natural resource through their collective action (ref. discussions at Arctic Circle conference 2017, and the North water polynya conference 2017). Thus when the fishers argue that the fish stock are more abundant than biologists think, it is often assumed to be based on wishful thinking.
In addition to scientist and locals disagreeing, also accusations have been made from the scientists, stating that the Greenlandic government is deciding the TACs using a reversed precautionary approach. Meaning that the management has to be proven harmful, before it will be changed. They are accusing the government for only considering short term perspectives in their management, jeopardising the livelihood for all fishers in the future (pers. conv. Kaare Winther Hansen, biologist WWF Greenland).

Instead of clinging to prejudices, these causes can be settled by reviewing scientific literature. Here it is in fact seen that self-interest and too "wishful" abundance estimates have been proven sometimes to be true (CAFF 2013; Eckert et al. 2017), just as well as the scientific monitoring has been found to be insufficient or misleading (Johannes et al. 2000). These experiences should leave all parties more humble and willing to listen, test and engage in dialogue about all perceptions put forward.

6.4 CBM offers a way forward

PISUNA was first met with considerable scepticism from both scientists and the local hunters and fishers. Most of this scepticism has since been overcome as the programme has addressed local challenges, advanced local organisation, given the local fishers and hunters a voice in natural resource decision-making and established an equal and beneficial collaboration between the local communities and the authorities.
CBM can be viewed as a tool to open op for a constructive and more equal dialogue. By collaborating, all stakeholders gain a deeper insight into the motivations of one another. By engaging in an equal collaboration CBM create a field where TEK is respected and at the same time provide a databased foundation to support the locals' perception. Thus CBM has the possibility to out-level existing power and knowledge structures, possibly shifting the point of view from a 'them' to an 'us' situation, giving the locals an increased sense of influence and ownership of the natural resource management. For people who for so long have been overlooked, having your knowledge respected in the process of management decisions of common concern, should not be underestimated (Taylor & Mustonen 2012). Particularly not since this can result in a replacement of frustration by satisfaction and understanding, that has been shown to encourage positive environmental attitudes and sustainable behaviour (Poe et al. 2014; Danielsen, Jensen, et al. 2005).

6.5 CBM more than hard data - The comments section

Like other similar studies have found when assessing information emanating from the comments included in many CBM programmes, the comments section in PISUNA provided good correspondence in the content commented on together with a high degree of agreement among the different communities (Leite & Gasalla 2013; Beaudreau & Levin 2014; Neis et al. 1999). Thus providing improved confidence that the observed abundance trends reflect reliable patterns in the environment.
The comments strongly increase the level of information by the abundance trend observations. Several additional trends become apparent when analysing the comments: novel discoveries about distribution range, species interactions, food sources, body conditions etc. can be identified. The

comments section in PISUNA is directly relevant for managers, these provide substantial insight into ecosystem dynamics and confounding factors related to the abundance trends. Furthermore, the information that can be extrapolated from the various comments can easily be integrated into information guiding decision-making.

However, extrapolating this information satisfyingly is one of the principal challenges to integrating CBM and scientific data. This type of qualitative information does not readily suit the quantitative methods commonly used by natural scientists. In order to unravel the full potential of CBM data, it requires using new analytical methods and applying a cross-disciplinary approach. As mentioned science-driven monitoring represents deductive, synchronic observations whereas CBM with its holistic diachronic observations provide information in another format.

Thus it is a necessity that the biologist understand social science methods and learn how to interpret such data, likewise the social scientist needs to have a good understanding of natural sciences in order to comprehend the ecosystem implications and deduct the proper management advices (Danielsen, Burgess, et al. 2005; Wiber et al. 2003; Degnbol et al. 2006).

This is echoed by Hedeholm et al. who in a study about Atlantic cod from Nuuk fiord system, Greenland examined the extent to which genetic analysis corroborated with local knowledge. No consensus between fishers' understanding of offshore and inshore cod and the corresponding genetic categories could be found. But instead of writing this off as incorrect perceptions by the fishers, Hedeholmet al. 2016, found that the discrepancy was caused by scientists and fishers not talking about the same thing when they speak of inshore and offshore cod. When they revised some of the data in this light, and adjusted the research question, consensus became apparent. Likewise, they discovered that the design of the study was erred in that the local knowledge depended on specific timing and the study was conducted outside this period (Hedeholm et al. 2016).

This also underlines that CBM is proposed as a supplement to, and not a replacement of, traditional scientific ways of studying natural environments and resources. The feasibility of usage of CBM lies in the synergistic effects arising when *combining* results, not replacing one data set with the other.

6.6 The Greenland halibut and Atlantic cod management situation in Greenland

6.6.1 PISUNA as a best-example case

The Greenlandic Government has declared to support inclusion of local knowledge (Greenland government 1999). In practice, however a gap remains between government agency personnel and hunters and fishers, still sustaining traditional practices. Decisions in Greenland are largely top-down controlled, and actual reliance on local observations and understanding remains an emerging practice in Greenland (Huntington 2013). This underlines the importance of PISUNA, since this programme is one of the few very successful examples of how local people can participate in environmental monitoring in Greenland. Often PISUNA is highlighted by the Greenlandic government at national and international fora

When analysing the data from PISUNA, it has not been possible to get an exact account for how many of the proposed management suggestions, that has been processed by the authorities. Pâviârak Jakobsen, spokesman for the PISUNA participants, state that for long they did not know themselves either. However, they have just recently been informed that their proposals are being taking in to consideration by the government authorities, which they are very pleased with (personal conversation Pâviârak Jakobsen). By investigating the PISUNA management proposals (see below) it is found that, whether due to influence by PISUNA or not, most of management proposals have been dealt with by the Greenlandic authorities and decision makers.

6.6.2 Management suggestions for Greenland halibut:

1. **Establish a local authority bylaw to restrict net fishing in Uumannaaq Fjord**

From 1st of January 2012, a new regulation on net fishing for Greenland halibut was implemented. The local fishers' association now have the opportunity to consult the municipality in order to ban net fishing. Net fishing is now banned in 17 localities in Ummaanaaq management area. Furthermore, nets should not be left at sea for longer than 24 hours and if by accidents they are lost, all efforts should be made to retrieve the nets and if not possible it should be noted in the logbook and reported to the local wildlife manager (Government of Greenland 2012). Despite this new regulation, net fishing still presents a problem for Greenland halibut fishers. Lost ghost nets are a great nuisance to coastal Greenland halibut fishers whose lines get entangled and lost. Also illegal net fishing and the use of cod nets to catch Greenland halibut is a problem. http://sermitsiaq.ag/baeredygtighed-tilsidesaettes-i-disko-bugten.

2. **Make the acquisition of Greenland halibut license easier**

From the 1st of January 2017 it is possible to apply for dinghy licence for Greenland halibut at the local municipality office. Instead of sending in an application to APN now fishers with a license from the previous year can get a renewed license straightaway. Licenses for small vessels still have to send in an application to APN. APN is working on procedures to improve the license application procedure.

3. **Limit the trawling during spring, summer and fall, and to establish closed areas in Isuamiut - Saattuarsuit - Agissat – Tussaaq.**

It has not been possible to find out whether it has been discussed to limit the trawling season.

6.6.3 Management suggestions for Atlantic cod:

1. **Significantly increase the TAC**

The TAC has been increased noticeably every year, from 5000t in 2010 to 36.500t in 2017. In 2018, however the TAC was held at 36.500 the same as in 2017.

2. **Improve the processing plant capacities, hereunder the possibility to open up for the trade of Atlantic cod, if there is no Lumpfish to fish**

Royal Greenland, inform in a press release that the company has increased the capacity of the processing plants at Paamiut, Maniitsoq, Sisimiut og Kangaatsiaq (Royal Greenland 2015)

3. **Implement management procedures to control the increasing Humpback whale population**

In 2010, the International Whaling Commission agreed to allow hunting on Humpback whales in Greenland (the quota in 2018 is 12 individuals). GINR support this decision, their research show that the population of Humpback whales is increasing with approx. 9% yearly why sustainable harvest is possible. In 2007 GINR estimated that about 3000 Humpback whales are found in W Greenland(The Greenlandic Institute of Natural Resources 2012).

