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Assessment of recent adaptation actions in fisheries

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Assessment of Recent Adaptation Actions in Fisheries

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Assessment of recent adaptation actions in the fisheries

Executive Summary

As a contribution to ECOTIP's ambition to identify any ongoing and/or future tipping points in Arctic marine ecosystems – as well as the wider understanding of biodiversity change in the Arctic – this deliverable 4.1. presents a status on recent changes and adaptations as they have been identified and observed from within the Greenlandic fisheries. The deliverable presents a wide selection of impactful changes over the last 10 years as seen from an economic, social and cultural perspective. The knowledge presented here has been co-created in collaboration with the fishing industry (skippers and factory managers from Polar Seafood and Royal Greenland) and representatives from the fishermen's organization (KNAPK) and fishery management (APNN) in Greenland. Furthermore, coastal fishers/hunters and fishing communities in North, South and West Greenland have contributed with their knowledge which has been included in the research design by means of qualitative in-depth interviews and ethnographic fieldwork with more informal conversations and observations (see section 2 for further details).

The aim of this report is to account for the 'changes that have mattered' since the first climate change assessments were produced for Greenlandic fisheries in 2012 and 2017 (Government of Greenland 2012; AACA 2017). The report presents the knowledge communicated by fishery stakeholders when asked workshops or interviews to share their knowledge on the following themes: What are the major environmental changes observed by the fishery? Which changes have mattered to the fishery - and how? And what has made adaptation possible or difficult? How would you assess the current state and future of your community?

In summary, biodiversity change has already impacted fisheries in different ways. Skippers from the offshore fleet has observed - and adapted to – an incremental re-location of the Shrimp stock in Northwest direction. Fishery surveys confirm that fisheries have occurred north of 66°N since the 1980s, but since the beginning of the 2000s, the fishery has declined south of 66°N. The last couple of years, 85% of the catches have been caught north of 66°N. As one skipper puts it: *“Although the shrimp biomass may be the same, the fishery has experienced a loss of fish territory from South-West”*.

Meanwhile, new opportunities for pelagic fisheries, particularly mackerel, emerged. This was met with investments in building-up pelagic fishing capacity, but the offshore fishery is currently facing year-to-year variability of mackerel stocks within the EEZ. A growing thematic when it comes to biodiversity change is by-catch. Not only are there incidents of by-catches emerging where they did not use to be; by-catch regulations are also becoming more restrictive. But all in all, the offshore fishery considers itself to be in *‘a good condition for now’* and there is a continuous interest to explore new fishing opportunities further north, as well as opportunities to exploit by-catches for commercial purposes (or, adapt the by-catch regulation if possible).

In a similar optimistic vein, the coastal fishery in North Greenland is generally assessed to be doing well. Mammals and birds are observed to become more abundant as an effect of regulations. Cod and crab is observed to be increasing and new factories have opened while others have expanded storage and

processing capacity during the last decade. Significantly, fishery stakeholders agree that in the context of new and increased fishing opportunities, it is essentially the fish factories that currently sets the limits.

The positive experience of increased opportunities in the North does not mean, however, that the coastal fishery has not had its share of critical changes over the last 10 years. In the Disco Bay, Nuuk fiord and South Greenland, there have been years when capelin did not arrive or stay as long as it used to. Capelin is fished for food and for bait while also being central in the coastal food web, but here are no clear conclusions regarding the impact of these incidents.

Narwhales have become more present out of Upernavik where they are observed to scare off Greenland halibut from some fishing sites. Meanwhile, hunters from Upernavik also experience that the narwhale quota is too small and too competitive to satisfy the demand among hunters for food. In Nuuk, glacier retreat and less snow make reindeer hunting routes slower and longer. Normally the hunt could be conducted in one day, but it now becomes more difficult to make it back and forth before it gets dark.

Increased run-off and algae material is another interesting thematic that has emerged in some interviews. It is described by some fishermen in Nuuk (but not others) to compromise the effectiveness of the gillnets and making the fishery operations more cumbersome.

In South Greenland, the cod fishery saw a decline for a period of 4-5 years, but it has now started to 'normalize' again, fishery stakeholders and the fish factory informs. This poses some interesting questions as to whether what changes are related to 'paradigm shifts' of some sort, or are simply just periodic and/or connected to inflow of different offshore cod stocks.

In terms of adaptation capacity, both the offshore and the coastal fishers and hunters have demonstrated a high degree of capability and willingness to change strategies when they have been faced with environmental changes, regulations and diminishing market opportunities, which could otherwise have reduced their fishing possibilities. They have experimented with fishing seasons, fishing grounds and other marketing options. Their boats and deck technology has also become much more efficient. But oftentimes, fishers have simply also just worked harder and longer. These adaptation strategies, however, may also come with economic and physical costs.

Offshore skippers and fishers all along the coast seem to share the general impression that resources are both diverse and abundant and many fishers indicate that there are larger potentials in and beyond their fishing area than what is currently exploited. The sheer size of the Greenlandic fiords and coast lines have been repeatedly emphasised. In contrast to previous adaptation assessments, new/southern species have not emerged as an interesting potential in the talks with fishers and seafood companies when prompted. In general, fishers focus on known species that have been fished/hunted commercially before (e.g. shrimps in the Nuuk fiord¹ and trout in Nanortalik region) or known species which could be fished more intensely in new areas (e.g., shrimps north of 73°N, offshore).

¹ Trawling in Nuuk fiord and other fiords is now prohibited by legislation and thus the fishing technique may have to be adapted, if previous fisheries are to be re-established.

On a community level we note that increased or returning fishing opportunity alone may not necessarily 'trickle out' and benefit communities at large. Fishing communities in the north who experience growth or come-back in fishing and hunting opportunities are well positioned to maintain a fishing society where especially young men can pursue an income and lifestyle connected to fishery and hunting. But these communities may still be in need for better services, housing, infrastructure, sports and cultural activities if they are to maintain a diverse demography that include for example women with higher education or more diverse interests. The attractiveness of cultural and sportive in larger towns (e.g. cinemas, swimming pool and cafes) have been highlighted in various interviews.

In South Greenland, children from non-hunter households nowadays seem (also) to obtain much of their education in cultural heritage and invitations to land-based activities from outside of their households and in connection with different programmes offered by school or municipal institutions. Hence, it appears that community resilience is not only to be found within household knowledge and sharing practices, but also within municipal budgeting, sport associations and initiatives of individual teachers.

Cooperation between multiple actors is also relevant when discussing how the place-based values - including the commercial and subsistence value of locally caught fish - could be expanded through more innovation and cooperation all over Greenland.

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1. Introduction: 15 years of climate change studies and adaptation scenarios

1.1 The resilience of Inuit communities

A significant body of analyses, assessments, and scenarios regarding climate change adaptation in Greenland has been building since the mid-2000s. Early anthropological studies in Northwest Greenland highlighted the inherently adaptive hunting and fishing practices and the resilience of the Inuit mind-set (Nuttall 2009; Crate and Nuttall 2009; Tejsner 2012). With the prospects of changing weather and environmental changes, Greenlanders' perception of 'Sila' (insufficiently translates as 'weather') as always being in a state of 'becoming' is a resilience factor working at an ontological level. Meanwhile, the same studies warned that climate change would present unprecedented changes and from the early onset of climate change. ICC (Inuit Circumpolar Council) has particularly expressed concern with the loss of sea ice, and how it would impact not only travel routes, animal migrations and hunting practices, but also the reliability and transmission of Inuit knowledge.

In the wider Arctic region, the same concerns echoed and a budding of adaptation and resilience studies regarding 'the human dimension of climate change' followed (for a review of early Canadian case studies, see Ford et al. 2012). Food security has been a consistent theme and the resilience of Arctic food systems are known to include such factors as sharing mechanisms, hunting flexibility – including decisions to travel longer distances or shift to hunting by boat – and store food access (Ford et al. 2012; Ford and Goldhar 2012). A recent case among Inuit fishers in Pangnirtung, Canada, identified three community-level adaptive strategies, which are diversification, technology use and fisheries governance that employs a co-management approach. Further, this work recognized four place-specific attributes that can shape community adaptations, which are Inuit worldviews, Inuit-owned institutions, a culture of sharing and collaborating, and indigenous and local knowledge systems (Galappaththi et al. 2019). This body of anthropological literature has also highlighted the flexibility inherent in Inuit ontology, its customary sharing practices as well as the presence of alternative livelihood options and the mixed economy, which are fundamental to secure food security, well-being and livelihood.

The importance of the mixed economy and access to financial resources and monetary income to pay for hunting equipment and fuel has been highlighted (Poppel 2002, Ford et al. 2012). In fishery and hunting dependent Arctic communities, the availability of alternative sources of income and willingness to alter livelihood are equally important when hunting opportunities fail or harvesting becomes too dangerous (Ford and Goldhar 2012). An early analysis of the previous paradigmatic shift from cod to shrimp in Greenland's commercial fisheries also concluded, that different human and social capital within individual communities (Sisimiut and Paamiut) would influence adaptation capacity and adaptation outcome (Rasmussen 2005).