4. **Conduct thorough scientific studies of the Atlantic cod population in the area around Attu and Kangersuatsiaq to provide information to support the management**

It has not been possible to get a comment from GINR in time for the thesis deadline

It is noteworthy that the proposals if implemented will benefit the people having put them forward. International experiences however suggest that successful CBM programmes also often leads to people implementing and suggestion management decisions that will mean restriction on their own personal resource use (Danielsen et al. 2007). CBM has been found to encourage people to take a long term perspective on the use of resources through facilitating agreements at community and municipal level to increase or reduce the use of resources (CAFF 2013).

When looking outside the scope of PISUNA, the fact is that collaboration between scientist, fishers and politicians is limited with regard to the management of Greenland halibut and Atlantic cod. The estimates of these fish stocks remain causes of controversy and conflict.
However, the underlying problem is bigger than the Greenland halibut or Atlantic cod debate. The dismissive scepticism towards the other stakeholders blocks the way for successful new collaboration. I.e. one of the disagreements for Greenland halibut, is about the observed declining average sizes. Today the average size in Disko bay is 52-54 cm, whereas before 2001 the average size was 60-62 cm (the minimum catch seize for Greenland halibut is 42 cm.) Local fishers and the fishers' association explain that the Asian market considers small fish to be of higher quality and are thus demanding these. Therefore, the prices have gone up levelling out the difference between small and big fish. Thus more small fish is being landed now (personal conversation Pâviârak Jakobsen, spokesman for the PISUNA fishers, see also statement in KNR by leader of KNAPK in 2014 Petrus Biilmann https://knr.gl/da/nyheder/biologer-små-hellefisk-i-disko-er-i-farezonen).
Biologist respond by stating this might explain the strong decline seen 10 years ago, however it does not account for the continuous gradual decline in sizes observed since (personal conversation Kaare Winther Hansen, biologist WWF Greenland). And so it continues, the same is the case for Atlantic cod, here disagreements about the Atlantic cod stock estimates have been present ever since the stock around 2000 again showed signs of recovery. The local fishers are reporting about huge catches of Atlantic cod, and that they are unnecessary limited by the quotas. Despite the TAC being significantly increased from year to year - drastically exceeding the biological advice, still many fishers complain about the management and requests for the TAC to be further increased.

The longstanding conflicts between fishers and scientists are spilling over in various situations and are blocking the way forward for sustainable management (Hedeholm et al. 2016; Christine et al. 2012). The history of bad experiences, results in mistrust and frustration from all parties. The Government stuck in the middle, ending up increasing the TAC to much higher levels than the biological advice, but still not high enough to satisfy the fishers. Furthermore, the Olympic fishing management, has resulted in the quotas being reached before the end of the year, thereby closing the fishery. In these situations, the Government is pressured to open up for additional quotas in order to keep the employment and industry going. At the moments everybody loose - the fishers, the scientists, the ecosystem and the managers. This is underlined by Degnbol et al 2006 in the article with the telling title *"Painting the floor with a hammer: Technical fixes in fisheries management"* The future is very uncertain when looking at the Greenland halibut and Atlantic cod stocks, two of the most socio-economically important species in Greenland.

7 Conclusion

This study presents an updated detailed characterisation of Arctic CBM programmes as being: Widely distributed across all eight nations in the Arctic and very diverse in what type of attributes were monitored. The Arctic CBM programmes are interdisciplinary and monitor attributes within several disciplines. Mainly biological attributes are monitored- however, also abiotic and socio-cultural attributes are covered to a high degree. Likewise, the programmes cover a wide biome range. The programmes are relatively evenly distributed across the different biomes investigated in this thesis, though with a slight skew to programmes monitoring the coastal zone. The temporal coverage is very high, since monitoring is continuously conducted throughout the entire year.

Several reasons why community members wish to be involved in the Arctic CBM programmes exists, the primary ones being: to help sustain health and abundance of wildlife and to protect the rights over land, sea and resources. CBM contributes to the communities by enhancement of pride and self-esteem, increased participation in natural resource decision-making and improved education and learning skills. Community members are mainly involved in the data collection stage whereas external agents are mainly involved in the use of the results. An overall high degree of involvement in all stages of both groups exists, suggesting that the CBM programmes results in equal terms of collaboration.

It is however evident that substantial confusion regarding the definition of CBM exits. Despite this being a survey explicitly targeting CBM programmes, 40% of the programmes turned out to be using CS methodology.

Out of the factors investigated in this thesis, the most distinguishing feature of Arctic CBM programmes compared to science-driven monitoring is the wide temporal coverage. CBM is conducted throughout all seasons of the year whereas science-driven monitoring is strongly limited by the academic calendar and is almost only conducted during the field season from June to September.

Consensus between CBM and scientific abundance trends is not straightforward to determine, in this thesis consensus is found to depend on the species in question and the resolution. Consensus exists for Atlantic cod, however only for Greenland halibut by downscaling the resolution from monthly to quarters of a year.

Furthermore, the PISUNA case study demonstrated how CBM can be used to provide environmental monitoring while also resulting in information that are directly relevant for management decisions. This however requires careful navigation around the multifaceted challenges, especially concerning working with various knowledge systems, adapting new interdisciplinary methods and establishing equity and mutual trust.

Here I argue, that both CBM and science-driven monitoring have inherent advantages and challenges. Neither of the methods are universally applicable and should thus only be used when appropriate for the specific monitoring purpose. However, by combining the two methods instead of trying to verify them against each other, synergies can emerge and both methods will be strengthened. In this way it will be possible to address the challenges faced by scientists conducting monitoring in the Arctic while also solving common community concerns by the local citizens. A combination of CBM and conventional monitoring can result in improved overall monitoring, hence a better foundation to secure sustainable management. Which additionally will improve the possibilities of ensuring a continued supply of natural resources for the local communities. Thus an advantageous situation for all stakeholders.

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Appendix 1

	Programme	Brief description	Country	Link
1	**Fávllis**	Sámi fishery research network concerning local ecological knowledge of fjords. The overall goal is to document ecological change in the fjords of Finnmark using local knowledge	Norway	http://site.uit.no/favllis/
2	**Piniarneq**	Yearly hunting registrations from all over Greenland. Send in by Greenlandic hunters to the Ministry of fisheries and Hunting and the hunting council. The aim of the program is to provide data to inform management for sustainable use of hunted wildlife	Greenland	http://naalakkersuisut.gl/da/Naalakkersuisut/Departementer/Fiskeri-Fangst/Fangst-og-jagtafdelingen/Jagtbevissystemet
3	**Federation of Icelandic River Owners information on all aspects of Icelandic sport fishing**	By monitoring catch statistics (angling of salmon/trout), the aim is to encourage sustainable harvest of salmon/trout, and ensure long-term income for the river owners from selling fishing permits to anglers.	Iceland	http://angling.is/en/
4	**Tromsø bird phenology**	Database containing the arrival dates of spring migrants in North Norway (UiT in collaboration with the Tromsø Ornithological Society). The aim is to give the members of a newly established local ornithological society in Tromsø, and members of the general public something meaningful to do while simultaneously hopefully increasing their interest and knowledge of birds and at the same add to the scientific monitoring by providing the annual data to monitor spring migration phenology.	Norway	https://dataverse.no/dataset.xhtml?persistentId=doi:10.18710/4MCRQ

5	**Húsavík Whale observation programme**	The University of Iceland's Research Center in Húsavík uses sighting data from tourist vessels. The aim is to obtain a better understanding of the environment, this is done by collecting sighting data from volunteers using whale watching vessel as a platform of opportunity	Iceland	https://www.northsailing.is/2011/02/25/researches/
6	**Traditional ecological knowledge by summer farmers and Sámi reindeer herders**	The aim is to monitor traditional land use and knowledge in the mountain areas of northern Scandinavia, and the summer farmers and Sami reindeer herders that are the traditional land users in this area	Sweden and Norway	https://pub.epsilon.slu.se/14552/7/axelsson_linkowski_w_170906.pdf
7	**LEO (Local Environmental Observer Network)**	The aim is to document environmental change, provide targeted technical consults and surveillance for emerging health threats. This is done by enrolled members posting observations of events that are unusual and significant.	Alaska (USA)	https://www.leonetwork.org/en/docs/about/about
8	**The great seal count programme**	The aim is to count the number of seals that are hauling out along the coast line of the two peninsulas Vatnsnes and Heggstaðanes, to find out the number of seals in the area, as well as where they chose to haul-out. The count is based entirely on volunteer efforts who help gather data to be used in research while also enjoying seal watching and nature	Iceland	http://selasetur.is/en/research/557-2/the-great-seal-count/
9	**Reindeer husbandry plan programme (Renbruksplan)**	The aim is to collect and compile Sami reindeer herder´s traditional knowledge to use in land-use consultations. To develop management plans for reindeer pasture areas based on data about reindeer movement and area preferences. Data is collected using satellite imagery, field work in the summer, GPS tracking, and GIS	Sweden	https://www.sametinget.se/renbruksplaner