Key stressors to the adaptive capacity of Inuit have been identified to include rising costs of commodities and fuel, increased privatization of fish quota, constrained access, and delayed responses to environmental changes (Hendriksen and Jørgensen 2015; Ford and Goldhar 2012; Tejsner 2012). Fisheries governance is expected to have significant influence on adaptation strategies as they set the

shape the condition for the fisheries, including the relationship between self-owning coastal fishers and seafood companies when it comes to quota access and landing obligations. In Greenland specifically, the relationship between the large-scale seafood companies and the small-scale fishers has been characterized as one of ‘pernicious harmony’, including both symbiosis and competition (Snyder and Jacobsen 2017). The fishery policy landscape in Greenland also includes competing constructions over ‘what is to be sustained’ in Greenlandic fisheries which pitches large-scale and small-scale fisheries against each other (Jacobsen 2018). An analysis of subject positioning, discourses and networks has also concluded, that while coastal fishers exercise a strong influence on the yearly coastal TAC policy cycle (Jacobsen and Raakjær 2012), the Self-Government administration and the large-scale seafood companies have greater agenda-setting power in larger reform works that seek to restructure access regimes (Jacobsen and Raakjær 2014). Furthermore, MSC has been emerging as a significant non-governmental policy actor impacting TAC policies and bycatch regulations in Greenland (Søbye 2019; Long and Jones 2020).

In general, it has been emphasized that climate change is only one of several change processes impacting Arctic societies; climate change could be perceived as an ‘amplifier’ of other changes (Nuttall and Crate 2009) and multiple change processes were observed to interact. For example, in relation to fishery governance as well as the wider context of increased accessibility to Arctic as a resource frontier within not just fisheries, but also extractive industries and shipping (Nuttall 2012).

While vulnerability and risk continue to frame much of the discourse and research activities, this initial focus has been supplemented with a recognition of new opportunities for Arctic communities (Ford et al 2012; Greenland Self-government 2012). In the process, resilience as a concept has also been revisited to include creative processes of subject-formation in order to recover, develop and challenge existing social systems and the way communities actualize an alternative way of life (Hayashi and Walls 2019).

1.2 Climate change adaptation scenarios for the Greenlandic fishing and hunting sector

Climate change adaptation in Greenlandic fisheries also represents a national and policy- and stakeholder-oriented research and consultation field. Greenland Self-Government, the Institute of Natural Resources and the Greenland Climate Research Centre has – in cooperation with fishery stakeholders – conducted a range of adaptation assessments for Greenlandic fisheries as a socio-economic sector. The hunting and fishery sector was selected as the object for the first climate change adaptation strategy from the Greenland Self-Government, published in 2012 (Government of Greenland 2012). In 2015, future climate change scenarios for fisheries in the Baffin Bay/Disco Bay were also explored together with stakeholders under the auspices of AMAP’s AACAC assessment (Jacobsen et al. 2018). The key change scenarios and recommendations by the two assessments are listed in appendix A.

Recently, the EU polar net project INTAROS assessed key tendencies in the decadal changes for 33 species of demersal fish found between 1993 and 2016 (Sejr et al. 2021 in preparation), preliminarily concluding that Greenlandic fisheries are witnessing an increased production. The study found “substantial increase in average biomass combined with increases in average individual weight, average trophic level and composition of dominant species”. Measured against the base line of previous studies, this finding is interpreted as “a partial recovery of an over-exploited system and that fish stocks are rebuilding from a low level”. The likely causes are proposed in terms of large-scale climatic drivers, possibly combined with decreased trawling effort and by-catch mitigation: “Climate change-related melting of

sea ice and the Greenland Ice Sheet likely sustained increased primary production by increasing light and nutrient availability. Increases in temperature and salinity indicate increased inflow of Atlantic water, which increase connectivity to lower latitude systems. Finally, decreased trawling effort combined with mitigation measures to decrease by-catch may have decreased fish mortality. This suggests that a combination climate change and long-term hydrographic variability may have facilitated the recovery of fish stocks” (Sejr et al 2021 in preparation).

In this updated assessment of recent adaptation in Greenlandic fisheries, we are building on 15 years of studies regarding the human dimension of climate change adaptation as previous cross-disciplinary scenarios of climate change adaptation in Greenlandic fishery and hunting (appendix A). While many of these scenarios provide observations, scenarios and recommendations, they are now 5-10 years old, and thus we take the opportunity to ask: What have the *actual* changes and adaptation actions looked like in the last 10 years?

2 Method

The analysis is based on qualitative data on changes and adaptation in Greenlandic fisheries, which has been co-constructed by a team of social and natural scientist in collaboration with a broad range of Greenlandic stakeholders representing fisheries and coastal community interests. Co-creation activities include:

1. A stakeholder workshop conducted in Nuuk, November 8th 2021
2. A series of individual semi-structured interviews with 5 coastal fishers in Nuuk, 15-18 November 2021
3. Ethnographic fieldwork in Nanortalik, including visits to Qaqortoq, May 2nd – 13th 2022
4. Ethnographic fieldwork in Upernavik, including visits to Inarsuit and telephone interview to Aappilattoq June 28th – July 7th 2022

To assess adaptations in the management system, we also draw on our own on-going observations in the period 2010-2022, including the compilation of relevant new and reports as well as informal updates and recurrent fieldstrips in connection with other research projects.

2.1 Stakeholder workshop

The workshop focused roughly on changes observed since 2010. Thus, the workshop served as an early follow-up to some of the first climate change assessments for fisheries in Greenland (Government of Greenland 2012; AMAP 2017) including a re-visit of earlier discussions of risk and opportunity in relation to perceptions of climate change related to Greenlandic fisheries.

The agenda and format of the workshop was designed to co-produce knowledge regarding changes and adaptation in Greenlandic fisheries. The format of the workshop was planned by ECOTIP researchers with input from the participating stakeholder organizations.

The workshop invitation was distributed to the Ministry of Fishing and Hunting, KNAPK, Royal Greenland, Qajaq Trawl, Niisa and Sikuaq Trawl and Greenland Business Association. A total of 15 people contributed to the workshop, including 9 stakeholders from Polar Seafood, Royal Greenland, KNAPK and one from

the Ministry of Fisheries and Hunting. 6 scientists participated from the Greenland Institute of Natural Resources, Aalborg University and the Arctic University of Norway.

The workshop was organized as a qualitative group discussion among the participating stakeholders around open-ended questions related to the following themes:

1. Observed changes in the marine environment and fish resources by industry, fishery managers and researchers
2. Observed/implemented adaptation in the offshore and coastal fishery
3. Identification of future risk, opportunities and/or knowledge gaps by stakeholders

During the workshop, fishery stakeholders and scientists cooperated around the knowledge sharing—often confirming the knowledge presented by each other. The workshop dialogue was audio-recorded, transcribed, and the content of the discussion was subsequently coded according to themes using NVivo software. A workshop report summarized the ‘observations of change and adaptation’ for the offshore and the coastal fishery respectively and serves as (previously unpublished) data for this article/deliverable.

2.2 Interviews with coastal fishers in Nuuk

Subsequently, a series of interviews with coast fishers in Nuuk ($n = 5$) was conducted, covering similar questions of recent changes and adaptation, but only with respect to the coastal fishery in the Nuuk area. Knowledge in these interviews were in practice often constructed as a follow-up to a previous study of the Nuuk cod fishery, conducted by the same interviewer-team in 2014 (Hedeholm, Jacobsen and Nielsen 2016). It included two of the same (still active) commercial fishermen together with three ‘new’ fishers. Interviews were conducted in Greenlandic or Danish. They were recorded, transcribed and anonymized with consent of participants and subsequently coded in Nvivo in the same manner as the fieldwork data described in the section below.

2.3 Ethnographic fieldwork in Nanortalik and Upernavik communities

In addition, ethnographic field work was planned and conducted in two Greenlandic communities. With updated knowledge from the Nuuk fishery in Mid-west Greenland, we wanted to widen the geographical span to North and South Greenland. Nanortalik, located at the very southernmost tip of Greenland, is administratively part of the South Greenlandic region, where the fishing industry diminished with the decline of the cod and the shrimp fishery. It is also a geographical area lying where the high formations of East Greenland meets the lower formations of West Greenland and where infrastructure, fishing and hunting is uncompromisingly defined by the coming and going of ‘*storisen*’ (the great ice) – the drifting sea coming down from the east coast of Greenland and curving its way around south Greenland. It is also a region, about which it was indicated at the workshop, that fishers may be able to talk about ‘new/rare’ species from the south. Visiting Qaqortoq allowed for a day of fieldwork, focusing on new species at the local fish market and the consumption of local foods.