10	**Skolt Sámi river restauration of Näätämö river**	The aim is to monitor the health and status of Näätämö river and catchment areas, especially Atlantic Salmon stocks, whitefish and sea trout. Using these monitoring steps the aims include restauration of those river channels changed by Metsähallitus in the 1960s and 1970S back into their natural states. This is done by restoring spawning areas and fry habitats of e.g. salmon, trout and grayling.	Finland	http://www.snowchange.org/efforts-in-the-skolt-sami-areas-of-naatamo-watershed-finland/collaborative-management-along-the-naatamo-watershed/
11	**BuSK (Katersaatit Building Shared Knowledge)**	This project develops planning tools that enhance the use of participatory techniques, and gives assistance for decision makers concerning land use planning and natural resource governance. The aim is to ensure sustainable use of resources and ensure local and indigenous control (The Greenlandic program is still under construction)	Greenland	https://www.researchgate.net/project/BuSK-Building-Shared-Knowledge-capital-to-support-natural-resource-governance-in-the-Northern-periphery-2
12	**Alaska Arctic Observatory and Knowledge Hub (AAOKH)**	The aim is to share information from community-based observations on cryosphere change conducted by northern Alaska communities. A Knowledge Hub that provides tools and observational data of relevance to communities in the context of a changing seasonal cycle and offers community members to share insights and observations.	Alaska (USA)	https://arctic-aok.org
13	**Moose observations by hunters (Älgobs)**	The aim is to conduct population monitoring on moose, this is done by hunters observations of moose every year during the first month of the hunting period in relation to effort in hours of observation.	Sweden	http://www.viltdata.se

14	**Sea Ice for Walrus Outlook (SIWO)**	The SIWO provides weekly reports from April through June with information on sea ice conditions relevant to walrus in the Northern Bering Sea and southern Chukchi Sea regions of Alaska. The aim is to create a resource for Alaska Native subsistence hunters, coastal communities, and others interested in sea ice and walrus. This is done in order to support human safety, food security, and preserve cultural heritage.	Alaska (USA)	https://www.arcus.org/siwo
15	**wildlife triangle scheme**	The aim is to monitor populations of grouse and medium-sized mammals in Finland. About 6000 volunteers, mainly hunters, participate annually in the nation-wide network of about 1000 studied wildlife triangles twice a year.	Finland	https://www.riistakolmiot.fi/sv/
16	**Snow depth measurements for the Finnish Meteorological Institute**	The aim is to monitor the changing year-to-year snow-coverage. The Finnish meteorological institute has determined the depth of snow cover in Finland since 1919. The measurements are based on volunteers measuring manually the snow-pack depth at the same place and the same time.	Finland	No webpage
17	**Centre for Support of Indigenous Peoples of the North (CSIPN)**	The aim is to document the impacts of climate change on Indigenous peoples of Yakutia and Kamchatka, Russia. In order to develop a method for compiling information at community level through questionnaires and observations	Russia	http://www.csipn.ru (in Russian)
18	**Birdlife Iceland (Fuglavernd)**	The aim is to work for the protection and conservation of Iceland's birds and their habitats and to promote enjoyment, understanding and studies of birds and their habitats. Monitoring is done by weekly counts of individuals and species seen in the same garden during one hour in local gardens in towns and rural areas.	Iceland	https://fuglavernd.is/english/

19	**Winterberry programme Citizen Science for Understanding Berries in a Changing North**	The aim is aim is to better understand how berry resources are changing. This is done by engaging Alaskans in research on berry resources and find ways to make the findings more valuable to communities.	Alaska (USA)	https://sites.google.com/alaska.edu/winterberry/
20	**Arctic and Earth SIGNs community based monitoring**	The aim is to facilitate youth and child participation in co-development of monitoring projects with educators and community leaders on a local issue while also contributing to larger ongoing monitoring projects at state or regional scales.	Alaska (USA)	https://sites.google.com/alaska.edu/arcticandearthsigns/
21	**Evenk and Izhma peoples Programme**	The aim is to promote sustainable use of living resources and protect indigenous peoples' rights over land and resources in Komi Izhma and in Yakutia, Zhigansk.	Russia	No webpage
22	**Nordland eider duck Programme (Ærfugl)**	The aim is to protect the Eiders from disturbance during the breeding season and to promote the practice of the traditional eider down uses and handicrafts.	Norway	http://www.eiderducks.no/?side=hjem
23	**PISUNA (Piniakkanik sumiiffinni nalunaarsuineq)**	The aim is to detect changes in natural resources and their use as early as possible in order to guide decision-making on resource management. This is done by community focus group discussions supplemented by patrol records by community members in 9 communities on the W coast of Greenland	Greenland	http://www.pisuna.org/

24	**Arctic Borderlands Ecological Knowledge Society (ABEKS)**	The aim is to monitor and assess changes in the range of the Porcupine Caribou Herd and adjacent MacKenzie Delta area in North West Territories of Yukon, Canada, and in Alaska in order to improve understanding of these changes and share local, traditional and scientific knowledge for co-management. This is done by engaging local experts who hunt, fish, gather berries, and observe wildlife to relay observations about their local ecosystem. management planning, and conservation	Canada and Alaska	https://www.arcticborderlands.org
25	**Yukon River Inter-Tribal Watershed Council (YRITWC)**	The aim is to empower Indigenous communities within the Yukon River Watershed. This is done by collecting high quality environmental data using the best available technology and guided by Indigenous Knowledge.	Canada and Alaska	https://www.yritwc.org
26	**Walrus Traditional knowledge monitoring Program in Chukotka /Guardians of the Walrus Haul outs (Haul out Keepers)**	The central goal of this project is to monitor the main walrus haul outs in Chukotka coast based on a partnership of biologists (ChukotTINRO) and Native peoples (ATMMHC).The aim is to gather and document information about the knowledge hunters have about walruses	Russia	http://eskimowalruscommission.org/wp-content/uploads/2016/01/Walrus-TEK-2009-final-report-Zdor_ENG_final.pdf
27	**IMALIRIJIIT: A community-based environmental monitoring program in the George River watershed, Nunavik**	IMALIRIJIIT means "Those who study water", in Inuktitut. The aims are; to establish a sustainable community-based environmental program of the George River watershed. To collect baseline data of water quality and contaminants in local country food in the George River area (Nunavik, Canada), before the opening of a rare earth mine. To develop local capacities in environmental science and interactive mapping. To foster multigenerational and multicultural exchanges through a land-based, hands-on and multidisciplinary approach.	Canada	https://www.researchgate.net/publication/326996694_IMALIRIJIIT_a_community-based_environmental_monitoring_program_in_the_George_River_watershed_Nunavik_Canada

28	**Faroese hare citizen science programme**	The aim is to obtain statistics about the hare population. Hunters can report their catch on a facebook page, from here the information feed into a database, helping researchers to monitor the wild hare populations.	The Faroe Islands	http://sciencenordic.com/citizen-science-faroe-islands-helps-both-hunters-and-animals
29	**Monitoring of Pilot whales on the Faroe Islands since 1584** 	The aim is to monitor the population of Pilot whales to ensure sustainable use of resources. This has been done by catch statistics since 1584	The Faroe Islands	http://heimabeiti.fo/default.asp?menu=97
30	**Marian Watershed Stewardship Programme**	The objective of the Marian Watershed Monitoring Program is to begin collecting baseline information about the water and fish on Tłįchǫ lands and in locations the Tłįchǫ feel are the most important, prior to any major development pressure (such as the NICO mine by Fortune), and to continue collecting this data over time. Community members are being trained to collect samples, analyze the samples, and report findings back to the rest of the community members. The program will monitor fish, water, sediment, sediment cores and dendrochronology. Both western and Aboriginal science will be drawn on to obtain a clear picture of baseline conditions in the Marian Watershed and potential changes over time.	Canada	https://www.tlicho.ca/news/marian-watershed-stewardship-program

Questionnaire D: COMMUNITY-BASED MONITORING PROGRAMS

SPØRGSMÅL SVAR

Sektion 1 ud af 4

Questionnaire D: COMMUNITY-BASED MONITORING PROGRAM

Questionnaire D has 4 sections:

Section 1: Central questions
Section 2: General information
Section 3: Community members
Section 4: The data

The questionnaire can be accessed, updated and resubmitted repeatedly until the given deadline. After each submission, a page will appear with the following text:

Your response has been recorded.
See previous responses
Edit your response

Click on "Edit your response", save the URL of the appeared editing page, and reuse that link every time you need to access, update, and resubmit the form.

9. CENTRAL QUESTIONS

Beskrivelse (valgfri)

9.1 What is the aim of the monitoring program? *

(2-3 lines. Examples: To protect rights over land and resources; To encourage sustainable use of resources; To protect threatened biota; To obtain a better understanding of the environment; Monitoring is just part of everyday life; Other)

Lang svartekst

9.2 Does the monitoring program link to natural resource governance (management of the resources), or to scientific research? Explain (3-4 lines) *

Lang svartekst

9.3 Has the monitoring contributed in any way to the local community? (Positively or negatively? How? Provide example. 2-3 lines) *

Lang svartekst

9.4 Do you supply or pass on your monitoring data to other organisations? *

- [ ] Yes
- [ ] No, not today
- [ ] No, but we would like to

9.5 Which stages of the monitoring process were the community members and external agents (scientists, government staff) involved in? *

- [ ] Community members: the DESIGN of the monitoring system
- [ ] Community members: the DATA COLLECTION in the monitoring system
- [ ] Community members: The DATA INTERPRETATION in the monitoring system
- [ ] Community members: The USE OF THE RESULTS from the monitoring system
- [ ] External agents: the DESIGN of the monitoring system

- [ ] External agents: the DATA COLLECTION in the monitoring system
- [ ] External agents: The DATA INTERPRETATION in the monitoring system
- [ ] External agents: The USE OF THE RESULTS from the monitoring system

Efter sektion 1 **Fortsæt til næste sektion**

Sektion 2 ud af 4

GENERAL INFORMATION

Beskrivelse (valgfri)

9.6 (7.1.) What is collected as part of the data?

For example: date, location, species, number of individuals, conditions of individuals, trends, oral history information, land-use characteristics, management suggestions, etc. Try be as precise as possible

Lang svartekst

9.7 Who do you consider to be the users of the data/results from the monitoring programme?

Write who you believe/ know make use of the data.

Lang svartekst

9.8 What landscape type is monitored by the monitoring programme?

Evaluate the degree of scientific and technical expertise that underpins the measurement program. High evaluation implies sustained curation, development and exploitation, recruitment of skilled personnel, etc.

- [ ] Taiga or boreal forest
- [ ] Tundra
- [ ] Freshwater
- [ ] Coastal
- [ ] Sea
- [ ] Other

9.9 Who decided on what and where data should be collected?

For example: Scientists, government staff, community members, or others

- [ ] Scientists

- [ ] Government staff
- [ ] Community members
- [ ] Other

9.10 (7.2.1) Briefly describe the methodology. Do you have a formal description of methodology? If yes, can you provide it as a link or a hard copy?

Lang svartekst

9.11 Do you use some kind of measure of effort?

For example, number of hunting trips, hooks and net used? (explain)

Lang svartekst

9.12 (1.11.) What equipment do you use during monitoring activities?

Lang svartekst

9.13 What is the frequency of data collection?

Write the intervals between succesive bouts of data collection

Kort svartekst

9.14 Is monitoring done during certain periods of time?

For example is the monitoring done at certain times of the year, certain times at day or at certain time intervals

Lang svartekst

Efter sektion 2 **Fortsæt til næste sektion**

Sektion 3 ud af 4

3. COMMUNITY MEMBERS

Beskrivelse (valgfri)

9.15 How many community members participate in the monitoring process?

Kindly estimate approximate proportion of women, men, children and elders

Lang svartekst

9.16 How were the community members chosen? Explain

Examples: Were they appointed by somebody based on their background, or they did they themselves propose their involvement, or other? Write 2-3 lines

Lang svartekst

9.17 What is the organizational level of the community members participating in the monitoring programme

Select the application area(s) that is(are) most relevant for your data collection

- ◯ NONE: Only informal, or no organization at all
- ◯ LIMITED: Leaders appointed but otherwise no organization
- ◯ SOME: Besides leaders several other roles also appointed
- ◯ HIGH: Well-established organization, and the role of the organization in the monitoring process is formally recog

9.18 What are the sources of motivation for community members to

participate in the monitoring system?

Lang svartekst

9.19 Do the community members get compensation/salary for being involved in the monitoring programme? Provide 2-3 lines

Lang svartekst

9.20 Do community members obtain feed-back on the findings from the monitoring?

Yes/no. If yes, explain how and by whom.

Lang svartekst

9.21 How can community members suggest changes to the monitoring programme?

Lang svartekst

Efter sektion 3 **Fortsæt til næste sektion**

Sektion 4 ud af 4

4. THE DATA

Beskrivelse (valgfri)

9.22 How is data ownership and data access clear to participants? Explain

Lang svartekst

9.23 (6.4) Are there data validation processes built into the monitoring programme? If yes, explain

For example by triangulation across community members, or across villages, or across methods.

Lang svartekst

9.24 (6.6.) Is the data quality being checked? If yes explain how

For example data spreadsheets can be checked for data encoding errors before being put on a website.

Lang svartekst

9.25 What language is the original data in?

If there is an interpretation process, describe this

Lang svartekst

9.26 (5.12) How long after data collection is the data available to users

Select one of the available choices.

- ◯ Data are accessible after an unknown period
- ◯ Data are accessible some years after acquisition
- ◯ Data are accessible within 6 months after acquisition
- ◯ Data are accessible within a month after acquisition
- ◯ Data are accessible within a week after acquisition
- ◯ Data are accessible within a day after acquisition
- ◯ Data are accessible within 3 hours after acquisition

○ Data are accessible in real time

○ Andet...

9.27 (7.2.3) Has any assessment of the programme been undertaken? If yes, explain (2-3 lines)

Lang svartekst

9.28 Did your monitoring programme change since the start of the monitoring? If yes, how?

Lang svartekst

9.29 Anything else you like to add about the monitoring programme?

For example: challenges and opportunities, or feedback on this form.