Upernavik is part of the three Greenland halibut management districts together with the Disco Bay and Uummaanaq. Since the 1980s, the commercial Greenland halibut fishery (originally conducted from the sea ice) has been the primary commercial fishery in northwest Greenland, where the mixed economy is

particularly strong and includes various ice- and sea-based hunting activities (Delaney, Hendriksen and Jacobsen 2012). At the stakeholder workshop it was informed that the ice-scape hunting and fishing area has undergone changes due to the diminishment of sea ice and recently, a gill net cod fishery has also started to take off, indicating a diversification and a general increase of fishing opportunity.

In addition to fisher interviews, data for this deliverable also includes broader observations, conversations and interviews concerning the towns overall development and activities, including not least demographic changes, the labor market, private entrepreneurship, and changes in the food system. Knowledge has been constructed with input from a wide range of local experts, including offshore skippers, cutter owners and dinghy owners; managers and fisher representatives; the two larger seafood companies in Greenland as well as independent fishers from three different regions; fishers in various ages (30s, 50s, 60s); active fishers and a fisher, who left the fishery when the cod 'disappeared'; factory managers as well as local market managers and sales persons; school teachers and municipal authorities/workers within recreation and labor market; entrepreneurs and private business owners; tourism agencies and museum inspectors; citizens who engaged in public space to chat and tell about the town and/or climate change. While all participating fishers and skippers were men, women have been interviewed formally and informally in relation to their sealskin and food expertise. Furthermore, women were well represented among scientists, managers, municipal authorities, schoolteachers, tourism actors and community entrepreneurs.

Knowledge exchanges with Greenlandic speaking fishers were conducted by Danish-speaking researchers in cooperation with two Greenlandic- and Danish-speaking research assistants. The interviews were recorded and transcribed with permission from the interviewee. For ad hoc and more informal conversations during fieldwork, summaries of the conversations were noted the same day. Last but not least, unpublished interview material and personal observations by the lead author from a previous project (2017-2018) in South Greenland² have also been included to supplement the analysis.

2.4 Analytical strategy

Transcribed fisher interviews and field notes have been coded according to relevant themes using NVivo software. Coding helps us identify recurring and relevant topics across boundaries of multiple interviews, which significantly reduces disorientation in further work when handling a large amount of qualitative data at once. -For example, one theme identified all empirical examples of changed opportunities and practices related to fishing and hunting – when utilized in NVivo, the program keeps a list of respondents who gave input on the chosen theme, along with their statements, and it becomes easier to navigate and find the data needed. The purpose of this was to develop a grounded analysis of actual changes within the last 10 years, based on response by the fishers. The coding allowed for a comparison between early observations of change and 'change scenarios' in the early climate change assessments and literature in Greenland (2009-2014) vs. actual 'changes-that-mattered', as they have manifested themselves to fishers by 2022. A second coding identified '*adaptation and coping strategies*' to identify and facilitate a discussion of the adaptation capacity of different actors in the fishery.

² [Sustainable business and demography: Exploring critical links between gender youth and small-scale business development in fisheries and tourism in South Greenland — Aalborg Universitets forskningsportal \(aau.dk\)](#)

Project: ECOTIP

Deliverable (D4.1 – Assessment of Recent Adaptation Actions in Fisheries):

The different thematic of adaptation and the associated adaptation is presented and, when relevant, compared to previous adaptation assessments and scenarios presented in Appendix A. In the final discussion, we offer a discussion of adaptation capacity and resilience in the Greenlandic fisheries and fishery dependent communities in North and South Greenland respectively.

3 Adaptation in the offshore fisheries

3.1 Changes in abundance and re-location of existing fishery resources

The relationship and potential shifts between cod and shrimp was a key thematic the first climate change assessment. At the workshop, however, it was the shifting location shrimp biomass which emerged as the key thematic. Skippers and seafood companies alike agreed, that over the last 20 years the shrimp biomass has moved further North. A stakeholder from the offshore fishery summarized the change like this: *“Over the last 20 years, the [offshore shrimp fishery] has maybe moved a little further northwards, in general. In a period, they fished further west and then they only fished in the Eastern side, close to land. And then they moved north”*. This movement of the shrimp biomass was also confirmed by the GINR scientist: *“It is correct that in the late 1990s there was a larger share of the biomass south of 66°N. But in the middle of the 2000s it shifted, and since then 80% of the shrimp biomass has been north of 66°N. And there has been a tendency for it to move more eastwards”*.

A shrimp trawler skipper explained the tendency like this: *“Although the shrimp biomass may be the same, the fishery has experienced a loss of fish territory from South-West”*. *In the late 1990s there was a larger share of the biomass south of 66°N. But in the middle of the 2000s it shifted, and since then 80% of the shrimp biomass has been north of 66°N. And there has been a tendency for it to move more eastwards”*.

Noteworthy, the incremental re-location of the shrimp biomass over the last 20 years has not proved to be a challenge for the trawling fleet in terms of adaptation. The fleet has been able to shift the fishing grounds, following the biomass northwards. Furthermore, the decrease in ice cover and bad weather off the East coast of Greenland has even increased the physical access to shrimps on the east coast, providing the fishery with a *‘good fishery of large and fine shrimps’*. The main adaptation thematic from the workshop is therefore further exploration and exploitation of shrimps north of 73°N – this interest in the ‘hidden’ or ‘new’ opportunities in the more northern waters that was in fact also expressed back in 2014. Currently, the issue seems to be the distance and operation costs. It is not profitable enough for the fleet to explore this area systematically due to the distance: *“It is very difficult to make ends meet because the distance is so great and the fishery per day is not. But there is a great value in these big fine shrimps, and Greenland only misses out if there is no fishing in the area”*.

In order to make ends meet, the skipper suggest and additional TAC share for the fishery north of 73°N as a way to make the exploration more profitable: *“It is a shame that there is no extra quota for the areas north of 73 °N in in addition to our TAC. Then we could adapt our fishery and not, like now, only fish sporadically as it may fit within a fishing trip”*.

3.2 New bycatches

Bycatch has emerged as an important adaptation issue – perhaps even more than what was expected by the earlier climate change assessments. This may also, reflect the fact that by-catch regulation has increasingly managed to define the fishery governance agenda in connection with the MSC certification of Greenlandic fisheries. The offshore fishery has in 2020 and 2021 experienced a sudden inflow of *small red fish* (one year old redfish at approx. 6-9 cm) on some of the shrimp fishing grounds. The fishers expect

that this fish fry has been transported with sea currents (as opposed to red fish spawning and growing up in the area). The fishery is curious as to the causes for this phenomenon and GINR currently leans towards the hypothesis that it may be caused by changing environmental conditions and/or changes in abundance for the red fish cohorts. According to the trawl fleet, the small red fish appear in greater volume from 67°N to 68°N and from 56°W and westwards. The Canadian shrimp fishery on Flemish Cap and scientific surveys from 2020 confirms the observation. The small red fish are caught as by-catch and constitute an issue because by-catch regulation demands that the fishery changes location when it exceeds 5 percent of a given haul. The fishery informs that by-catch of small red fish cannot be exploited for commercial purposes.

Furthermore, the by-catch of *polar cod* has emerged as a by-catch issue. A trawler skipper informs that the polar cod is 'climatizing', by adapting to changing environment and temperatures. Polar cod have been observed further North. 30-35 year ago, many Polar cod were observed at the East-West edge at approx. 67°N at depths ranging from 300 – 500 m and near the Canadian EEZ. In those areas, polar cod are now less abundant but have been moved further north of 73°N. The offshore fishery observes the polar cod as a by-catch in the fishery.

Currently, polar cod by-catch is not exploited due to the formulation of the by-catch regulation. If this regulation could be changed, the polar cod could be used for bait in the coastal fishery and thus diminish the large and pricy import of bait from abroad. It was suggested to arrange a meeting with the participation of fishery managers, industry and scientists, where the goal is to discuss how to solve this problem and possibilities of changing the current by-catch regulations.

3.3 *New pelagic fisheries*

The mackerel fishery in East Greenland has been considered a new fishery and been a major theme in previous climate change assessments. Since 2012 when mackerel fishery took off it relatively fast became an important and profitable fishery, where Greenlandic companies made substantial investments in new pelagic vessels to pursue this new offshore possibility. However, for the last 2-3 years mackerel has not been present in the Greenlandic Exclusive Economic Zone (EEZ). Presently the mackerel fishery is limited to explorative and scientific fishing for monitoring purposes and no commercial fishery for mackerel is conducted.