Lang svartekst

9.30 Your name (the encoder of the meta-data)

Kort svartekst

Appendix 3 Greenland halibut database

	Community	Name of coordinator	Year	Quarter of the year	Month	Species/ resource use	Name of area	Total number of field trips	Quantity caught (fish: in tonnes)	Method of hunting / fishing	Trends over time (0 no change, 2 increase, 1 decline, - dont know)	Additional comments	Comments on importance and possible explanation	Suggested management action
2	Akunnaaq	Gerth Nielsen	2010	1	2	Greenland Halibut	Akunnaaq				2	Increase in catch per unit effort. When there were less trawlers, there were more Greenland Halibut. When there are large numbers of seals, or Narwhale and Beluga arrive to the area, the Greenland Halibuts seem to disappear.		
3	Akunnaaq	Gerth Nielsen	2010	1	3	Greenland Halibut	Akunnaaq				2			
4	Akunnaaq	Gerth Nielsen	2010	2	5	Greenland Halibut	Akunnaaq				2			
5	Akunnaaq	Gerth Nielsen	2010	2	4	Greenland Halibut	Akunnaaq				2			
6	Akunnaaq	Gerth Nielsen	2011	3	7	Greenland Halibut	Sea area LB23/LB24	4		Dinghy	2	There was an increase in the catch per unit effort. The population seemed to have recovered from previous low numbers.		
7	Akunnaaq	Gerth Nielsen	2011	3	8	Greenland Halibut	Sea area LB23/LB24	6			2			
8	Akunnaaq	Gerth Nielsen	2011	3	9	Greenland Halibut	Sea area LB23/LB24	10			2			
9	Akunnaaq	Gerth Nielsen	2014	1	3	Greenland Halibut	Akunnaaq	20+			2	Increase in number and size.		It is recommended that the acquisition of Greenland Halibut license is made easier.
10	Akunnaaq	Gerth Nielsen	2014	1	2	Greenland Halibut	Akunnaaq	20+			2	Increase in number and size.		It is recommended that the acquisition of Greenland Halibut license is made easier.
11	Akunnaaq	Gerth Nielsen	2014	1	1	Greenland Halibut	Akunnaaq	20+			2	Increase in number and size.		It is recommended that the acquisition of Greenland Halibut license is made easier.
12	Akunnaaq	Gerth Nielsen	2014	2	6	Greenland Halibut	Akunnaaq	20+			2	Greenland Halibuts are increasing in size and numbers	Young Greenland Halibut used to get incidentally killed by shrimp trawlers. Now shrimp trawlers have installed grates to avoid killing the fish.	It is recommended that the acquisition of Greenland Halibut license is made easier. Rules about losing the license when you have not used it should be cancelled.
13	Akunnaaq	Gerth Nielsen	2014	2	5	Greenland Halibut	Akunnaaq	20+			2	Greenland Halibuts are increasing in size and numbers.	Young Greenland Halibut used to get incidentally killed by shrimp trawlers. Now shrimp trawlers have installed grates to avoid killing the fish.	It is recommended that the acquisition of Greenland Halibut license is made easier. Rules about losing the license when you have not used it should be cancelled.
14	Akunnaaq	Gerth Nielsen	2014	2	4	Greenland Halibut	Akunnaaq	20+			2	Greenland Halibuts are increasing in size and numbers.	Young Greenland Halibut used to get incidentally killed by shrimp trawlers. Now shrimp trawlers have installed grates to avoid killing the fish.	It is recommended that the acquisition of Greenland Halibut license is made easier. Rules about losing the license when you have not used it should be cancelled.
15	Akunnaaq	Gerth Nielsen	2015	1	1	Greenland Halibut	Akunnaaq			Pound net	2	The size and numbers of Greenland Halibuts have been increasing in recent years.	When sea-ice departs, seals return, and Greenland Halibut disappears (to avoid the seals).	
16	Akunnaaq	Gerth Nielsen	2015	1	3	Greenland Halibut	Akunnaaq			Longline	2	The size and numbers of Greenland Halibuts have been increasing in recent years.	When sea-ice departs, seals return, and Greenland Halibut disappears (to avoid the seals).	
17	Akunnaaq	Gerth Nielsen	2015	1	2	Greenland Halibut	Akunnaaq			Longline	2	The size and numbers of Greenland Halibuts have been increasing in recent years.	When sea-ice departs, seals return, and Greenland Halibut disappears (to avoid the seals).	
18	Akunnaaq	Gerth Nielsen	2015	3	7	Greenland Halibut	Akunnaaq	70	2	Longline	2	Increasing size and increasing numbers observed.	The population increasing, probably because there is plenty of food. The fish are getting bigger and bigger.	To further increase the population, we recommend to limit the trawling during spring, summer and fall, and to establish closed areas in Isuamiut - Saattuarsuit - Agissat - Tussaaq.
19	Akunnaaq	Gerth Nielsen	2015	3	9	Greenland Halibut	Akunnaaq	80	0		2	Increasing size and increasing numbers observed.	The population increasing, probably because there is plenty of food. The fish are getting bigger and bigger.	To further increase the population, we recommend to limit the trawling during spring, summer and fall, and to establish closed areas in Isuamiut - Saattuarsuit - Agissat - Tussaaq.
20	Akunnaaq	Gerth Nielsen	2015	3	8	Greenland Halibut	Akunnaaq	80	0		2	Increasing size and increasing numbers observed.	The population increasing, probably because there is plenty of food. The fish are getting bigger and bigger.	To further increase the population, we recommend to limit the trawling during spring, summer and fall, and to establish closed areas in Isuamiut - Saattuarsuit - Agissat - Tussaaq.
21	Akunnaaq	Aqqalu Olsen	2016	1	3	Greenland Halibut	Akunnaaq	80	28	Pound net	2	Increasing size and increasing numbers observed.	More and more suitable fishing locations have been discovered, therefore we catch more.	
22	Akunnaaq	Aqqalu Olsen	2016	1	2	Greenland Halibut	Akunnaaq	50	27	Pound net	2	Increasing size and increasing numbers observed.	More and more suitable fishing locations have been discovered, therefore we catch more.	
23	Akunnaaq	Aqqalu Olsen	2016	1	1	Greenland Halibut	Akunnaaq	80	25	Pound net	2	Increasing size and increasing numbers observed.	More and more suitable fishing locations have been discovered, therefore we catch more.	
24	Attu	Karl S Marcussen	2016	2	6	Greenland Halibut	Attu	150	2,4	Longline	2	Increasing size and increasing numbers observed	After the small shrimp fishing vessels stopped trawling the Greenland Halibut has come back.	The present management is fine. No changes are suggested.
25	Attu	Karl S Marcussen	2016	2	5	Greenland Halibut	Attu	150	0		-			
26	Attu	Karl S Marcussen	2016	2	4	Greenland Halibut	Attu	100	0		-			
27	Ilulissat	Matthias Knudsen	2010	2	5	Greenland Halibut	Sea area M12		56	ongline 1300 hook	2	Aside from long-line, for 15 days nets were also used.		
28	Ilulissat	Matthias Knudsen	2010	2	6	Greenland Halibut	Sea area M12		50	ongline 3600 hook	2			
29	Ilulissat	Matthias Knudsen	2010	3	7	Greenland Halibut	Sea area M12		16	ongline 1 300 hook	2	During June and July, many individuals of Greenland Halibut were fatty, they had firm meat and small heads; many individuals were with eggs.	They were believed to have come from the North.	
30	Ilulissat	Matthias Knudsen	2010	3	9	Greenland Halibut	Sea area M12		12	ongline 3000 hook	2		During c. 1970 to c.1980, coastal trawling for shrimps was undertaken with small vessels without grates. They had a large by-catch of small, almost transparent Greenland Halibut. After grates were introduced in c. 1990, the abundance of coastal Greenland Halibuts was reported to have generally increased.	
31	Ilulissat	Matthias Knudsen	2010	3	8	Greenland Halibut	Sea area M12		12	ongline 1 300 hook	2			

32	Kangersuatsiaq	Edvard I. Kristiansen	2016	3	9	Greenland Halibut	Kangersuatsiaq	22	15	Longline	0	Unchanged sizes and numbers observed.		Besides the quota management system, there is also 'strict' management of purchasing (indhandling) sites. Therefore, only low volumes are sold (indhandlingstal).
33	Kangersuatsiaq	Edvard I. Kristiansen	2016	3	8	Greenland Halibut	Kangersuatsiaq	40	40	Longline	0	Unchanged sizes and numbers observed.		Besides the quota management system, there is also 'strict' management of purchasing (indhandling) sites. Therefore, only low volumes are sold (indhandlingstal).
34	Kangersuatsiaq	Edvard I. Kristiansen	2016	3	7	Greenland Halibut	Kangersuatsiaq	25	30	Longline	0	Unchanged sizes and numbers observed.		Besides the quota management system, there is also 'strict' management of purchasing (indhandling) sites. Therefore, only low volumes are sold (indhandlingstal).
35	Kitsissuarsuit	Tom Mølgård	2013	3	7	Greenland Halibut	Kitsissuarsuit				2	Greenland Halibut is found between Kitsissuarsuit and Maniitsoq in the summer.	We have quota for fishing Greenland Halibut in that area.	
36	Kitsissuarsuit	Tom Mølgård	2015	3	8	Greenland Halibut	Kitsissuarsuit	1	0,1	Longline	2	never before been fishery for Greenland Halibut at K	This year we for the first time had the opportunity to get a license to fish for Greenland Halibut and the fishing has begun.	It should be possible to get GHL 47 license.
37	Kitsissuarsuit	Tom Mølgård	2015	3	7	Greenland Halibut	Kitsissuarsuit	4	0,5	Longline	2	There have never before been fishery for Greenland Halibut at Kitsissuarsuit.	This year we for the first time had the opportunity to get a license to fish for Greenland Halibut and the fishing has begun.	It should be possible to get GHL 47 license.
38	Kitsissuarsuit	Tom Mølgård	2015	3	9	Greenland Halibut	Kitsissuarsuit	0			-			
39	Kitsissuarsuit	Tom Mølgård	2016	3	7	Greenland Halibut	Kitsissuarsuit	20	1,7	Longline	2	Increasing numbers observed. They are beautiful, large and thick fish.	Good food basis is probably why the population is increasing.	
40	Kitsissuarsuit	Tom Mølgård	2016	3	9	Greenland Halibut	Kitsissuarsuit	10			2	Increasing numbers observed. They are beautiful, large and thick fish.	Good food basis is probably why the population is increasing.	
41	Kitsissuarsuit	Tom Mølgård	2016	3	8	Greenland Halibut	Kitsissuarsuit	20			2	Increasing numbers observed. They are beautiful, large and thick fish.	Good food basis is probably why the population is increasing.	
42	Qaanaaq	Jens Danielsen	2016	1	3	Greenland Halibut	Qaanaaq	15	2	Longline	2	This year we have been able to fish Greenland Halibut in areas where we have not fished on this species in the past. Sizes and catch are unchanged.	There has been change in sea-currents and icebergs, and we have found new fishing grounds for this species. Fish size is unchanged.	Unchanged management recommended.
43	Qaanaaq	Jens Danielsen	2016	1	2	Greenland Halibut	Qaanaaq	15	1	Longline	1	This year we have been able to fish Greenland Halibut in areas where we have not fished on this species in the past. Sizes and catch are unchanged.	There has been change in sea-currents and icebergs, and we have found new fishing grounds for this species. Fish size is unchanged.	Unchanged management recommended.
44	Qaanaaq	Jens Danielsen	2016	1	1	Greenland Halibut	Qaanaaq	8	0,5	Longline	1	This year we have been able to fish Greenland Halibut in areas where we have not fished on this species in the past. Sizes and catch are unchanged.	There has been change in sea-currents and icebergs, and we have found new fishing grounds for this species. Fish size is unchanged.	Unchanged management recommended.
45	Qaarsut	Karl Tobiassen	2010	2	6	Greenland Halibut	Fishing area off Qaarsut		48	ongline 2000 hook	2	Many individuals were fatty, they had firm meat and small heads. Many individuals were with eggs.	In other years, the community members moved elsewhere to fish Greenland Halibut as this species disappeared from the area during summer (often at the time of arrival of Harp Seal in June-July) but in 2010 the Greenland Halibuts stayed in the area even into September. The fatty Greenland Halibuts are believed to have come from the north. We are concerned that many nets are being set over our long-lines and that some nets are left at sea when the sea freezes over. This results in many rotting fish, which attract Greenland sharks.	It is recommended to establish local authority bylaw to restrict net fishing in Uummannaq Fjord.
46	Qaarsut	Karl Tobiassen	2010	2	5	Greenland Halibut	Fishing area off Qaarsut		21	ongline 1800 hook	0	In 2009, there was sea-ice until May so the community members fished from sledges at more shallow water with typically only 200 hooks on each line.		
47	Qaarsut	Karl Tobiassen	2010	3	7	Greenland Halibut	Fishing area off Qaarsut		21	ongline 3700 hook	2	Many individuals were fatty, they had firm meat and small heads. Many individuals were with eggs.	In other years, the community members moved elsewhere to fish Greenland Halibut as this species disappeared from the area during summer (often at the time of arrival of Harp Seal in June-July) but in 2010 the Greenland Halibuts stayed in the area even into September. The fatty Greenland Halibut are believed to have come from the north. We are concerned that many nets are being set over our long-lines and that some nets are left at sea when the sea freezes over. This results in many rotting fish, which attract Greenland sharks.	It is recommended to establish local authority bylaw to restrict net fishing in Uummannaq Fjord.
48	Qaarsut	Karl Tobiassen	2010	3	8	Greenland Halibut	Fishing area off Qaarsut		12	ongline 1200 hook	2	Usually the community members don't fish Halibut in August. At this time of the year, their focus is at hunting seals.		
49	Qaarsut	Karl Tobiassen	2010	3	9	Greenland Halibut	Fishing area off Qaarsut		3,6	Longline 600 hooks	2			

Appendix 4 Atlantic cod database

1	Community	Name of coordinator	Year	Quarter of the year	Month	Species/ resource use	Name of area	Total number of field trips	Quantity caught (fish: in tonnes)	Method of fishing	Trends over time (0 no change, 2 increase, 1 decline)	Comments	Importance and possible explanation	Suggested management action
2	Akunnaaq	Gerth Nielsen	2010	2	6	Atlantic Cod	Akunnaaq				2	Increase in catch per unit effort.		
3	Akunnaaq	Gerth Nielsen	2010	2	5	Atlantic Cod	Akunnaaq				2	Increase in catch per unit effort.		
4	Akunnaaq	Gerth Nielsen	2010	2	4	Atlantic Cod	Akunnaaq				2	Increase in catch per unit effort.		
5	Akunnaaq	Gerth Nielsen	2010	4	12	Atlantic Cod	Akunnaaq				2	There were areas where Atlantic Cod was very plentiful.		
6	Akunnaaq	Gerth Nielsen	2010	4	11	Atlantic Cod	Akunnaaq				2	There were areas where Atlantic Cod was very plentiful.		
7	Akunnaaq	Gerth Nielsen	2011	1	1	Atlantic Cod	Akunnaaq				2			
8	Akunnaaq	Gerth Nielsen	2011	3	8	Atlantic Cod	Sea area LB23/LB24	25			2			
9	Akunnaaq	Gerth Nielsen	2014	1	3	Atlantic Cod	Akunnaaq	20+		Pound net	2	This year Atlantic Cods are larger and found 'everywhere'.		The 15,000 tonnes quota is not enough. Higher quota is recommended.
10	Akunnaaq	Gerth Nielsen	2014	1	2	Atlantic Cod	Akunnaaq	20+		Pound net	2	This year Atlantic Cods are larger and found 'everywhere'.		The 15,000 tonnes quota is not enough. Higher quota is recommended.
11	Akunnaaq	Gerth Nielsen	2014	1	1	Atlantic Cod	Akunnaaq	20+		Pound net	2	This year Atlantic Cods are larger and found 'everywhere'.		The 15,000 tonnes quota is not enough. Higher quota is recommended.
12	Akunnaaq	Gerth Nielsen	2014	2	6	Atlantic Cod	Akunnaaq	20+		Pound net	2	This year Atlantic Cods are larger and found 'everywhere'		The 15,000 tonnes quota is not enough. Larger quota is recommended.
13	Akunnaaq	Gerth Nielsen	2014	2	5	Atlantic Cod	Akunnaaq	20+		Pound net	2	This year Atlantic Cods are larger and found 'everywhere'.		The 15,000 tonnes quota is not enough. Larger quota is recommended.
14	Akunnaaq	Gerth Nielsen	2014	2	4	Atlantic Cod	Akunnaaq	20+		Pound net	2	This year Atlantic Cods are larger and found 'everywhere'.		The 15,000 tonnes quota is not enough. Larger quota is recommended.
15	Akunnaaq	Gerth Nielsen	2014	4	12	Atlantic Cod	Akunnaaq	10		Pound net	2	Increasing size and increasing numbers observed.		Increased quota is recommended.
16	Akunnaaq	Gerth Nielsen	2014	4	10	Atlantic Cod	Akunnaaq	20		Pound net	2	Increasing size and increasing numbers observed.		Increased quota is recommended.
17	Akunnaaq	Gerth Nielsen	2014	4	11	Atlantic Cod	Akunnaaq	25		Jig	2	Increasing size and increasing numbers observed.		Increased quota is recommended.
18	Akunnaaq	Gerth Nielsen	2015	1	3	Atlantic Cod	Akunnaaq			Pound net	2	Now and in recent years Atlantic Cod has been caught all around the year. There used to be a time of the year without Atlantic Cod.		
19	Akunnaaq	Gerth Nielsen	2015	1	1	Atlantic Cod	Akunnaaq			Pound net	2	Now and in recent years Atlantic Cod has been caught all around the year. There used to be a time of the year without Atlantic Cod.		
20	Akunnaaq	Gerth Nielsen	2015	1	2	Atlantic Cod	Akunnaaq			Jig	2	Now and in recent years Atlantic Cod has been caught all around the year. There used to be a time of the year without Atlantic Cod.		
21	Akunnaaq	Gerth Nielsen	2015	3	7	Atlantic Cod	Akunnaaq	70	11	Jig, Pound net	2	Increasing size and increasing numbers observed.	Atlantic Cods have plenty of food. In the summer when the sea is calm you can see shoals of Atlantic Cod perched at the water surface.	Optimizing officially approved authorized buyers (indhandligssteder) is recommended, as well as higher quota.
22	Akunnaaq	Gerth Nielsen	2015	3	9	Atlantic Cod	Akunnaaq	80	18	Jig	2	Increasing size and increasing numbers observed.	Atlantic Cods have plenty of food. In the summer when the sea is calm you can see shoals of Atlantic Cod perched at the water surface.	Optimizing officially approved authorized buyers (indhandligssteder) is recommended, as well as higher quota.
23	Akunnaaq	Gerth Nielsen	2015	3	8	Atlantic Cod	Akunnaaq	80	15	Jig	2	Increasing size and increasing numbers observed.	Atlantic Cods have plenty of food. In the summer when the sea is calm you can see shoals of Atlantic Cod perched at the water surface.	Optimizing officially approved authorized buyers (indhandligssteder) is recommended, as well as higher quota.
24	Akunnaaq	Gerth Nielsen	2015	4	12	Atlantic Cod	Akunnaaq				2	Increasing size and increasing numbers observed.		Same quota as last year is recommended.
25	Akunnaaq	Gerth Nielsen	2015	4	11	Atlantic Cod	Akunnaaq				2	Increasing size and increasing numbers observed.		Same quota as last year is recommended.
26	Akunnaaq	Gerth Nielsen	2015	4	10	Atlantic Cod	Akunnaaq				2	Increasing size and increasing numbers observed.		Same quota as last year is recommended.
27	Akunnaaq	Aqqalu Olsen	2016	4	12	Atlantic Cod	Akunnaaq	14	15	Pound net	0	Increasing numbers and size.	Good food basis.	Improved purchasing (indhandling) sites is recommended.
28	Akunnaaq	Aqqalu Olsen	2016	4	11	Atlantic Cod	Akunnaaq	25	15	Pound net	0	Increasing numbers and size.	Good food basis.	Improved purchasing (indhandling) sites is recommended.
29	Akunnaaq	Aqqalu Olsen	2016	4	10	Atlantic Cod	Akunnaaq	25	15	Pound net	2	Increasing numbers and size.	Good food basis.	Improved purchasing (indhandling) sites is recommended.
30	Attu	Per Ole Frederiksen	2014	4	12	Atlantic Cod	Attu	20		Pound net	2	Increasing numbers observed.	Restrictions in fishing and the warmer sea are possible reasons why the Atlantic Cod wander further north.	The quota is recommended set to 20-25,000 tons.
31	Attu	Per Ole Frederiksen	2014	4	11	Atlantic Cod	Attu	20		Pound net	2	Increasing numbers observed.	Restrictions in fishing and the warmer sea are possible reasons why the Atlantic Cod wander further north.	The quota is recommended set to 20-25,000 tons.
32	Attu	Per Ole Frederiksen	2014	4	10	Atlantic Cod	Attu	20		Pound net	2	Increasing numbers observed.	Restrictions in fishing and the warmer sea are possible reasons why the Atlantic Cod wander further north.	The quota is recommended set to 20-25,000 tons.