4 Adaptations in coastal fisheries and hunting

4.1 Adaptation to diminishing ice

The decrease of sea ice in North Greenland has been a major driver of change within at least the past 10 years or more: *"We may have to go further back than 10 years, but the sea ice cover is definitely decreasing. I don't think anyone questions that³. In the Disco Bay, Uummaannaq and Upernavik we see*

³ Indeed, the decrease of sea ice and the societal impacts in North West Greenland is well-described on the basis of both scientific and LEK knowledge. The references are too many to start listing here.

shorter and shorter periods of sea ice cover. Sometimes there is no sea ice at all” (factory manager, Royal Greenland)

Although the decrease of sea ice can be considered to have happened very fast when we speak of climate change in general, it is noteworthy that fishers in North Greenland have seemingly had ‘sufficient’ time to adapt their modes of transportation and fishing equipment: *“It (the decrease in sea ice) is something that has not happened very quickly and thus the fishers have been good at adapting, but it is a fact that this change has occurred. There is not as much dog sledge and snow mobile driving anymore and there is more sailing”*.

Another positive effect of decreased sea ice in North Greenland is better logistics: *“We see that RAL⁴ has a schedule that says they don’t sail in winter. But as we are then approaching the winter period, they go: ‘all right, we can also sail the next two times’. So you can say that this gives some increased possibilities around logistics – that you can get supplies in, but of course also the products out. In that way, in my job, I don’t see anything where things have gone all wrong. To the contrary, I experience that it [the decrease in sea ice cover] has provided more opportunities than 25 years ago.”* (factory manager, Royal Greenland) Nonetheless, respondents in the Upernavik district commented on the changes in sea ice and their implications for the mode of fishing in winter, as well as related changes in distributions of marine mammals (e.g., narwhales) and mobilities in the villages and Upernavik. One fisher interviewed was less concerned because he was fine to adapt to winter fishing via boat as opposed to snow mobile or dogsled. However, others were less at ease with the change. Those respondents pointed to the time of year when the ice solidifies (from October or November to presently in January) and the ice’s instability as its thickness was not sufficient to withstand breaking in the waves. Thus, safety is one of the concerns, but also the ability to move more freely between the island villages and its implications of winter mobility and insulation.

A lot of discussions were had about the lack of ice in the autumn during narwhale migrations from the north toward the south and thus a tendency of these marine mammals to remain in the Upernavik area for a longer period. Fishers and those working in the fishing industry explained that the presence of narwhales in the area changes the Greenlandic halibut’s position within the water column and away from long-line fishing areas.

Although not referred to as such, the change from dog sledding to snow mobile is notable in connection to cultural heritage, especially in terms of intangible cultural heritage and tacit, local knowledge. Although sleds and dogs are still visible in the yards of Upernavik residences, many interview participants underscored how much this had changed. A man working at one of the Upernavik fish factories explained that with the smaller period of ice, its uncertain timing and conditions, there was now insufficient time to train dogs for the sled and thus a move toward the snow mobile. A man in one of the island villages lamented the loss of routes that he would take with his father to key fishing and hunting grounds that simply could no longer be used because of the lack of ice. The explanations for the shift away from dog sledge are likely to be manifold and dependent on geographical and socio-economic context. A recent detailed case study of LEK (Local Ecological Knowledge) in the Disco Bay area also found that local fishers are changing fishing strategies and adapting to a changing environment caused by climate

⁴ Royal Arctic Line, owned by the Greenland Self-Government, is *the* single shipping company operating the towns on the west coast of Greenland.

change. The poorer sea ice conditions in the southern branch of the fjord system, combined with the fact that it is increasingly challenging to reach fishing sites, have resulted in fishers from Qasigiannuit not going to the Icefjord as much as they used to (Schiøtt, Tejsner and Rysgaard 2021).

In Nuuk, glacier retreat on land and less snow cover down towards the coast has had a negative effect on reindeer hunting. A hunter explains that walking on the glacier was faster than walking in the terrain, while decreasing snow cover causes reindeer to migrate further inland. This makes hunting trips – which could normally be made in a day trip from Nuuk - more time consuming.

In South Greenland the lack of sea ice has impacts for the traditional ice-based hunt of hooded seal which is an important food item not only in South Greenland, but also in the North: *“Especially in the North, many are asking for the Hooded seal, because it is dried or frozen and then you can just eat it. But he says it is mostly in April and May because it is the ice that determines when there is most hooded seal and when they can catch most hooded seal. But it is never harp seal or ringed seal, they can be there year-round. But the hooded seal, the famous south seal, it comes with the ice. The season is only one month to one month and a half. Then hunters go out to the islands where you can be for one or two months. Here they make supplies for a whole year. But he has heard that there are also some who have regular customers up north. There are many who are interested in buying it up north.”* (Fisher from Nanortalik, translated)

4.2 Adaptation to increased abundance and/or market options

All previous climate change assessments operate with the possibility of increased abundance of fishery resources and a northward migration of key species in the current fisheries. This has certainly been the case in North Greenland (see also Hansen 2018), where it has now become possible to engage in a greater variety of fisheries. Whereas the community was previously landing Greenland halibut and crabs to ‘trading ships’, two fish factories are now established in Upernavik and fish factories and/or storage facilities have increased in the villages as well. The competition between two fish factories have had a positive impact on fish prices. At one of the factories in Upernavik, one of the overarching points made was that the halibut fishery in this area was relatively ‘new’ (about 30 years), especially in comparison to further south in Uummaanaq (a ‘70 year’ fishery) and Ilullissat (a ‘100 year’ fishery) with positive implications for the average size of the individual fish caught.

Fishers and factories in Northwest Greenland have primarily been targeting Greenland Halibut, but an expansion to crab fisheries and gill-net cod fishing is now taking place: *“In North Greenland there is a positive effect because it is possible to fish for different species: cod, Greenland halibut and now, crabs in Upernavik. In Uummaanaq area they have just started gill-netting for cod, previously that was impossible”* (factory manager, Royal Greenland).

In Upernavik, a shift from ‘Uvak’ to ‘cod’ over the last 20-25 years has been observed by long-term residents. In Upernavik, interviewed fishers inform that they are catching cod, wolffish and crabs, but that they are not sold to the factory either because prices are too low (cod) or that the factory does not buy it (wolffish). The fish is then used for own consumption (e.g. dried cod) and for local sale to neighbors.

In Manitsog, West Greenland, the Royal Greenland's factory has started to buy living fish from gillnet fishers in the region, which are then transported to the factory for a new filet product of higher quality called 'Nutaag'. A fisher from Nuuk now observes that this has meant an increased cod fishery in the Nuuk fiord and he now worries about the state of the local cod: *"They are coming down here and fish all these cod in the area, which are then transported, (to the factory). If they continue like that, the stock will quickly decline. He is not fond of that idea"* (Fisher from Nuuk, translated).

The coastal fishery has become more efficient with larger motors and an increased automatization of the deck equipment onboard the fishing vessels, which has significantly increased the efficiency of the fishers compared to 10-15 years ago. Technological innovations include automatized long lines and net haulers. Otherwise, the application of catch equipment used for different fisheries is stipulated by the conservation regulations which have not changed considerably.

4.3 Adaptation to absence of fishery resources and/or marketing

The interviewed fisheries and stakeholders have observed some increases in coastal fishing opportunities as species have moved northward. However, they have also been experiencing periods with absence and 're-location' of key species from the coastal areas and the individual fiord systems. Significant examples are capelin and cod.

The capelin is a key species in the food web and seasonal migration of various predator species in the fiord, including cod and whales. Fishers and landing facilities have observed that the capelin has not been present on the usual coastal fishing grounds in the past 2-3 years. This has been the case in both South Greenland, Nuuk and Qeqertassuaq:

"It is important to look at the food chain. There is very little capelin coming south in September/October. There are many whales that stay further out because they don't have anything to eat" (Fisher from Narsaq in 2018, translated).

"For some reason it has become more difficult to find the capelin here in the Nuuk fiord. It stays in the fiord for a shorter period, or on deeper water. That is what fishers have observed for the last two years. In earlier times the capelin could be fished for a longer period. This is no longer the case. Perhaps there is way too much water on the surface" (Fisher representative, workshop).

"It is the same in Qeqertassuaq. Two years ago, capelin was landed to the fish factory. But the last two years nothing has been landed in Qeqertassuaq because there wasn't any to be fished" (Seafood company, workshop).

"I was also in Qeqertassuaq in June and they said that there used to be a shoal of capelin arriving out at the beach. It hasn't arrived the last 2-3 years" (Fishery manager, workshop).

Coastal fishers have observed that the melt water from glaciers in West Greenlandic fjords have recently become more 'muddy' or 'slimy' during summer. This phenomenon impacts gill net cod fishers as it makes the cod go to deeper waters (where they cannot be 'reached' by the gill nets). It started in South Greenland around 5-6 years ago and within the last 2-3 years it has also been observed in the Baffin Bay as well. However, South Greenland may now be 'normalizing' again according to coastal fishers: the water is becoming 'clear' again and the cod is returning to the fishing grounds where it used to be. It is

unclear what the 'mud' or 'slime' is constituted of, but many of the fishery stakeholders suggested that it must be connected to an increased melt from the fiord glaciers, e.g., silicon run-off and/or nutrient increase⁵.