33	Attu	Per Ole Frederiksen	2015	3	9	Atlantic Cod	Attu	90	9		2	Increasing size and increasing numbers observed.	Due to strict quotas, the Atlantic Cod is only fished in a small area. Because of the strict quotas, the fishermen are only allowed to catch about 5% of what could be possible.	Larger quotas are desirable.
34	Attu	Per Ole Frederiksen	2015	3	8	Atlantic Cod	Attu	120	9		2	Increasing size and increasing numbers observed.	Due to strict quotas, the Atlantic Cod is only fished in a small area. Because of the strict quotas, the fishermen are only allowed to catch about 5% of what could be possible.	Larger quotas are desirable.
35	Attu	Per Ole Frederiksen	2015	3	7	Atlantic Cod	Attu	120	9		2	Increasing size and increasing numbers observed.	Due to strict quotas, the Atlantic Cod is only fished in a small area. Because of the strict quotas, the fishermen are only allowed to catch about 5% of what could be possible.	Larger quotas are desirable.
36	Attu	Per Ole Frederiksen	2015	4	12	Atlantic Cod	Attu	80	10		2	Increasing size and increasing numbers observed.	There are lots of food for Atlantic Cod. The species partly disappears when seals turn up. Food items such as wing-snails, jellyfish, sandeel, scallops and the presence of warmer sea-water make the conditions fine for Atlantic Cod.	We recommend that the quota is increased to 30,000 tons. Quota allocation should follow the conditions in 'the real world'.
37	Attu	Per Ole Frederiksen	2015	4	11	Atlantic Cod	Attu	150	20		2	Increasing size and increasing numbers observed.	There are lots of food for Atlantic Cod. The species partly disappears when seals turn up. Food items such as wing-snails, jellyfish, sandeel, scallops and the presence of warmer sea-water make the conditions fine for Atlantic Cod.	We recommend that the quota is increased to 30,000 tons. Quota allocation should follow the conditions in 'the real world'.
38	Attu	Per Ole Frederiksen	2015	4	10	Atlantic Cod	Attu	150	40		2	Increasing size and increasing numbers observed.	There are lots of food for Atlantic Cod. The species partly disappears when seals turn up. Food items such as wing-snails, jellyfish, sandeel, scallops and the presence of warmer sea-water make the conditions fine for Atlantic Cod.	We recommend that the quota is increased to 30,000 tons. Quota allocation should follow the conditions in 'the real world'.
39	Attu	Per Ole Frederiksen	2016	1	3	Atlantic Cod	Attu	80	4	Pound net	2	The size of fish caught in nets is unchanged (because of the mesh size). The size and number of fish caught using jig is however increasing.	Last year there was more sea-ice than this year. We noticed that the sea was warmer. This year there were only thin sea-ice at Attu. It has become more humid.	It is suggested that the quota is increased to 40,000 tons. It is suggested that thorough Atlantic Cods studies this year also are done in North Greenland..
40	Attu	Per Ole Frederiksen	2016	1	2	Atlantic Cod	Attu	120	10	Pound net	2	The size of fish caught in nets is unchanged (because of the mesh size). The size and number of fish caught using jig is however increasing.	Last year there was more sea-ice than this year. We noticed that the sea was warmer. This year there were only thin sea-ice at Attu. It has become more humid.	It is suggested that the quota is increased to 40,000 tons. It is suggested that thorough Atlantic Cods studies this year also are done in North Greenland..
41	Attu	Per Ole Frederiksen	2016	1	1	Atlantic Cod	Attu	120	7	Pound net	2	The size of fish caught in nets is unchanged (because of the mesh size). The size and number of fish caught using jig is however increasing.	Last year there was more sea-ice than this year. We noticed that the sea was warmer. This year there were only thin sea-ice at Attu. It has become more humid.	It is suggested that the quota is increased to 40,000 tons. It is suggested that thorough Atlantic Cods studies this year also are done in North Greenland..
42	Attu	Karl S Marcussen	2016	2	6	Atlantic Cod	Attu	150	1,5	Jig, Pound net	2	Increasing size and increasing numbers observed.	The number of Atlantic Cod is very large compared to past years. Possibly because of plenty of food resources resulting from a change in sea currents.	If there is no Lumpfish to fish, it is recommended to open the Atlantic Cod trade.
43	Attu	Karl S Marcussen	2016	2	5	Atlantic Cod	Attu	150	2	Jig, Pound net	2	Increasing size and increasing numbers observed.	The number of Atlantic Cod is very large compared to past years. Possibly because of plenty of food resources resulting from a change in sea currents.	If there is no Lumpfish to fish, it is recommended to open the Atlantic Cod trade.
44	Attu	Karl S Marcussen	2016	2	4	Atlantic Cod	Attu	100	2	Jig	2	Increasing size and increasing numbers observed.	The number of Atlantic Cod is very large compared to past years. Possibly because of plenty of food resources resulting from a change in sea currents.	If there is no Lumpfish to fish, it is recommended to open the Atlantic Cod trade.
45	Attu	Karl S Marcussen	2016	3	9	Atlantic Cod	Attu	100	20	Jig, Pound net	2	The number of Atlantic Cod is increasing. They are also becoming larger and larger.	We think there is plenty of food for Atlantic Cod and that the quota is too small.	It is recommended to improve the officially approved authorized bying place (Indhandlingssted).
46	Attu	Karl S Marcussen	2016	3	8	Atlantic Cod	Attu	100	16	Jig, Pound net	2	The number of Atlantic Cod is increasing. They are also becoming larger and larger.	We think there is plenty of food for Atlantic Cod and that the quota is too small.	It is recommended to improve the officially approved authorized bying place (Indhandlingssted).
47	Attu	Karl S Marcussen	2016	3	7	Atlantic Cod	Attu	80	16	Jig	2	The number of Atlantic Cod is increasing. They are also becoming larger and larger.	We think there is plenty of food for Atlantic Cod and that the quota is too small.	It is recommended to improve the officially approved authorized bying place (Indhandlingssted).
48	Attu	Per Ole Frederiksen	2016	4	11	Atlantic Cod	Attu	120	80		2	Increasing numbers, increasing size.	The increasing population is believed to be a response to warmer sea water.	It is recommended to increase the quota to +40.000 tonnes.