As a form of adaptation, some gill net cod fishers are experimenting with their fishing seasons. On the one hand it was reported that some fishers have shortened their cod fishing season. On the other hand, it was also suggested, that some fishers may have expanded their gill net season in an attempt to increase the income from the cod fishery (starting their fishery as early as March-April or ending as late as November. In Nanortalik, gill net fishing for cod had been put on halt for a period.

To coastal fishers, it is relevant to understand changes in the fiord systems better, including phenomenon like 'muddiness' which impact the fisheries: *"The fiord systems means a lot for the sea temperature. As was being said, polar water masses are coming from North. But the coastal fishers always talk about the melting of the inland ice. A lot has been happening there the last five years because of climate change. We need more knowledge about this when we are to adapt in one way or the other"*. Adaptations to 'absence' of the usual fish resources in the fjord system is not entirely clear from this study. Instead, normalization and return is a theme emerging from the interviews. After a period of low fisheries, fishers and the factory in Nanortalik is now seeing a return fish to the coastal areas, including cod as well as wolffish and salmon. However, in South Greenland there is a persistent call to make more out of the available resources. A previous interview with a fisher Narsaq, South Greenland, pointed to the same issue: *"In Iceland last year: they use 100% of what they fish. But here in Greenland we only use three species: Greenland halibut, redfish and cod. The fishery goes well at our neighbors – but everything else is discarded in Greenland. He has asked the municipality and the Self-Rule to make better use of the resources to the benefit of the fishers"* (Narsaq fisher, translated).

4.4 Adaptation to market and prices

Fishers adapt to the seasonality of the resources. But this adaptation is essentially facilitated or made complicated by marketing options and regulations. Adaptation to low market prices and limited marketing options is a key thematic in many of the interviews in Nuuk and South Greenland:

"When there is reindeer season, then you can either fish or go reindeer hunting. And then you can easily replace one activity with another. And if there are too many hunting for reindeer, then I cannot sell much of it, and then you can for example shift to the fisheries and land to the factories" (Fisher from Nuuk).

"The factory in Qaqortoq also owns this factory in Nanortalik. But in the lumpsucker season, only Qaqortoq buys lumpsucker. But they cannot buy it here in Nanortalik because the factory is different. That is why they catch seals here in Nanortalik now to sell sealskin even though it is lumpsucker season. So, what we are lacking is good management. When there is lumpsucker season there should also be (opportunities to sell it). Because the factories have the same owner" (Fisher from Nanortalik).

⁵ A recent study by Schjøtt al. (2021) mentions the observations by fishers of a 'slimy' substance in Ilulissat Ice Fiord in connection with lake draining event (lake *Tiningnilik*). Schjøtt herself hypothesizes that *"This upwelling of nutrients from the sediments may potentially stimulate an algal bloom of colonial Phaeocystis that creates a gelatinous structure that is odorous"*.

"[...] and the price for cod was so low at that time, like now, the prices just dropped. His cutter has a harpoon and so he was catching a lot of whales at that time. Otherwise, he would probably have given up the profession" (coastal fisher, Nuuk).

Oftentimes, like shown in the quotes above, fishers have the opportunity to maneuver different species and trading options to increase profit or simply, stay afloat with their business. But another adaptation strategy is also described by fishers indirectly: volume and intensity. When economic hardness hits in terms of *low prices for cod* for example, there are sometimes no other obvious strategies than to work harder, to sail longer or to increase the working days and to increase the volume: *"The price we receive for cod is much lower compared to other countries. You must work very hard to make it go around. For example, you have to fish a lot in a dinghy or a cutter to fill them up. You have to fill them up in order for the fishery to go round. And it is hard work. It wears you down. There are sort of high seasons where you work almost around the clock to fill up the boat. So it is hard and physically exhausting"* (Fisher from Nuuk).

This current adaptation strategy where volume compensates for low price is taking a toll on the human capital of the fisherman, very concretely in terms of the body. Fisher interviews touched upon this thematic of hard physical labor many times, and it is not uncommon for fishers and their colleagues to have cope with serious and untreated injuries, and to have left the fisheries due to health issues. The fishers see a solution in higher fish prices. The low price also actors as a barrier for development and experimentation, a fisher assess:

"I don't think there's any optimism in the city [Nuuk] [...] it's so cheap in this city with the cod, you don't really go for, how do you say it, you don't really experiment. Everything is so expensive! Diesel is expensive, the crew has to live, so we need to catch a lot. But when the cod is so cheap, it's difficult, right? If you start to catch well, the factories just lower the prices".

4.5 Adaptation to new species

The coastal fisheries and fish factories have not started to include any fish species that were not already known and being fished and sold to fish factories in Greenland. It is still the same species that are being fished and processed (although sometimes in other places and/or in different volumes): *"We don't suddenly see a lot of some species that we haven't seen before. It is still the common species – Greenland halibut, redfish, catfish, and then of course some capelin when in season. And some roe and so on. It is the common species we see. We don't have others. At least so it seems"* (Royal Greenland factory management).

"He says that the fishers and hunters go mostly for what pays off. He says that they don't catch a lot of herring. They are more focused on what they can sell" (Fisher in Nanortalik, translated).

From interviews with fishers and local market vendors in Qaqortoq, we learned that some 'rare' species are sometimes caught and put on sale on the local market. There is little sale, however, because only the older generation will know how to use it. According to interviews in Narsaq in 2018 the national food college Inuili had experimented with preparing bycatches (salted, smoked etc.) from the following species: eel, shark, wolffish and shorthorn sculpin. We also learned about a fisher in Nanortalik who was planning to fish for eel in 2022.

Importantly, we learned that fishers point to many known species that have been traded earlier but which are not landed and produced by the factories today. In Nanortalik, trout was mentioned. In Nuuk, it was shrimps in the fiord.

4.6 Adaptation to changes and regulations within hunting

During fieldwork and interviews in Upernavik district, it was apparent that the halibut fishery's growth arose because of limitations on wildlife hunts, with implications for food security, subsistence, income, safety, and cultural heritage. The license-limited halibut fishery without individual (or tradable) quotas, allows fishers to pursue this fishery relatively freely in comparison to mammal and bird hunts. For context, Upernavik district can still very easily be characterized as a hunter-fisher society with different strands of formalized wage economy, subsistence hunt, sharing practices and norms, and different modes of commercial fisheries entangling. Nonetheless, diminishing opportunities for hunting have pushed individuals into fisheries.

Older residents pointed to the 1970s/80s transition from sealing-based economy to fisheries-based economy, highlighting the implications of international environmental NGO actors on the livelihoods of those in Upernavik district. Interview participants also spoke about the limitations on the narwhale hunt and how this has increased the competition among hunters, created crowding effects (due to timing and increasing number of participants, who wish to partake for a right to a share) with implications for safety, including boat collisions. Similar points were made about polar bear limitations and how quickly the 'quota' is met.

Seasonal limitations of birds (e.g., Auk and Eider Duck) were also highlighted with notes that these birds were viewed as plentiful in the area, but the shorter hunting season allowance meant a shorter time to prepare for winter and secure food.

It is common wisdom in Greenland, that the meat and blubber from mammals help you keep warm and that it has healing effects when you have for example caught a cold. Interview persons highlighted whale, seals and polar bear meat as particularly warming. The early exhaustion of hunting quota due the rush for Olympic quotas is a problem for the hunter who needs to travel longer distances. For, as one hunter explained pointing to the crisp bread on the lunch table, store bought food does not suffice in keeping him warm during the long hunting travels.

A highly experienced seal skin seamstress has noted that sealskins have become oilier and more difficult to work with. She started making this observation in 2012 when she started making the national costumes. The meat is fine, but the sealskin cannot be used for clothing and for making the white skin fabric. If the skin is left lying for one year, it starts to crack. The cause for the oiliness is unclear but looking at the television news about oil spills she cannot help but wonder if it can be related to such events. The oil is observed to be 'kind of black'. The seamstress is currently experiencing with multiple ways to wash and dye the sealskin so it can be used for other purposes than the 'white fabric'. But the skin behaves differently and is very hard.

Due to climate change, seals are sometimes also observed to be shedding during summer and not only in April.

A hunter from Upernavik informs that he has not observed any changes related to the seal itself. However, he himself is no longer hunting the harp seal. This is because it is a relatively large seal and there is no one to work with the large skin and since there are less sledge dogs, there is less need for the meat in Upernavik. He notes, however, that the seal may still be hunted from the villages where dogs (and sea ice) are still more present.

5 Community level adaptation to change

5.1 Cultural heritage

In Upernavik it appears that food culture and cultural heritage in general is maintained and passed on to children via the hunting households. Most fishers and hunters will say that they took to fishing and hunting because they had been observing their parents. So, for example, a couple working with hunting and sealskin sewing told that their grandchildren had recently taken an interest in seal skin sewing from simply watching them as they carried out these activities. As such, cultural heritage is carried on as a living and skill-based practice to the next generation within the households.

Meanwhile, even in such households, grandparents will say that the younger generation does not get to experience the same food as they have experienced. This was especially the case with sea birds in Upernavik, where regulations have reduced the catch in the household. The thinning and instability of sea ice around Upernavik town has implied a shift away from dog sledges and on to open-water fishing from dinghies. Still, some of the villages in Upernavik district still have land-fast sea ice. Nevertheless, a decline in dog sledge practices is happening. We did not explicitly discuss if and how the community was working to maintain dog sledge culture and knowledge.

East Greenland and South Greenland has over the last decade seen a decline in sea ice which may be termed a paradigm shift in sea ice cover. In Nanortalik, this has challenged the traditional catch of hooded seal as described above. During our visit in May 2022, the sea ice had returned and after years without it, the traditional seal product was being produced and sold again. However, there were almost no sale on the local market. An interviewee raised concern that they were marketed at too high a price for pensioners to afford. The sale price had recently been increased to match the price at the local market in Qaqortoq (the largest town in the regions and the municipal center), which he deemed to be too high a price for many people in Nanortalik.

In connection with diminishing hunting and fishing practices in South Greenland, the school and the Municipality were organizing various activities for children in the community to teach about cultural heritage of increase well-being among youth. In many of these activities, they would practice land-based skills such as camping, fishing and collecting plants for tea. As a means to transfer local knowledge, a schoolteacher had been taking children to visit traditional hunting camps and conduct interviews with hunting couples processing seals there. Parent support to childrens' presentation day at school had been high. Important barriers to such initiatives have been the coordination with hunters and the costs of boat charter. As we understood, the price of boat charter is a significant economic barrier to the

municipality. For the school, it had been difficult to buy a seal from a hunter because of differences over the payment method.

5.2 Declining fisheries and migration

Fieldwork in Nanortalik showed that there have recently been difficulties with sustaining coastal fisheries in the fiord system and there are fewer fishers today than in the 1990s. South Greenland has generally suffered from declining fisheries for a longer period. According to Greenland Statistics, the amount of people owning a fishery and hunting license has decreased since the 1995 until 2020 - in Upernavik it has gone from roughly 450 to 400, peaking around 2002-2003 with 500 people. In Nanortalik, it has decreased from around 175 to barely 60 people, peaking around 1995.

Still, it was noted that some families are now returning to the villages and that population numbers fluctuate a bit. We note that the offshore landings to the factory seemingly function as a buffer that has kept the production going even when inshore landings were low. This speaks to the dependence of smaller communities on the local fish factory, but also on offshore landings. One local expert stated that the factory is the stable employer and the backbone of the community. However, a fisherman also assesses that the exclusive focus on cod is part of the explanation for the declining fisheries in Nanortalik: *"There are far fewer fishers today than there was in the 1990s, because the factory in Nanortalik only wants cod. When there isn't much sea ice and when the cod is here, then there are fishers. But there aren't many fishers. And some are part-time fishers. But there aren't many fishers today. It is mostly second-generation fishers like for example his son, and there are others whose son is also fishing. But it is not all"* (fisher from Nanortalik, translated).

In contrast, North Greenland has recently experienced an increase in factory production capacity and fishing communities in North Greenland are generally very optimistic about their future, as described in the previous section about increased fishing opportunities.

Seeking to link biodiversity change and community demographics (migration), we note that current out-migration is not explained in terms of fisheries, neither in Upernavik or Nanortalik. We note from interviews with Majoriaq and young entrepreneurs in the town that cultural and leisure activities are of importance to the younger generation when they make decisions to move away, while the strong sense of community and the natural surroundings are important to those who come back. Availability of jobs in the fish factory or in fisheries, however, are not highlighted when speaking of migration even though they are recognized for their livelihood options. In comparison, the merger of the municipality back in (year) and re-location of high-skilled administrative jobs is remembered to have caused out-migration of skilled community members.

An interview participant from Majoriaq in Upernavik discussed the challenges of developing innovation and entrepreneurship in the area due to multiple structural challenges while also acknowledging political, social, and cultural conventions influencing economic transition. During interviews Upernavik residents raised concerns about the peripheralization of Upernavik in the context of municipality configurations. Some interviewed felt there was a great deal of political power and resources centered in the municipality's largest town, Ilulissat, and that Upernavik was not experiencing the same level of service and infrastructure upgrades (e.g., sanitation, road repairs). Ferry service to Upernavik ceased about 15 years ago and now residents (and travelers) of the community and outlying villages must rely

on air transport alone or personal watercraft. These constrained mobilities in turn influence educational opportunities of local youth, creating a requirement to leave the community for Aassiat, Nuuk, and elsewhere for training and education. Although some acknowledged that this was a somewhat accepted reality of living in Upernavik district, perhaps the recognition of the appeal of being a fisher should be viewed in this context and with its offer to remain in one's home community and rural place (Ounanian 2019). In this way, Upernavik parallels other coastal communities where peripherality is constructed and experienced in connection to livelihoods and educational opportunities and attainment.

5.3 Innovation

The tourism sector is developing and includes a strong focus on local foods and some combination of tourism and fisheries (Jacobsen and Bjørst 2018). Entrepreneurship is supported by Greenland Self-Rule and has taken off over the last 10 years, most recently with the Food Lab Greenland. Small-scale entrepreneurs have been or are experimenting to develop new products based on local resources including, to name a few: fresh vegetables from agriculture and urban hydroponic systems; local beer, yarn and fur design; ceramics; ice cream, fish-skin chips, dried seaweed, gourmet salt and beauty products with local herbs. Importantly, Royal Greenland is also expanding its pilot production of seaweed in Maniitsoq. South-Greenland - with Inuili and its sheep farms - has also succeeding in profiling itself as 'Greenland's pantry', also in the context of warming temperatures.

Nonetheless, a north-south divide in connection to food product innovation may be occurring. There were multiple calls for adding value to fish products before they were shipped out of Upernavik district, but also noted frustration that it did not seem to materialize and the question of whether the labor force and logistics could be developed. Polar Seafood in Upernavik has developed a crab processing on site (de-shelling and cooking) before export to almost exclusively the Japanese market. Equally, one may add, the local fish factory in Nanortalik is exclusively producing and selling Bacalao for the Portuguese market.

All stakeholders agree that the fishers are highly adaptive and that it is the capacity of fish factories which may be the largest factor limiting the production in the coastal fishery: *"So if one wishes to exploit (the new opportunities), then it is more about the factories' capacity. The fishers can easily adapt to what is available in their area"*. Currently, the factories in North Greenland are more geared to Greenland halibut and the factory in Nanortalik only buys cod. In the view of coastal fishers, the narrow selection of species is a major restriction representing lost potential to benefit fisheries and communities:

"It's the factory owners who decide what fish should be traded and which fish they will accept. The fishers go for what the factories want [...] But he says that they can catch all sorts of fish, you know, nearby, where they can find it [...] t's just the factories that – when they are buying, it's just the cod. He hopes that the factory owner can lead a change like that. So they can benefit the town" (Fisher in Nanortalik, translated).

Even the equipment of the fish factories has not changed much, workshop participants agree. The fish boxes for example, are the same as 20 years ago. The lack of innovation is explained with reference to the relatively low volume which makes innovation and investment less profitable. Currently, the most advanced equipment is to be found at the shrimp factories and at the factory in Maniitsoq⁶.

⁶ In Maniitsoq a new catch and production method has been developed to produce the new cod filet product *Nutaaq cod*.

When it comes to explaining the current limits in fish factory capacity, technological equipment is not highlighted to the same extent as the lack of ‘stable’ fish factory employees; this is considered a major bottle neck and a general issue for many fish factories around the country, including those in Nuuk.

Entrepreneurship and new types of businesses in for example tourism can diversify the economy, services and cultural experiences of local communities. In line with a previous interview study in Narsaq, Qaqortoq and Narsarsuaq in South Greenland (Wennecke, Jacobsen and Ren), we noted that local entrepreneurs in Nanortalik also see a lot of place-based potentials in the communities which they consider unique and different from other South Greenlandic communities. However, like observers in Narsaq they also point to the challenge of accessing bank loans in Greenland, which they deem to be far less accessible to entrepreneurs in declining communities, located in the margins of the municipal growth centres.

6 Reflections on adaptation capacity in Greenlandic fisheries and hunting

In assessing the adaptation capacity for the **offshore fishery**, we note that the offshore fishery itself expresses content with the situation and that it has generally been able to adapt to the environmental changes: They have been able to make the desired technological investments to pursue new pelagic fisheries and they have been observant and mobile enough to ‘follow’ incremental shifts in the location of the shrimp biomass. Furthermore, the seafood companies express satisfaction with the structural infrastructure, including the economic adaptation that has occurred in the offshore fishery: the offshore vessels have become fewer, larger and more efficient and the fishery is considered attractive in terms of working conditions, salary level and company profits. Overall, they consider the offshore fisheries to be *‘stable for the moment’*.