49	Attu	Per Ole Frederiksen	2016	4	10	Atlantic Cod	Attu	120	80		2	Increasing numbers, increasing size.	The increasing population is believed to be a response to warmer sea water.	It is recommended to increase the quota to +40.000 tonnes.
50	Attu	Per Ole Frederiksen	2016	4	12	Atlantic Cod	Attu	120	80		2	Increasing numbers, increasing size.	The increasing population is believed to be a response to warmer sea water.	It is recommended to increase the quota to +40.000 tonnes.
51	Ilulissat	Matthias Knudsen	2010	2	6	Atlantic Cod	Sea area M12		0	Trawl	1	Humpback Whales arrived and fed repeatedly in the Atlantic Cod fishing area. Nets: 7 m, mesh size 62-67 mm. (Month May-Sep. had similar numbers)		It is recommended to control the substantial increase in Humpback Whale population.
52	Ilulissat	Matthias Knudsen	2010	2	5	Atlantic Cod	Sea area M12		0,5	Trawl	1	Nets: 7 m, mesh size 62-67 mm.		
53	Kangersuatsiaq	Edvard I. Kristiansen	2016	1	3	Atlantic Cod	Kangersuatsia	30	0	Longline	2	Increasing numbers are observed and most are of medium size. There are only few large individuals.	Long lines for Atlantic Cods are now placed for no longer than one hour as there are so many Atlantic Cods.	We recommend that the Atlantic Cod surveys carried out up here in the north, also near Kangersuatsiaq, to also clarify the options here.
54	Kangersuatsiaq	Edvard I. Kristiansen	2016	1	2	Atlantic Cod	Kangersuatsia	50	3	Longline	2	Increasing numbers are observed and most are of medium size. There are only few large individuals.	Long lines for Atlantic Cods are now placed for no longer than one hour as there are so many Atlantic Cods.	We recommend that the Atlantic Cod surveys carried out up here in the north, also near Kangersuatsiaq, to also clarify the options here.
55	Kangersuatsiaq	Edvard I. Kristiansen	2016	1	1	Atlantic Cod	Kangersuatsia	5	3	Longline	2	Increasing numbers are observed and most are of medium size. There are only few large individuals.	Long lines for Atlantic Cods are now placed for no longer than one hour as there are so many Atlantic Cods.	We recommend that the Atlantic Cod surveys carried out up here in the north, also near Kangersuatsiaq, to also clarify the options here.
56	Kangersuatsiaq	Edvard I. Kristiansen	2016	2	6	Atlantic Cod	Kangersuatsia	40	5	Longline	2	Atlantic Cod is now caught in our community all year round.	The presence of Atlantic Cod is new. The last four to five years, the population has very much increased. During summer, fishermen who fish at Aappilaatoq have observed Atlantic Cod even in shallow water.	A thorough Atlantic Cod study here in the North is recommended.
57	Kangersuatsiaq	Edvard I. Kristiansen	2016	2	5	Atlantic Cod	Kangersuatsia	25	5	Longline	2	Atlantic Cod is now caught in our community all year round.	The presence of Atlantic Cod is new. The last four to five years, the population has very much increased. During summer, fishermen who fish at Aappilaatoq have observed Atlantic Cod even in shallow water.	A thorough Atlantic Cod study here in the North is recommended.
58	Kangersuatsiaq	Edvard I. Kristiansen	2016	2	4	Atlantic Cod	Kangersuatsia	15	5	Longline	2	Atlantic Cod is now caught in our community all year round.	The presence of Atlantic Cod is new. The last four to five years, the population has very much increased. During summer, fishermen who fish at Aappilaatoq have observed Atlantic Cod even in shallow water.	A thorough Atlantic Cod study here in the North is recommended.
59	Kangersuatsiaq	Edvard I. Kristiansen	2016	4	12	Atlantic Cod	Kangersuatsia	20	1	Jig	0			
60	Kangersuatsiaq	Edvard I. Kristiansen	2016	4	11	Atlantic Cod	Kangersuatsia	60	5	Jig	0			
61	Kangersuatsiaq	Edvard I. Kristiansen	2016	4	10	Atlantic Cod	Kangersuatsia	60	5	Jig	0			
62	Kitsissuarsuit	Tom Mølgård	2013	3	9	Atlantic Cod	Kitsissuarsuit				2	Increased size and increased numbers were observed. You catch Atlantic Cod whereever you put a hook into the water.		
63	Kitsissuarsuit	Tom Mølgård	2013	3	8	Atlantic Cod	Kitsissuarsuit				2	Increased size and increased numbers were observed. You catch Atlantic Cod whereever you put a hook into the water.		
64	Kitsissuarsuit	Tom Mølgård	2013	3	7	Atlantic Cod	Kitsissuarsuit				2	Increased size and increased numbers were observed. You catch Atlantic Cod whereever you put a hook into the water.		
65	Kitsissuarsuit	Tom Mølgård	2014	4	12	Atlantic Cod	Kitsissuarsuit	20	0,05	Jig	2	Increasing numbers are observed.	Probably because of there is plenty of food.	Increase the quota.
66	Kitsissuarsuit	Tom Mølgård	2014	4	11	Atlantic Cod	Kitsissuarsuit	10	0,3	Jig	2	Increasing numbers are observed.	Probably because of there is plenty of food.	Increase the quota.
67	Kitsissuarsuit	Tom Mølgård	2014	4	10	Atlantic Cod	Kitsissuarsuit	15	1,05	Jig	2	Increasing numbers are observed.	Probably because of there is plenty of food.	Increase the quota.
68	Kitsissuarsuit	Tom Mølgård	2016	3	9	Atlantic Cod	Kitsissuarsuit	10			2	Increased size and increased numbers were observed.	Good food basis is probably why the population is increasing.	Larger quota is recommented.
69	Kitsissuarsuit	Tom Mølgård	2016	3	8	Atlantic Cod	Kitsissuarsuit	20	1		2	Increased size and increased numbers were observed.	Good food basis is probably why the population is increasing.	Larger quota is recommented.
70	Kitsissuarsuit	Tom Mølgård	2016	3	7	Atlantic Cod	Kitsissuarsuit	20	0,8		0			
71	Niaqornaarsuk	Lars Petersen	2014	4	12	Atlantic Cod	Niaqornaarsu	18	22,9		2	Increased size and increased numbers were observed.		
72	Niaqornaarsuk	Lars Petersen	2014	4	11	Atlantic Cod	Niaqornaarsu	20	47,4		2	Increased size and increased numbers were observed.		
73	Niaqornaarsuk	Lars Petersen	2014	4	10	Atlantic Cod	Niaqornaarsu	22	56,3		2	Increased size and increased numbers were observed.		
74	Qaanaaq	Jens Danielsen	2016	1	1	Atlantic Cod	Qaanaaq			Longline	2	This year we caught "new" fish on longlines, such as: Redfish, Grenadier, Wolf Fish, Atlantic Cod and Greenland Cod. We enjoy eating the new fish.		

Appendix 5 PISUNA field sheet

Koordinators navn: Name of coordinator:		År, kvartal: Year, quarter:	

Bygd: Community:							Tendens* Trend*				Kommentarer vedr. antal, størrelser af fangstdyr, først/sidst observeret, etc. Comments regarding number, size of hunted animals, first/last observed, etc.	Evt. betydning og mulig forklaring af tendens* Significance and possible explanation of trend*	Anbefaling til forvaltningen (evt. uddyb på separat ark) Management recommendation (elaborate on separate sheet)
Art/ påvirkning Species/ impact	Måned Month	Lokalitet Locality	Samlet antal ture Total number of trips	Antal set Number seen	Fangst i alt Caught in total	Metode Method	Uændret Unchanged	Flere More	Færre Less	Ved ikke Don't know			

Bidragsydere: Contributers: Koordinators underskrift: Signature of coordinator:	*Tendens er i forhold til samme periode sidste år *Trend compared to same time last year, same area ** Brug gerne flere ark, til flere arter/påvirkning ** More sheets can be used if there are reports on more