Greenlandic vessels have no access to fish mackerel in other countries’ EEZ. As pelagic fisheries are conducted by specialized large-scale and capital-intensive vessels it may become difficult to maintain a pelagic fleet if pelagic fishing possibilities remain limited and thus the capacity can only be used a few months per year. But Greenland fishing companies holding quotas is better off to enter joint-venture arrangements with foreign companies or charter foreign vessels to conduct the fishery. The focus on adapting by-catch regulations in order to make productive use of the by-catch seems to reflect an opportunistic approach to turn constraints into opportunity.

When it comes to understanding and assessing adaptation capacity of **the coastal fishery**, the structural conditions for marketing the catch seems critical to coastal fishers and hunters. The structure of the land-based processing industry facilitates access to international markets and the ‘opening’ of factories and new productions are part of the ‘positive stories’ of adaptation capacity in North Greenland. In the case of Nanortalik, the landing of cod from offshore trawlers have implied that the factory could keep going even in periods where the coastal fishery for cod was declining.

At the same time, however, factory decision-making is a prevalent and sensitive subject as it *also* constitute a limiting factor for adaptation in the experience of many fishers. And oftentimes it appears that fishers in Nuuk and South Greenland are more busy adapting low fishing prices and narrow landing

opportunities than they are in adapting to environmental changes. For it is eventually the factories which decide what can be landed where and by whom and at what price. This monopsony – whereby one buyer controls the market - sometimes causes fishers to sail a whole day to land at the next town or even having to throw out parts of his catch. The seafood companies provide competitive loans to coastal fishers, who in turn risk experiencing restrictions in landing access from a competing factory. In practice, only one seafood company is often represented in most towns, with the exception of Nuuk and the more lucrative Greenland halibut fishery districts. The monopsony structure is sometimes levelled by co-ownership by local fishers or local competition between two companies. As a strategy of local empowerment, fisher-owned factories have been established now and then.

On the topic of innovation and adding value to fisheries products that can be captured in the local economy, there seems to be interest, but gaps in implementation. This could be an area of development and intervention from the municipality, other public and/or private actors, and processing factories to develop means to increase the value of the catch, products for export, and local wages and spinoff enterprises. It should be noted that the introduction of a second factory in Upernavik has raised the price for fish in the area.

Related to adaptation capacity and resilience is question the physical pressure and associated health risks in the coastal fisheries and hunting. An adaptive strategy in the coastal fishery seems to be to focus on quantity and simply work harder and longer to make ends meet. Hunters and fishers alike will also just be travelling longer in search for hunting and fishing grounds. Some of the risk coming from repetitive and heavy lifting has been somewhat reduced with recent advancement in deck-technology which has made the fishery operations lighter and more efficient.

Assessing the adaptation capacity of the **management system**, we note that management-induced pressures on coastal hunters and fishers include the perception of overly restrictive quotas, but also and perhaps not least: the ‘crowding’ or ‘rushing’ behaviour that results when fisheries and hunting is managed by an olympic quota system that does not consider regional differences or an even distribution throughout the year. This is observed to have resulted in in inequality of geographical access (e.g., when a migratory stock has been hunted to the quota-limit before it arrives further north/south), destruction of fishing gear (e.g., when long lines are being cut in Nuuk fiord when dinghies and cutters fish in the same spots) and dangerous situations (e.g., during whale hunts).

This speaks to the relevance of pursuing co-management institutions in either distributing the TAC quotas in new ways and/or including LEK when setting the TACs. In that respect we note that some solid and interesting initiatives for co-management and local capacity building has been building, responding to decades of demand for more inclusion of LEK and co-management institutions. The ‘Pisuna’ platform for community-based monitoring of the living resources can be highlighted as an interesting new initiative, which has been supported by the fishery ministry. ICC has also been leading a major initiative to establish a *regional co-management institution* in the North Water Polynia as a marine protected area governed by and taking into account Inuit needs and knowledge (Pikialasorsuaq Commission 2017). This project responds very well to calls for local capacity building, regional management and conservation in combination with indigenous usage in an area being made more accessible by climate change. However, the initiative has not been sought implemented by the Greenlandic Self-government to date (Sermitsiaq 20.04.2011).

Overall, there is a call for greater and better use of resources like by-catch, species that are currently not processed by factories in a given region and/or species that are considered to be overly restricted by

quota. When new or increased exploitation is taking off, however, there is the latent challenge of overfishing and sudden crowding of local fishing places. Currently, it appears that management is lacking 'behind' in governing new fisheries and crowded spaces in the sense that trawlers and coastal fishers/hunters alike are left to themselves in making tactic and strategic choices on how to adapt to their fishing peers and competitors. This may result in some 'organic' or market-based solutions, where fishers move between different fisheries and hunting strategies to reduce cost (e.g., to avoid damages to gear) or to get the best prices at the local market. In that regard, fisher flexibility and resilience is supported by the relative ease of applying for obtaining licenses to multiple fisheries as a coastal fisher, and the presence of multiple different marketing options (e.g. the local market, elder homes and other informal networks) in addition to the fish factory.

But when crowding occurs and management does not interfere, it can also simply result in overfishing of fish quotas as seen in the NE Atlantic mackerel fishery. The movement and relocation of straddling and migrating stock in international waters had been identified as potential governance issues in previous adaptation studies. However, the international cooperation over shared pelagic stocks became an issue with respect to the newly developed mackerel fishery in Greenland. Greenland decided to set autonomous quotas for its offshore fishery in the suspension of the MSC certification of the mackerel fishery in the NE Atlantic. This is a paradox then the Greenlandic fishery sector simultaneously operates with an ambition to certify all of its own fisheries.

That Greenland halibut quota exceed the advised quota in the Disco Bay has received a good deal of focus from management and industry representatives. This study did not include interviews from the Disco Bay and Uummaanq. But according to workshop participants, the fishery and the management system needs to respond (adapt) to the increased physical access to areas in North Greenland where the ice used to protect the fish, but where fishers now have more access. Stakeholders note that the districts are very large, and that the fishery tend to concentrate on limited fishing grounds (out of Uummannaq). The option of area-based closures was discussed together with the option of spreading out the fishery to new fishing grounds. However, stakeholders also acknowledge that fishers experience much by-catch of Greenlandic shark when they start to fish in new areas – a by-catch which ruins their nets and causes economic loss: *"It is difficult to explore new fishing grounds because it is much more expensive to the fishers. Because there are so many Greenland sharks in the different new areas. It is a problem when one is to try out new areas. They destroy a lot of net and long lines (...) as soon as they start to bleed, they eat each other"* (Fisher representative).

In addition to expanding to new fishing grounds, diversifying a fishery to include additional species was also discussed as an adaptation strategy. It was suggested that it could lower the pressure on areas and on stocks that are currently fished beyond scientific advice.

In assessing the adaptive capacity of **communities in the margin of their municipalities** we noticed that even though fishers and hunters may experience temporary comebacks in hunting and fishing, the flow of money, food and cultural practice not automatically 'trickle down' from the participating fishers and into the wider community. If children and other community members are not part of hunter households and if food prices in the local market are geared towards higher income households at the municipal centre, then the locally harvested food and hunting practices are not accessible to a large group of people. The municipality in Nanortalik as well as community members in Upernavik are very well aware of this internal inequality when they note that 'not all have access to boats', not even in the villages.

In Nanortalik, which has experienced years of decline as a fishing community, we took notice of the municipal and school initiatives in teaching children land-based skills and cultural heritage. In this context, a suggestion that could increase children's access to land, skills and cultural heritage even further could perhaps be to support fishers, hunters and boat owners in finding ways to strengthen their cooperation with the school and municipality initiatives even further. A concrete idea could perhaps be the establishment of funds or international funding for development projects for education purposes and/or social innovation.

Upernavik still has the characteristic of a hunting society and cultural heritage is passed on to new generations in the hunting household to the extent that it is still possible to hunt, prepare and eat the traditional resources in a traditional way. This is no longer always the case due to primarily quota restrictions. That the next generation will not learn to make use of and benefit from certain local species as 'resources' is somewhat of a paradox as one of the key concepts in sustainability is exactly to ensure these resources for the next generation.

When it comes to 'new species', we get the impression from these and previous interviews that local people talk more about 'rare species' and that there has already been a local familiarity with many of the southern species for own consumption – like for example herring, mackerel and eel. But it may mostly be the older generation who knows how to cook them. Meanwhile, experimentation and food innovation seem to be occurring outside the households now – for example at the food college. This seems to imply that also in this respect, the adaptive capacity of the community may lie in increased cooperation between public institutions, fish factories, knowledgeable fishing/hunting households and food entrepreneurs.

6.1 Suggestions for focus points

There is no doubting the resilience of Inuit communities, and the recent biodiversity changes that has brought a new challenge in adaptation. With it has come a series of issues as well as possibilities, though it seems there is a lack of infrastructure both to accommodate the issues and to utilize the possibilities. Throughout this research we have encountered different opinions and ideas for this, and to end this text we will here bring to attention some of the elements we have identified underway.

During this research, many discussions of issues in the adaptation to ecosystem changes have been discussed, and multiple respondents have expressed concern in many different areas of investigation. Focusing on local and fisheries development as interdependent and connected to each other, we have identified some of the common themes and will here create an overview of proposed courses of action to accommodate these challenges.

Local development

There is a lack of resources to spend on local development of smaller towns in Greenland, and a sense that most resources go towards development of bigger cities, leaving smaller towns behind and 'stuck'. A sense of 'belonging' is not always enough to keep residents, especially younger people, living in the towns, which further can cause deterioration as they look to other places for more opportunities that

the smaller communities currently cannot offer. Redistribution of resources to support smaller towns' development in areas such as housing, business spin-offs, financialization and culture leisure activities should be a focus to counteract this.

Another point is an increased focus on cultural heritage, where better opportunities for students in schools to engage with fishing practices - events like traditional hunting camps and seal processing for school children. Education opportunities are limited in smaller communities and increasing youth interactions in fisheries and hunting would likely help the diminishing of it.

To support local communities further, we suggest a focus on supporting the following points:

- Improved housing and infrastructure
- Cultural, sport and leisure activities and the passing on of cultural heritage skills to the youth.
- Better financialization for entrepreneurs in peripheral communities

Fisheries development

Declining fisheries can prove an issue with the dependence of local factories and changing fishing opportunities and prices would give more breathing room for an expansion of the fishery.

In the fisheries development, intervention from the municipalities, private and public actors and processing factories should work toward increasing the value of catches. For example, raising another fishery factory in Upernavik has brought up competition that can help raise prices for fish. Changes in access and abundance also seems to call for an adaptation of the current fishery management system. Overly restrictive or unevenly distributed quotas that does not fit with what fishermen experience results in imbalances in the fisheries. For example, fishermen 'rush' or 'crowd' resources when they're available while under a quota system that does not consider regional differences or yearly distribution when species move from one area to another – this is especially relevant with the changing of temperatures and species availability.

Another point is to utilize more fishery options. Not all species available are of interest to factories and can be sold. If allowing more diversity in the sale, there would be an increased interest in fishing for more different species. One can imagine this would alleviate pressures on currently crowded species, such as cod. This is also connected to new opportunities in fisheries as a result of decreasing ice, new routes, ecological changes bringing in new species, and shifting the status quo – allowing changes in sales will allow for easier adaptation to changing ecosystems.

An adaptation in by-catch rules could help. With changes in appearing species and abundance, by-catch also changes, so avoiding, allowing for and/or facilitating usage of these catches is both a challenge and an interesting potential. As an example, influx of polar cod by-catch could be utilized for bait instead of relying on imported bait transported half way across the globe.

To support fisheries adaptation capacity further, we suggest a focus on the following points:

- Greater diversity in fish sale
- Innovation around by-catch
- Business spin-offs in the fisheries

- Consider regional differences in access to Olympic fisheries and hunting
- Better financialization for entrepreneurs in peripheral communities

We recognize these suggestions demand a large work-around that may not be feasible within a short timeframe - and the current situation with biodiversity change and possible regime shifts is yet another unknown factor, where further adaptations will most likely occur as the situation demands - as it has done for the past 10 years. We can for now, however, raise some of these issues identified from collaboration with the people experiencing these changes, and bring them to attention.

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7 Appendix A. Overview of previous climate change scenarios and adaptation recommendations for Greenlandic fisheries)

	Greenland Self-Government 2012	AACA 2017
<i>Change scenarios</i>	<p><i>Greenland halibut could increase, but southern border of distribution could move north</i></p> <p><i>Offshore cod may re-establish itself on the banks of West-Greenland</i></p> <p><i>The shrimp stock may decline (due to predation from cod)</i></p> <p><i>As a cold-water specie, the snowcrab may be negatively affected.</i></p> <p><i>Arctic krill is likely to decline</i></p> <p><i>Capelin could increase, or decrease</i></p> <p><i>Lumpsucker. Unknown.</i> <i>Likely increase of warm-water stocks like redfish, halibut and catfish</i></p>	<p><i>Even in the short run (2030 scenario) fish stocks are expected to change their distribution and productivity.</i></p> <p><i>But due to the complexity of ecological processes, it is impossible to predict future tendencies in the long run (2080 scenario) (Who eats who – and how much? Recruitment of new individuals may fail, or not).</i></p> <p><i>New species expected in the region – e.g. haddock and mackerel</i></p> <p><i>But in particular, the size of existing stocks may increase. E.g. for cod, redfish, capelin, sand eel.</i></p> <p><i>The management of the fisheries will also have an effect on fish stocks. A ‘political factor’ that makes predictions even more difficult.</i></p>
<i>Recommendations</i>	<p><i>Fishery management:</i></p> <p><i>Make management plans for the fisheries</i></p> <p><i>Make a national monitoring strategy</i></p> <p><i>Provide better/more information to fishers</i></p> <p><i>Increase research in fish resources</i></p> <p><i>Prioritize shrimp (prey) or cod (predator)</i></p> <p><i>Enhance international cooperation over new, shared stocks</i></p> <p><i>Avoid overfishing (biodiversity loss)</i></p> <p><i>Introduce MPAs</i></p>	<p><i>Fishery management:</i></p> <p><i>Long-term management plans for ‘experimental fishing’: what is the objective, exactly?</i></p> <p><i>Flexibility in production technology</i></p> <p><i>Multi-species licenses in the coastal fishery</i></p> <p><i>Awareness towards new vulnerabilities or opportunities in different towns/districts</i></p> <p><i>Larger focus on monitoring social and economic processes (as well as environmental)</i></p> <p><i>Consider securing access to fishing (license/quota) and landing in all towns and settlements</i></p> <p><i>Innovation and entrepreneurship:</i></p>

	<p><i>Increase dialogue between fishers and management</i></p> <p><i>Make tailor-made adaptation in each fishery and region</i></p> <p><i>Introduce more selective fishing technology (by-catch)</i></p> <p><i>Subsidize multi-functional vessels</i></p> <p><i>Re-structure the fleet: Reduce number of small-scale fishers and re-skill fishers to alternative livelihoods</i></p> <p><i>Local capacity-building for action</i></p>	<p><i>Research and innovation (food, marketing, new products etc.)</i></p> <p><i>Consider creating interest and taste for new species (food security)</i></p> <p><i>Consider creating a more diverse mix of income/livelihood in towns and settlements (e.g. tourism-/fishery)</i></p>
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8 Appendix B – Interview Guide

1. **Your fishing:**

- How are your seasons? (Have they changed?)
- What have you fished through the ages? (Has that changed?)

2. **Observations of 'natural' changes:**

- o What are the most significant changes (In the marine environment)?
- o Ice layer
- o Freshwater Layer, Salt Content, Current
- o Temperature
- o Algae, Run-off (mud)
- o Fish, fish stocks
- o Food sources for animals and fish (stomachs)
- o Condition of the animals caught
- o New places where fish etc. stay?
- o Weather and storm – good/bad fishing days?

3. **New species specifically:**

- Have you observed 'new species'?
- Is there any new by-catch? Anything that can't be used?

4. **Adaptation in fisheries:**

- o What has changed for your business? What has that meant for you?
- o New fishing spots? (What has this meant for the economy, bycatch, etc.)
- o New gear? (What has that meant financial security or profits?)
- o Who are you selling to (now)?
- o Business situation
- o Where do you sell the catch to?
- o Have factories changed in volume, nature, or price of trade?
- o Would you like more shopping spots in the city?
- o Multi-species adaptability - dependence on factories
- o Catch you are taking home? (Are new species hiding here? E.g. Herring, octopus)
- o What do you typically catch for family and friends? Any changes in what is in demand or what you catch? For everyday life? For kaffemik?

Societal issues:

Impact

- o Food security, jobs, life at the port, do you take side jobs (supplementing income needs?)
- o Youth (demographics)
- o Do they live at home or do they leave home? How is the mobility?
- o Differences south/north (relocation statistics)

Project: ECOTIP

Deliverable (D4.1 – Assessment of Recent Adaptation Actions in Fisheries):

- o Future – is it necessary to start new professions, what would you like to see happen, what would not work?
- o Tourism

Economy

- o How do you make economic sense for new fisheries?
- o Distance, fuel, spread of fishing grounds